AIC PAINTINGS SPECIALTY GROUP POSTPRINTS

Volume 17
2005

The American Institute for Conservation of Historic & Artistic Works

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CLEANING ACRYLIC EMULSION PAINT; A TWO-PART STUDY.

Geneviève Saulnier, Conservator of Contemporary Art
Marie-Ève Thibault, Conservator of Paintings.

1. INTRODUCTION

Shortly after acrylic emulsions were introduced to artists as a painting medium, conservators and scientists voiced concerns about the materials' properties. Since then, researches have successfully enlightened conservators about acrylic emulsions' characteristics; however, few treatment suggestions have been published. This paper describes the efforts, in collaboration with the Canadian Conservation Institute and Queen's University's Master of Art Conservation program, to develop an effective cleaning method for unvarnished acrylic emulsion films.

Acrylic emulsion paint films dry by the evaporation and the absorption of water into the substrate. Some additives present in the polymer matrix are water soluble but not volatile. These additives dry or at the surface of the polymer film or at the interstices of the polymer spheres or within the substrate. From this result a stable film where acrylic spheres are stacked in a thigh polyhedral arrangement (Williams 1994). Cleaning methods currently used for painted surfaces involves solvents, aqueous solutions or dry cleaning materials. Most solvents and aqueous solutions affect dried acrylic paint formulations (Murray *et al.* 2002, Strain *et al.* 1993, Tanks 1991). Solvents swell or dissolve dry acrylic paint films while aqueous solutions dissolve water-soluble additives present within or at the surface of the paint film. The pigments and interface of the polymer spheres can also develop capillary movement of solutions (Stringari and Pratt 1993, Michalski 2000). Although erasers have been used for cleaning acrylic paint surfaces, the effects of dry-cleaning on acrylic emulsion paint films are not well known.

The scope of this project was to evaluate dry cleaning materials as cleaning agents for unvarnished acrylic emulsions. Dry-cleaning products have proven to be effective, especially in the paper conservation field, as they tend to remove layers of dirt without disrupting fragile substrates. During the first part of the experiment, five types of erasers were tested on acrylic emulsion samples. The paint was applied on nonabsorbent substrates. A synthetic layer of dirt was applied on the samples, which were cleaned at three different environmental conditions. The second part of the experiment discarded the application of a dirt layer, the environmental conditions and the erasers that damaged the paint surfaces in the first part. The cleaning tests were performed on samples applied on absorbent substrates. For both parts, data on gloss, color changes and morphology was collected before and after cleaning.

2. EXPERIMENTAL, PART-1

2.1 SAMPLES

Samples were made out of Liquitex® Artist-grade, Medium Viscosity emulsion paint. Five colors were chosen in order to detect the variable results that may be obtained on chemically different films. Cadmium red medium hue, ivory black, titanium white, matte medium and gloss medium paint were applied on glass slides with a Sheen Film Applicator (200µm clearance) and then stored vertically for a period of six

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months. The resulting samples had very different visual properties. For some colors, the non-absorbent nature of the glass substrate enhanced the migration of the additives to the surface of the polymer film. The additives found on the gloss medium samples had a networking shape visible to the naked eye (Fig. 1). Under magnification, these additives took the shape of rococo feathers (Fig. 2). The red and white samples' additives were round-shaped (Fig. 3). The ivory black and matte medium were the only colors that didn't show any migration of additives. Both had a large number of filler particles visible under 20x magnification and had very busy surfaces, also responsible for giving their matte sheen.

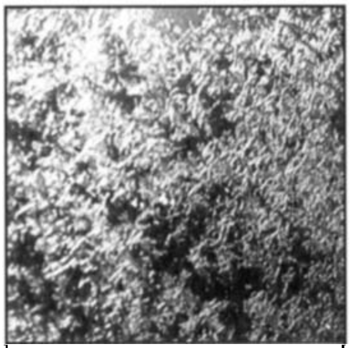


Fig. 1. Gloss medium sample (detail). Raking light.

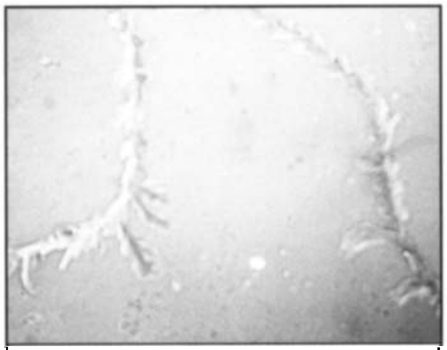


Fig. 2. Gloss medium sample at a 20X magnification. Transmitted light.

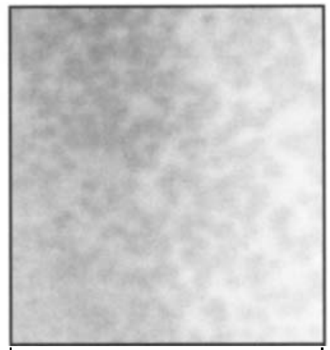


Fig. 3. Titanium white sample (detail). After dirt application.

Because of time constrictions a naturally occurring soiling process could not be obtained. A simplified recipe for dust and dirt that consisted of silica and carbon particles mixed in mineral oil was applied onto the samples (Wolbers 1992). The samples were put in an oven at 35°C for four days to accelerate the embedding process of the dust into the paint film. The excess dust was removed with a 50psi air stream provided by an airbrush. The resulting dust film was very uniform and composed mainly of small size particles. For all samples, the surface additives absorbed the dirt to a greater degree than the polymer matrix (fig. 3).

2.2 ERASERS

Five erasers were selected for their availability and properties. They are: Staedler Mars Plastic 52650 (grated and block form), Staedler Art Eraser 525G20, Groom/Stick (Picreator Enterprises Ltd.), Opaline (Durasol Chemical Company), and Dry Cleaning Sponge (Maritime Chemicals and Equipment Limited). The erasers were tested on the samples following the instructions available in the CCI Technical Bulletin 11 (Cowan and Guild 2001). A series of ten repetitions was chosen for every type of eraser.

2.3 ENVIRONMENTAL CONDITIONS

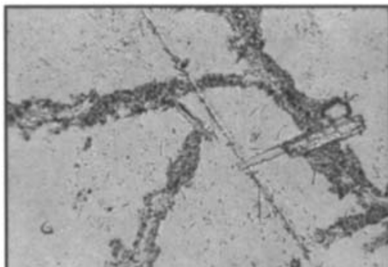
Three environmental conditions were introduced in order to evaluate the response of the acrylic emulsion samples to mechanical cleaning. The erasers were not subjected to these conditions since it could have altered their physical properties. Critical levels of temperature and relative humidity (R.H.) were chosen in order to obtain significant responses and results. The first environmental condition (24°C ± 2 and 45%±3 R.H.) replicated museum or laboratory conditions, in which treatment is more susceptible to happen. At this temperature, the acrylic paint film is relatively soft and has elastic properties. The second environmental condition subjected the samples to low temperature (0°C ± 2 and 45%±3 R.H.). At low temperature acrylic emulsion film is susceptible to become hard, and would therefore sustain abrasions or surface deformations caused by mechanical cleaning. The last environmental condition was carried under low levels of relative humidity (24°C ± 2 and 0%±3 R.H.), where the acrylic emulsion films tend to have a net increase in elastic modulus and strength (Erlenbacher *et al.* 1992). On the other hand, the film's ability to stretch decreases. To lower the humidity levels could lower the acrylic film's hydration state and susceptibility to moisture making the film capable of withstanding mechanical cleaning (Douglas 1996).

2.4 INSTRUMENTAL METHOD OF ANALYSIS

Data on the gloss, color, and surface morphology was collected before and after dirt application, and after cleaning. A Micro-Tri-Gloss by BYK Gardner Inc. and a Minolta Spectrophotometer CM-2022 were used to collect data on the gloss and color changes respectively. An incident light microscope (ELSEC 764UV + Monitor, Model no.: 04346 by Littlemore Sientific) was used at 10, 20, 40, and 100x magnifications to examine the surface condition. The samples that were cleaned at low levels of R.H. and temperature were allowed to reach ambient levels before collection of the final data.

3. RESULTS PART-1

3.1 VISUAL EXAMINATION



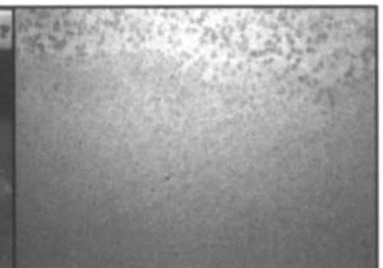


Fig. 4. Gloss medium sample cleaned with Opaline at environmental condition 1. 20X magnification. Transmitted light.	Fig. 5 Ivory black sample cleaned with Steadler Mars Plastic 52650 (grated) at cold temperature.	Fig. 6 Red sample (detail), cleaned at environmental condition 1. Bottom portion was cleaned with Staedler Mars Plastic 52650 (grated).

Visual examination of samples was performed before and after dirt application, and after cleaning. The following remarks are based on an unaided examination and 20x magnification, which was judged highly sufficient for detecting damages and residues.

Eraser residues were frequent on samples cleaned with Opaline. A residue is visible in fig.4 at the far right/center area. The residues were bamboo-shaped and partially embedded into the polymer matrix. Although eraser residues could not be detected under magnification Staedler Art Gum 525G20 and Groom/Stick left cleaning marks detectable without magnification, especially on samples cleaned at low R.H. and T°. The ivory black samples had a colder hue when cleaned at the first environmental condition with Staedler Mars Plastic 52650 (grated). Staedler Mars Plastic 52650 (block) left whitish strokes on all samples when cleaned at low R.H. and T° (Fig. 5). All samples were left with considerable amounts of dirt residues for the exception of samples cleaned with Groom/Stick and Staedler Art Eraser 525G20, which were also very successful in cleaning the gloss medium samples when comparing their performance with other erasers.

Polymer abrasion was found on all samples and was mostly caused by the presence of dirt particles at the surface of the samples. The only eraser that inherently caused abrasions is Opaline (Fig. 4). Morphological disruption was found on samples cleaned with Staedler Mars Plastic 52650 (block). This latter flattened and dislodged the polymer surface, forming wavy strokes that were consistent with the left to right cleaning motion. The block eraser also gave all samples a burnished appearance.

The additives found at the surface of the red, white and gloss medium samples were greatly affected by mechanical cleaning. Opaline did abrade, partially remove or spread the additives at the surface of the polymer matrix when cleaned under all environmental conditions (Fig. 4). This phenomenon was also noticed on samples cleaned with Dry-Cleaning Sponge but to a lesser extent. Staedler Mars Plastic 52650 (grated) was the only other eraser that lowered the contrast between the darkened additives when cleaned at low R.H. or under standard levels (Fig.6).

3.2 GLOSS CHANGES

Color	Cadmium Red			Titanium White			Ivory Black			Gloss Medium			Matte Medium		
Env. Condition*	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Staedler M.P. (grated)	X	X		X	X	X	X	X	X		X		X	X	X
Staedler M.P. (block)														X	X
Groom/ Stick	X	X		X	X	X	X	X	X				X	X	X
Opaline		X		X	X	X	X	X	X				X	X	X
Dry-cleaning sponge	X	X			X		X	X	X		X		X	X	X
Staedler Art Eraser		X		X	X	X	X	X	X		X		X	X	X

* **1**: 24°C ± 2 and 45%±3 R.H. / **2**: 0°C ± 2 and 45%±3 R.H./ **3**: 24°C ± 2 and 0%±3 R.H.

Fig. 7. Gloss changes

The gloss results are summarized Fig. 7. The areas marked with and X are results that fall into the acceptable change range. For the exception of the matte medium samples cleaned at low temperature and R.H., Staedler Mars Plastic 52650 (block) eraser could not recover any of the sample's gloss. Successful gloss recovery of the gloss medium's samples occurred especially during cold cleaning. None of the red samples recovered a gloss close to the original while cleaned at low levels of relative humidity. In general, gloss recovery is color dependent; matte samples such has the black and matte medium samples obtained better results.

3.3 LIGHTNESS CHANGES

Samples that were cleaned at standard levels of R.H. and temperature obtained the best results. Compared to gloss results, changes in lightness are more consistent between colored samples; however, there is a net tendency from each color to respond differently to mechanical cleaning. As can be seen in Fig.8, better results were obtained on red samples while none of the matte medium's results are acceptable.

Env. Condition	24°C ± 2 / 45%±3 R.H.					0°C ± 2 / 45%±3 R.H.					24°C ± 2 / 0%±3 R.H.				
Color	R	W	B	G	M	R	W	B	G	M	R	W	B	G	M
Staedler M.P. grated	X	X	S	S	S	S	M	S	S	O	X	M	S	S	M
Saedler M.P. block	X	S	S	X	S	S	M	S	S	M	S	O	S	S	M
Groom/ Stick	X	S	X	S	S	S	M	S	S	M	X	M	X	S	M
Opaline	S	S	X	S	S	S	S	S	S	M	S	M	S	S	O
Dry-Cleaning Sponge	X	S	X	S	S	S	M	S	S	M	S	O	S	S	M
Staedler Art Eraser	X	S	X	S	S	S	S	S	S	O	X	M	X	S	M

X: No change in lightness/ S: Slight change/ M: Visible Change/ O: Not acceptable change

Fig. 8 Lightness changes

4. DISCUSSION

When comparing and including the visual examination, gloss and lightness results, it is possible to grade performances obtained from specific erasers. The erasers that performed best are Staedler Mars

Plastic 52650 (grated), Groom/Stick and Dry-Cleaning Sponge. Samples cleaned with Staedler Art eraser 525G20 are somewhat less consistent but overall results could be considered as adequate. Gloss, lightness and visual examination results obtained during this first part of the experiment are highly influenced by some parameters such as the non-absorbent surface, presence of dirt and the environmental conditions. The non-absorbent nature of the substrate enhanced the migration of the additives to the surface of the samples. The additives were visually glossier and softer then the polymer itself and were easily removed or spread onto the surface of the polymer during cleaning. The dirt was absorbed to a greater degree by the additives present at the surface of the samples. During cleaning at low temperature and R.H., these darkened additives were left on the surface of the polymer and were thus highly disfiguring. The presence of dirt particles was the main cause for polymer abrasion for the exception of samples cleaned with Opaline. Staedler Mars Plastic 52650 (block) damaged the morphology of the samples because of its physical properties. Samples that were subjected to low temperature and humidity responded differently then samples that were cleaned at normal environmental condition. In general, samples cleaned at standard levels of temperature and R.H. obtained the bests results.

5. EXPERIMENTAL, PART-2

The aim of the second part of the experiment was to withdraw some of the variables included in the first part that affected clear reading of true performances of the erasers on acrylic samples. Results comparable to ones that would be obtained in normal instances were obtained by omitting dirt application as well as the cold and low relative humidity environmental conditions. In order to prevent or minimize migration of additives, paint was applied on commercial primed cotton canvas, an absorbent substrate. Due to their poor performances, Opaline and Staedtler Mars Plastic 52650 (block) were eliminated.

5.1 SAMPLES

Paint was applied on canvases with a brush. For each color, the paint samples were made out of the same quantity of paint, achieved by carefully weighting the wet paint for each sample. They were then left to dry for a month after which they were artificially aged at 35°C and 40% R.H. for a period of 13 days. Unaided and microscopic examination concluded that none of samples showed migration of additives at their surface indicating that the additives were absorbed by the substrate, evaporated or trapped within the polymer matrix.

5.2 CLEANING TECHNIQUES

The experiments conducted involved a series of cleanings reproducing the cleaning techniques used in Part 1; this series was called Cleaning Method-1 (C-1). Since the scope of the following experiment was to evaluate the physical consequences of dry cleaning techniques on acrylic emulsion paint samples, half of the samples were cleaned twice (C-2), which meant that 20 twenty cleaning motions were performed on each sample. Although that many repetitions may not be necessary in normal instances, double cleaning was thought to provide clear results on the types of damages done by each type of eraser. All erasers' residues or crumbs were brushed away using a hake sheep-hair brush.

6. RESULTS

6.1 VISUAL EXAMINATION

Similarly to the first part of the experiment, the tackiness of both kneadable erasers caused the substrate to lift up as the erasers were stamped on the samples' surfaces. This phenomenon appeared to be proportionate to the extent of stamping performed, where it increased during the second set of cleaning. Most Dry Cleaning Sponges had a pink hue after cleaning cadmium red samples. The presence of pigment particles was confirmed after magnified examination.

Visual examination of the samples after cleaning concluded that none of the samples showed signs of abrasion, morphologic damages, or shifts in color or gloss. The observations are applicable on both cleaning sessions. The abrasion expected to take place at the top of the threads, especially in the Cleaning Method-2, was not observed, even at a magnification of 125x. The possibility of damage that would be visible at higher magnifications cannot be excluded. Even if the eraser residues were brushed away after cleaning, microscopic particles of Staedler Mars Plastic 52650 (grated) and Dry Cleaning Sponge remained on the surface of random samples. The sponge deposits might be explained by the fact that small cubes of sponge were cut with a scalpel prior to cleaning. Since these cubes were roughly cut, they may have been prone to disintegrate or lose particles compared to the intact, maybe more stable, machine-cut faces. Gloss medium samples seemed less susceptible to retain eraser residues, as no signs of foreign particles were detected on any of the samples.

6.2 GLOSS CHANGES

Although a change in gloss was expected, all values for both cleaning methods where within the acceptable range. These results were totally unexpected when considering the data obtained in the first part of the experiment. The lack of surface additives may have played an important role in resulting gloss data; however, paint samples that did not had any visible surface additives such as the black and matte medium samples should have encountered gloss changes likely to samples cleaned during the first part of the experiment. This confirmed that the presence of dirt particles affected the gloss of the samples before and after cleaning. To the naked eye, no unevenness or changes in gloss was observed.

6.3 LIGHTNESS CHANGES

The colorimetric results of samples cleaned with the first cleaning method (C-1) were similar to the gloss results in the way that changes in lightness were minimal, almost non significant. In general, ivory black and cadmium red were the colors most affected by the Cleaning Method-1. Both colors gained in lightness for all the erasers tested, especially when cleaned with Staedler mars Plastic 52650 (grated) and Groom/Stick. Cadmium red samples underwent a greater lightness change than the ivory black samples.

The colorimetric values obtained from the second cleaning method (C-2) showed that less changes in lightness occurred even if samples were subjected to extensive repetitions of mechanical cleaning. Since the cleaning actions were doubled, it was expected that twice the damage would occur but this was not the case. This lack of significant change may be due to the fact that the second campaign of cleaning took place one month after the first one. During this period, it is possible that the paint films had more time to settle and gain in toughness, which may have enabled the samples to withstand mechanical cleaning. Overall, only very slight changes in lightness occurred on the matte medium samples treated with Staedtler Mars Plastic 52560 (grated) and Groom/Stick.

7. CONCLUSION-DISCUSSION

This experiment tested different types of erasers on acrylic emulsion paint films in order to assess damages that may happen during surface cleaning. During the first part of the experiment, the samples were subjected to artificial dirt and different environmental conditions which proven to affect the behavior of the samples toward mechanical cleaning. In order to minimize the variables and assess the true performance of the erasers, a second experimental part was conducted in which the dirt, cold and low relative humidity environmental conditions were discarded. The erasers that considerably damaged the paint samples in the first part were also withdrawn.

Both experiments enabled better understanding of drying mechanisms of emulsion paints; thus the migration of the additives, the behaviour of emulsion formulations toward dirt and different environmental conditions. On non-absorbent substrates, the additives present in paint formulations migrate to the surface of the paint matrix. These additives were visible without magnification and became even more disfiguring after the application of a synthetic layer of dirt, which was absorbed to a greater degree than the polymer itself. The additives were partially or totally removed during mechanical cleaning depending on the environmental condition at which the samples were subjected. In general, cold and low R.H. hardened or de-hydrated the additives, fixing them to the polymer surface. The lack of additives on the second set of samples was caused by the absorbent nature of the substrate. During this set of experiment, none of the troubles enumerated above were encountered and it was thus possible to truly assess the effects of mechanical cleaning on acrylic emulsion samples. Confronting the lack of gloss and lightness changes, and morphological damage, it is possible to recommend the use of dry-cleaning techniques on acrylic emulsion paint films. This experiment tested five types of erasers, from which only one could be fully recommended. Staedler Mars Plastic 52650 (grated) proved to successfully remove a layer of dirt from acrylic emulsion paint films without disrupting physical and aesthetic properties such as the gloss and lightness.

8. AKNOWLEDGEMENTS

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SOURCES OF MATERIALS

Acrylic emulsion paint:
Liquitex Artist-Grade Medium Viscosity
Binney & Smith Inc. USA

Dirt:
Bone Black
Kramer Ppigments Inc.
228 Elizabeth Street
New York, NY, USA, 10012
Tel: 001-212-219-2394

Universal Oil
Motorex; Oil of Switzerland.
Bucher AG, CH-4900 Langenthal.

Silica (S-153) (Floated powder)- About 240 mesh
Fisher Scientific Company
Chemical Manufacturing Division
Fair Lawn, NJ, USA 07410

Erasers:
Staedler Mars Plastic 52650 and Staedler Art Eraser 525G20
Steadler Inc. Germany

Groom/Stick
Picreator Entreprises Ltd.
44 Park View Gdns.
Hendon, London, England
NW4 2PN

Opaline
Durasol Chemical Company

Dry-Cleaning Sponge
Maritime Chemicals and Equipment Ltd.

Instrumental methods of analysis:
Film Applicator
Sheen Instruments. Scientific engineers.
Sheendale Road, Richmond.
Surrey England

Micro-Tri-Gloss
BYK-Gardner Inc.
2435 Linden Lane
Silverspring, USA, MD 20910

Spectrophotometer CM-2022
Minolta Co. Ltd. Japan

A NOVEL APPROACH TO CLEANING I: USING MIXTURES OF CONCENTRATED STOCK SOLUTIONS AND A DATABASE TO ARRIVE AT AN OPTIMAL AQUEOUS CLEANING SYSTEM

Chris Stavroudis, Tiarna Doherty, and Richard Wolbers

INTRODUCTION

The Modular Cleaning Program is a new database system designed to assist the conservator in the cleaning of works of art. The Modular Cleaning Program débuted in September, 2003, at the Verband der Restauratoren symposium "Surface Cleaning – Materials and Methods". Version 1.3 of the Modular Cleaning Program was released via Conservation On Line in February of 2004. The Modular Cleaning Program is an interactive computer program that is best understood by demonstration and use. As that option is not available in the context of a written work, we will examine the history of surface cleaning, discuss the features of the cleaning program, and present two case studies.

The Modular Cleaning Program builds upon developments in cleaning theory and extends the theoretical towards the practical. Innovations include the use of pre-mixed, concentrated stock solutions which facilitate the rapid formulation of test cleaning solutions; formulations based on physical constants, equilibrium equations and other theoretical constructs; and the use of a computerized system to coordinate the mixing and testing of the solutions. While developed from the perspective of paintings conservation, the methodology is universal and applicable to any aqueous cleaning.

The first case study will illustrate the removal of a grime layer from an aged varnish on the painting "Lion" by Jean-Baptiste Oudry. The second case study illustrates the removal of a grime layer from an unvarnished Solomon Nunes Carvalho oil on panel painting, showing how the conservator can end up using a cleaning system that was totally unexpected.

A REVIEW OF AQUEOUS SURFACE CLEANING

Historically, in conservation and restoration treatises on paintings, little attention has been paid to surface cleaning in comparison to removing surface coatings. Manuals on the conservation of paintings have traditionally included brief discussions of dry methods of surface cleaning, including the use of dusting brushes and cloths, erasers, and sponges. Foodstuffs, including fresh breadcrumbs, "cakes", potatoes and onions have also been mentioned (Mora et al. 1984; Keck 1978). Older published instructions for surface cleaning paintings prove to be quite extraordinary as is the case with one presented in Theodore De Mayerne's manuscript from the seventeenth century: "Melt common carpenter's glue, which is quite thick, and pour it, melted over your picture, leave it after it has set for the space of [lacuna] on your picture – then lift it off, all in one piece. This brings with it all the dirt. See if this can come off without damaging the piece" (Caley 1990).

Water and saliva, used for spit-cleaning, are perhaps the most common materials used for surface cleaning paintings. The addition of materials to water (whether 'de-ionized' or not) has predominantly been limited to the addition of alkalis. Ammonia is perhaps the most common alkali that has been added to water in the twentieth century to adjust the pH of the solution for surface cleaning easel and wall paintings (Mora 1984). The use of methylcellulose gels and paper pulps with water-based systems have also been advocated where prolonged contact with the surface is necessary and/or when mechanical action should be avoided.

Advancements in the petrochemical industry at the end of the nineteenth century lead to the development of numerous, inexpensive oils, which in turn led to the development of surfactants and detergents. With these new materials available, the approach to cleaning chemistry became more sophisticated in the twentieth century and commercial, proprietary cleaning products found applications in conservation.

The addition of "soap" to water-based cleaning systems is sometimes mentioned in cleaning manuals from the twentieth century, however, there is usually no mention of the specific types of soaps nor discussion of their chemical properties. Soaps have long been used in conservation studios even though their exact chemistry may not

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have been well understood. The use of strong soaps led to a warning against using soaps as a category of cleaning agent in the 1940 *Manual on the Conservation of Paintings*:

> It is perhaps not superfluous to issue a warning against a method of cleaning pictures still in use in recent years in many galleries – washing the painted surface with soap and water. The evil effects of this system are not immediately apparent; but the water may penetrate by capillary attraction through the slightest cracks or fissures in the paint film as far as the priming, which means that sooner or later the film will become detached or swollen, not to mention the bad effects on the varnish (International Institute of Intellectual Co-operation [1940] 1997).

In the second half of the twentieth century, conservators began using commercial detergents. Detergents found applications in cleaning painted surfaces after having been used in the fields of objects and textile conservation (Plenderleith 1956). For painted surfaces, detergents such as Triton X-100, Synperonic DNB, Igepal, and Vulpex were used (Ramer 1979; Barov 1990; Burnstock 1990). These detergents found wide application since they are soluble in water and/or solvents. Today, Triton XL-80N and Synperonic N are the more commonly used non-ionic surfactants (McCutcheons 2003).

The properties of surfactants have been exploited through the use of proprietary materials such as Photo-flo (developed for use in photography) and even products such as Barbisol, a shaving cream. These types of materials have been used by some conservators as saponifying additives or as additives that help break surface tension in cleaning applications (Rothe 2002).

Alternatives to water-based surface cleaning were also developed, such as those discussed by the paintings restorer Helmut Ruhemann in his description of the proprietary material "Cleaning, Reviving and Preserving Paste" from C. Robertson in London:

> The use of soap and water is to be strongly discouraged because it may cause irremediable harm to certain types of pictures in seeping through fissures in the paint and loosening it by dissolving the ground between paint and canvas. Alkaline wax emulsions are often used for removing this dirt surface. The widely used mixtures of much diluted wax and varnish have the great disadvantage of removing only part of the dirt and fixing the rest. Moreover they dry so slowly that they collect a great deal of dust before they are hard (Ruhemann 1968).

From mid-century onward a number of conservators began publishing their own formulations for surface cleaning systems. Some of the more famous formulations include "AB 57", which was introduced by Philipo and Laura Mora for surface cleaning insoluble salts that compromise inorganic incrustations on wall paintings (Mora 1984).

In the late 1980s Richard Wolbers introduced new approaches to cleaning paintings in a series of 5 annual workshops conducted at the Getty Conservation Institute (Wolbers 1988). His recent book *Cleaning Painted Surfaces,* is devoted to the subject of aqueous methods. It is important to note that Wolbers' methodological approach to the subject of surface cleaning may be applied to all types of painted surfaces. Wolbers advocates designing cleaning systems specific to the materials and cleaning challenge presented.

Leslie Carlyle was perhaps the first paintings conservator to find application for chelating agents in surface cleaning painted surfaces (Carlyle 1990). Wolbers incorporated them into his cleaning workshops in the late 1980s. Chelating agents found wider application in conservation in the mid 1980s and were the subject of a number of published research projects (Carlyle 1990; Phenix 1992).

In 1990 the conference "Dirt and Pictures Separated" was held. Papers presented at the conference, and published under the same title, addressed the chemistry of surface cleaning materials as well as the effects of surface cleaning on painted surfaces. Specific surfactants and cleaning agents discussed in the papers included Triton X-100, Synperonic N, di- and tri-ammonium citrate (Hackney 1990).

The developments in cleaning chemistry have led conservators to understand traditional methods of surface cleaning better. Towards the end of the twentieth century, conservators have tried to imitate the cleaning chemistry and properties of saliva for surface cleaning. Formulations that have been described as "synthetic saliva" have been published (Bellucci 1999; Wolbers 2000).

Computer programs, first introduced in the late 1980s, have been designed to assist conservators in their approach to solvent cleaning. Programs such as "TeasTime" and "Triansol: il Triangolo delle solubilità" have been created to help conservators design solvent-based systems for cleaning and have been based on the Teas diagram (Henry 1995; Cremonesi 1999). Most recently, "Solvent Solver" has been introduced (Ormsby 2001). These programs have been shared, at no cost, among conservators. The Modular Cleaning Program, described below, has been designed by a paintings conservator and is being offered for free to the conservation community.

THE BASIC PRINCIPLES

From 1997 to 2001 Richard Wolbers collaborated with the Getty Conservation Institute in development of the Gels Research Project to evaluate alternative methods of cleaning (Dorge 2004).

An aspect of this Project was the discussion of a "logic tree" approach to selecting cleaning systems – intended to be an insight, as it were, into Professor Wolbers' thought process when selecting a cleaning system (Dorge 2004, 141-144). The nascent system, as it applied to water-based cleaning, was modified by Chris Stavroudis, and built into the Modular Cleaning Program.

The aqueous cleaning systems introduced by Richard Wolbers can be considered to consist of 5 orthogonal components (mutually independent components). They are: water, pH buffer, chelating agent, surfactant, and gelling agent. For this reason, the concentrate system is based on a module of five. The test cleaning solutions are made to a total of five parts, which may include some or all of the five components. (If only one or two components are being tested, water is added to make up the total of five parts.) Hence, each stock solution is concentrated five times its normal working concentration. The computer screen has also been divided into five rows. Each row represents one of the five components, or more practically, one milliliter of a concentrated stock solution.

For example, to make a test solution, one mL of water is combined with one mL of a buffer concentrate solution plus, optionally, one mL of concentrated chelating agent solution, and/or one mL of concentrated surfactant solution, and/or one mL of concentrated gelling agent. If necessary, water is added to make up the final total volume of 5 mL.

The Modular Cleaning Program and the use of concentrated stock solutions allows the conservator to test a large range of mixtures in a short period of time. By testing far more cleaning options than one normally has the time to mix and test, it is hoped that conservation treatments can continue to move toward more delicate and sensitive cleanings.

The first parameter to consider in formulating an aqueous cleaning system is pH. Control of pH is important in aqueous cleaning systems. As a general rule, as materials age they oxidize. In organic materials, oxidation leads to the formation of acid functional groups on the surface exposed to oxygen in the air. The acid forms of the oxidized molecules tend to be less soluble in water than the deprotonated salt forms. Since acids react with bases, a higher pH will tend to deprotonate the acid and render it more soluble in water. So, as a general rule, higher pHs will assist in the solubilization of the oxidized material while lower pHs will tend to preserve an oxidized surface.

By buffering a cleaning solution, we ensure that the chosen pH of a solution is maintained during the cleaning. Buffers are weak acids or bases that, at certain pH values, minimize changes in the pH of a solution when additional acid or base is added to the mixture. Buffering a cleaning solution prevents the pH of the cleaning solution from changing as the oxidized organic material dissolves in the course of the cleaning.

Buffers are characterized by their pKa, their acid dissociation constant. Analogous to pH, the pKa is the pH of an aqueous solution, which contains equal parts of the acid form of the buffer and its base form. This is also the pH where the buffer will function most effectively at preventing pH changes from small additions of acid or base to the solution. A weak acid or base will function as a buffer within about 1 pH unit of its pKa value.

The Modular Cleaning Program uses the molecular weight of the buffer and its pKa to perform one of its primary functions, the calculation of the desired amounts of reagents to be mixed into concentrated stock solutions. The concentration of the buffer solution is specified by the conservator. Based on measurements by Richard Wolbers, the recommended target buffer concentration for paint surfaces is 0.05M. Therefore the concentration of the concentrated buffer stock solution is 0.25M (since it will be diluted by 5 when incorporated into a test cleaning solution).

On the computer screen each row is divided into three columns (fig. 1). The center column has buttons which allow the properties of the test cleaning solution to be modified. In the case of buffers, the conservator can choose to increase or decrease the pH of the test solution. Changing the pH usually means changing the buffer used (Tris, bicine, MES, etc.) because each weak acid or base has only a limited buffer range. In practical terms, this correlates with selecting a concentrated stock buffer solution to be used when mixing a test cleaning solution. Above the buttons is the description of the concentrated stock solution. In Figure 1, the pH 7.5 buffer is Tris (2-amino-2-(hydroxymethyl) propane-1,3-diol), neutralized with hydrochloric acid (HCl), the chelating agent is citric acid pH adjusted to 7.5 with sodium hydroxide (NaOH), and the surfactant is Triton XL-80N, a nonionic surfactant.

The left column shows the amount of the concentrated stock solution to be added to the test cleaning solution and a logo that is used to distinguish each solution. The logo also appears on the concentrated stock solution's label. Clicking on the left logo takes the conservator from the "Modular Cleaning Program" database to the "solutions" database, described below.

The right column shows hints or comments pertinent to the type of work being treated, such as how pH will affect an aged varnish layer or how pH influences the removal of the aged surface grime. Hints have been built into the database for some of the materials to be found on paintings. As the program is used by more conservators, hints will be added and expanded. The comments are not by any means a suggestion as to how the work of art should be cleaned, but rather a reminder of how each component of a cleaning system might affect what is to be removed and how it might affect the substrate.

The background color of the rows in the Modular Cleaning Program change to indicate the pH of the test cleaning solution. (The colors were chosen to resemble those used on pH test papers.)

In addition to water and a pH buffer, test cleaning solutions can be mixed to include surfactants, chelating agents and gelling agents. When using the system, the conservator would choose to add these components based on the progress of the test cleaning. They can be added to the testing scheme in any order. The following paragraphs will discuss each of these agents and how they are integrated into the Modular Cleaning Program.

The term surfactant is derived from "surface active agent" and is an encompassing term that refers to detergents, soaps, emulsifiers, wetting agents, and resin soaps. The first property we need to know about a surfactant is whether it is ionic or nonionic. A nonionic surfactant is a neutral species in solution, neither an acid nor a base. In practical terms, this means it can be used predictably at any pH. Ionic surfactants can be anionic (the surfactant molecule is an acid), cationic (a base), or zwitterionic (where the molecule consists of both acidic and basic functional groups). If a surfactant is anionic or cationic, being an acid or a base, it is further characterized by a pKa. The pKa and, if known, the solubility of the fatty, undisassociated molecule in water determine the minimum pH at which the surfactant can be used. If these values cannot be found in the literature, the database also accepts an ad hoc measurement of the pH at which the ionic surfactant solution separates into two phases, water and an oily or solid phase.

The other parameters that describe a surfactant are HLB, CMC, and aggregation number (plus its molecular weight). HLB is the hydrophilic lipophilic balance number, a measure of the relative size of the water-soluble portion of the surfactant in relation to the fatty portion of the molecule. Anionic surfactants can have HLB values as high as 40 (like sodium lauryl sulfate – Orvus), but non-ionics have a maximum HLB value of 20.

CMC stands for the critical micelle concentration. Detergency occurs when a critical amount of a surfactant in solution is reached and the surfactant molecules group into micelles. In an aqueous solution, the surfactant molecules orient themselves with their fatty ends to the inside and the water soluble ends to the outside of the micelles. Micelles can form around fatty, non-polar material and aid in it's being carried away in water. The concentration where micelles just begin to form is termed the critical micelle concentration. When formulating a detergent, you want to have surfactant present in excess of the CMC, so it can carry grime away, but not too much of an excess because that will have a tendency to leave excess detergent behind, complicating rinsing and clearance.

The aggregation number is the average number of surfactant molecules that form into a micelle. The aggregation number is characteristic for each surfactant. The larger the number the more surfactant you will have to put into solution in excess of the CMC to get a given concentration of micelles. A lower aggregation number means you can use a bit less surfactant.

The Modular Cleaning Program allows the surfactant to be specified either as a simple concentration or as a multiple of the CMC. A typical value is to have the working concentration of the surfactant at 5x the CMC, which means that the concentrated stock solution is at 25x the CMC. When both the CMC and aggregation numbers are known, the program also calculates the micelle concentration.

Surfactants are added to the test cleaning solution in the database by clicking on the "Yes, But Modify" button. As with the buffer, the surfactant can be increased or decreased by clicking on the buttons in the center column, selecting higher or lower HLB surfactants. The computer will not recommend an ionic surfactant below its critical pH.

A chelating agent, is a molecule capable of binding to a metal ion and bringing the metal ion into solution. The chelating agents conservators commonly use for surface cleaning are citric acid (as various citrates) and EDTA (ethylenediaminetetraacetic acid). Chelating agents have multiple coordination sites, which allow the molecule to envelop and bind to a metal ion.

Many of the coordination sites on a chelating agent are carboxylic acid groups, so chelating agents are specified by multiple pKa values – citric acid has three acid groups, EDTA has four and DTPA (diethylenetriaminepentaacetic acid) has five carboxylic acid groups, each having a different pKa value. At any given pH, the chelating solution will contain molecules with various combinations of disassociated acid groups. The amount of each species in solution is calculated by the computer at each concentrated stock solution's pH.

The effect of pH on chelating agents is very complex, and a thorough discussion of the topic is beyond the scope of this paper. One consequence of the complexity is that while some concentrated stock solutions can function at any pH, for instance you only need one bottle of a concentrated nonionic surfactant stock solution which can be added to any test cleaning solution, a separate concentrated chelating agent stock solution must be mixed for each pH.

Chelating agents are also characterized by their affinities (formation constants) for different metal ions. These formation constants will be used in a future version of the database to calculate the necessary concentrations of metal ion buffers to be added to a cleaning solution to minimize solubilization of a desirable ion, i.e. one that is part of the work of art. In this current version of the Modular Cleaning Program the formation constant for the calcium ion is used as the indication of strength of the chelating agent. Clicking the increase or decrease buttons for chelating agents in the database selects chelating agents with higher or lower values of the calcium formation constant.

Test cleaning solutions may also be gelled by adding a concentrated gelling agent. The database supports nonionic (cellulose ethers) and cationic (Carbopol) gelling agents. In practice, using the gelling agents is difficult because the concentrates, being five times the gel's working concentration, are very stiff and difficult to disperse in the test solution. The gelling agents are ranked by their viscosity at a given concentration.

There exist many other ways to modify an aqueous cleaning system and many of these will be incorporated into future versions of the Modular Cleaning Program. These modifications can be made by the conservator now, but are not supported by the database. The addition of co-solvents (small amounts of organic solvents), ionic buffers (soluble salts to modify the ionic strength of the test cleaning solution), enzymes, and multiple surfactants are all possibilities.

The Modular Cleaning Database is comprised of 19 interrelated databases, however, from the user's perspective, the system is made of five main parts. When the Modular Cleaning Program is started, after the "welcome" screen, the conservator is taken to the "background" page (fig. 2), where the parameters of the cleaning are established. This is where the work of art and conservator are identified, and the material being removed and the substrate from which it will be removed are entered. There are buttons on the "background" page to take the conservator to the "components" database, the "solutions" database, and the "solution sets" database.

The "components" database is the most conventional database with which the conservator will interact. It contains information on hundreds of chemicals used in conservation: buffers, chelating agents, surfactants, gelling agents, acids, and bases from which the concentrated stock solutions are mixed. It also includes solvents, which will be used in future versions of the software, and even some polymers and resins. It lists chemical composition, physical properties, and may list health and safety information, the MSDS, and include a link to the information the most current NIOSH (The US National Institute for Occupational Safety and Health) Pocket Guide to Chemical Hazards. (Not all chemicals in the database have NIOSH listings.) The MSDS information in the database is taken from Internet sources and is listed as an information-only reference. Conservators should always consult the MSDS sheet provided by their chemical supplier.

The physical chemical constants included in the "components" database in most cases include a reference to the publication from which they were taken. Numerous sources were consulted (Freiser & Fernando 1963; Weast 1972; Freiser 1992; Huibers 1996; Wolbers 2000; Lide 2002; Harris 2003; McCutcheon's 2003). In the case of surfactants, finding the necessary physical properties and physical constants has been challenging as many of these properties seem to never have been quantified as they are so complicated to measure precisely.

The "solutions" database is where components are mixed together to make the concentrated stock solutions. The database performs numerous calculations based on the physical constants located in the "components" database. Because the pH values of the concentrated solutions are known (having been chosen by the conservator and been set with a pH meter) the complex ionic equilibrium equations can be solved exactly. The "solutions" database also calculates recipes and mixing directions for the concentrated stock solutions and formats the appropriate labels that can be printed to identify the concentrated stock solution containers.

The "Modular Cleaning Program" database combines the concentrated stock solutions from the "solutions" database to make the test cleaning solutions. This database calculates the solution properties of all the components in the test cleaning solution. Though it only ever possesses one record, that is, the test cleaning solution that is being evaluated, the database combines information from almost all of the other databases to allow the conservator to orchestrate the testing process. When the optimal cleaning solution has been determined by testing, it calculates the formula of and recipe for the cleaning solution.

The "solution sets" database organizes and builds families of the concentrated stock solutions into sets that can be chosen by the conservator at the start of a treatment. In the future, customized sets of concentrated stock solutions may be developed for special cleaning problems like the cleaning of acrylic paint surfaces or stain removal from marble.

There is also a database that keeps track of the testing process. When the "Test it" button is clicked, that Modular Cleaning Program database copies the relevant information about the current test cleaning solution into the "test_it database". The conservator is prompted to enter information about the test cleaning solution's effect on the material being removed and on the substrate, which should be preserved. This information is retained and can be viewed (by clicking on the "view test results" button) or printed out (by clicking the "print" button from the view test results page) to document the testing process that lead to an optimal cleaning solution. It also allows testing to be resumed in cases where the testing is interrupted.

Navigation through the databases is simple and intuitive. All navigation is via mouse clicks, either on buttons or on key words on the screen. Specific knowledge of FileMaker Pro is not necessary to use the program. During a cleaning test, clicking on the left, logo column of a cleaning component will take the conservator to the information in the "solutions" database for that concentrated stock solution (fig. 3). From the "solutions" database, clicking on the button bars for any of the ingredients that comprise the concentrate takes the conservator to the information on that material in the "components" database (fig. 4). From the components database, clicking on the "Properties" button takes the conservator to the physical and chemical information that is specific for that material (fig. 5). The information presented for a chelating agent is different from that that characterizes a surfactant. Clicking on buttons takes the conservator deeper into the database. To return to the previous screens, the conservator need only click on buttons labeled "Back", "Done" or "Continue", depending on the context.

The Modular Cleaning Program is designed for the conservator to modify and extend. Because all of the calculations are based on physical properties, you can integrate a new material into your testing by simply entering it in the components database, adding the required physical properties, building the cleaning solutions, and adding the solutions to an existing solution set or creating a new solution set.

While the inner workings of the database are intricate and complex, using the system is easy and fast. A test cleaning solution can be made in less than a minute from the stock concentrate solutions. It is possible and appropriate to test numerous combinations of the stock concentrate solutions to arrive at the optimum cleaning result.

THE MODULAR CLEANING PROGRAM IN USE: CASE STUDY I

To demonstrate the cleaning system in use, the surface cleaning of the "Lion" by Jean-Baptiste Oudry (fig. 6) will be described here. The "Lion" is being conserved and restored at the Getty Museum in consultation with conservators and curators at the Staatliches Museum Schwerin, Germany. Tiarna Doherty, Assistant Conservator of Paintings at the J. Paul Getty Museum cleaned the painting.

The "Lion" (signed and dated 1752), along with 11 other portraits of animals painted by Jean-Baptiste Oudry, was bought by the Duke of Mecklenberg-Schwerin in the mid-eighteenth century and remains in the collection of the Staatliches Museum Schwerin.

The "Lion" measures 310 x 256.5 centimeters (122 x 101 inches). There is very little documentation regarding the display and conservation history of this painting. One of the largest paintings in the collection, the "Lion" has been in storage since the mid to late 19th century (Michels 2002). The smaller paintings in the collection appear to have been on display continuously and have thus been part of conservation and restoration campaigns.

When examined in 2001, the "Lion" had a very uneven surface due to the effects of aged varnish and a considerable amount of surface grime. It was decided that the approach to cleaning the "Lion" was to be two-fold: surface cleaning would be done before the varnish would be thinned or removed. This meant that our cleaning tests would be narrowly targeted to distinguish between the solubilities of the different layers. After removing the dirt layer we would be better able to control the thinning or removal of varnish, thus allowing for a slow and balanced aesthetic cleaning where the overall appearance of the painting would guide in the degree of cleaning.

In the preliminary examination of the painting, water and spit-cleaning tests were performed in order to see how much dirt could be removed from the surface. While it was evident that the painting was very dirty, little surface dirt could be removed using water or saliva alone. We anticipated that surface cleaning would require a modified water-based system. Fortuitously, the treatment of the Oudry painting coincided with the development of the Modular Cleaning Program by Chris Stavroudis.

After verifying that the paint and substrate were not adversely affected by water, the surface grime was tested with pH buffered water. Disposable polyethylene pipettes were used to measure the concentrated stock solutions (fig. 7) into small, polyethylene "weighing" cups, which were used to hold the test mixtures (fig. 8). The beginning step was to take 1 mL of distilled water, 1 mL of the concentrated buffer stock solution, and three additional mLs of distilled water and mix them in a numbered weighing cup. Five mLs of test solution are sufficient to evaluate the cleaning potential of the test cleaning solution in a number of areas on a painting.

The surface cleaning tests at pHs 5.5 and 6.5 were not substantially more effective than water alone. Water buffered to pH 7.5 was able to remove some surface grime. At pHs above 6.5 with citrate chelating agent (in addition to the buffer and a surfactant), some yellow-colored material was observed on the swab. It was surmised that the yellow material was degraded varnish removed from the surface. As the goal of the cleaning was to leave the varnish entirely intact, testing was continued without chelating agents.

Ultimately, water buffered to pH 8.5 with the addition of Triton XL-80N was found to remove the dirt effectively without seeming to disturb the degraded varnish layer. This solution was cleared by rinsing the surface with water buffered to pH 8.5.

The cleaning tests for the Oudry progressed through 35 solutions. There were often subtle differences in both the handling and the cleaning effect of the solutions. An advantage to using the computer to assist in the testing is that it keeps track of the testing progress. By numbering the polyethylene cups to match the tests, and entering the conservator's observations for each test into the computer, a detailed record of the testing process is available for inclusion in the treatment records.

Once the optimal cleaning system is determined one can choose the "Yes Clean:" button, which will calculate the amount of materials in the solution for a specified volume and provide mixing instructions so the conservator can prepare a larger batch of the cleaning solution.

THE MODULAR CLEANING PROGRAM IN USE: CASE STUDY II

The treatment of "Portrait of Elisha Caleb Dean", 1854, by Solomon Nunes Carvalho demonstrates how the Modular Cleaning Program can allow the conservator to find a cleaning solution that wouldn't have otherwise even been tested. The painting belongs to a private party and was treated by Chris Stavroudis, Conservator in Private Practice.

The Carvalho portrait is an oil (est.) painting on canvas. It is stretched over a wooden panel (actually, a piece of lumber) and measures 11" x 10" (fig. 9). The painting was framed in an oval frame, protecting the corners of the painted surface. The painting seemed like it had never been removed from the frame and while it has been abused, it did not seem to have ever been abused by a conservator. The painting was unvarnished.

The surface of the painting was leathery and uneven (see fig. 9). Because it had never been varnished or treated before, it was assumed that the surface grime was strongly adsorbed and that the surface had oxidized to a considerable extent. Therefore, to minimize the risk of dissolving original material, test cleanings were started at a low pH.

Testing with the Modular Cleaning System, buffers alone were not effective (neither was water or "spit cleaning"). Higher pHs were observed to cause blanching. Testing with surfactants added to buffers was not particularly helpful, although they did remove slightly more grime. This is to be expected. Research on soiling has demonstrated that fresh grime is readily removed by surfactants, but aged grime required a chelating agent (Wolbers 1992; Phenix & Burnstock 1992).

Tests with citrate as a chelating agent (along with the buffer and surfactant) were found to work much better, but left the surface dull and cloudy. Upon Richard Wolbers' recommendations for the original "logic tree", an EDTA concentrated stock solution had been incorporated into the stock solution set. While unfamiliar with cleaning with EDTA and presuming it to be too strong a chelating agent to use on a painted surface, it was tested nonetheless. When applied to a small area, the recovered surface was beautiful. The entire painting was cleaned with a solution mixed from the Modular Cleaning System – pH 5.5 (MES buffer) with Brij 700 and 0.05M EDTA and a small amount of HPMC to thicken the solution slightly. It was cleared with carbonated distilled water (acidic itself). Establishing the optimum cleaning solution required the mixing of 12 test solutions, taking perhaps 20 minutes.

Some shellac residue from the frame was removed from the surface of the painting with solvents and the whole surface was rolled with xylene to clear any residue. The recovered surface was almost presentable as it was, although it was a bit dry and under-saturated. In this case, the unexposed corners of the painting were a reference to the degree of saturation appropriate for the painting. The surface was lightly misted with a tiny amount of dammar varnish, which was brushed out with a dry brush (fig. 10).

CONCLUSION

The Modular Cleaning System and the use of concentrated stock solutions allows the conservator to test a large range of cleaning solutions in a short period of time. By testing far more cleaning options than one normally has the time to mix and test, the conservator can continue to move toward more delicate and sensitive cleanings. The database and the design of the modular cleaning concentrated stock solutions allow the conservator to concentrate on the aesthetics of a cleaning rather than on the mechanics of mixing cleaning solutions.

The Modular Cleaning Program calculates the formulations of both the concentrated stock solutions and the test cleaning solutions based on physical constants. This brings a rationality to the cleaning of works of art that historically was based on an almost ritual reliance on formulas. The availability of physical constants with references to their sources as well as health and safety information just a few mouse clicks away saves the conservator numerous trips to reference books.

Once the conservator has prepared the concentrated stock solutions they may be kept at-hand in the studio. Nearly all have excellent shelf lives and since such small volumes are used for testing, the set will last for a good number of test cleanings. For smaller works of art, the final cleaning solution can actually be made from the concentrates. The entire testing process minimizes waste.

By allowing the conservator to correlate the effectiveness of a cleaning with the modular components, their understanding of modern cleaning theory is positively reinforced. The system may also find application in conservation training programs

The Modular Cleaning System is evolving. In the planning for future versions are:

- A discussion of test solutions clearance (rinsing) and recommendations for clearance of each test solution.
- The ability to use two surfactants in the same test solution.
- The ability to add co-solvents, small amounts of organic solvents that extend the capabilities of an aqueous cleaning system.
- The ability to add ionic strength buffers.
- The ability to add metal ion buffers to minimize solubilization of desirable metal ions from the substrate.
- A comprehensive help system.

In a practical sense, there is an elegance to mixing small amounts of test cleaning solutions from stock solutions.

The system has some problems and limitations:

- It will never adequately handle emulsion based cleaning systems.
- FileMaker Pro does not support extremely complex mathematics or the generation of dynamic charts or graphs.
- The Modular Cleaning System is a tool for conservators to use. Computers cannot clean works of art. A database will never replace the intelligence and "eye" of the conservator.

The Modular Cleaning System is being freely distributed to professional conservators and may be downloaded from CoOL (Conservation On Line), at http://palimpsest.stanford.edu/byauth/stavroudis/mcp/. There are versions of the software for Windows and Macintosh operating systems. The 19 interrelated databases can be downloaded by conservators who already own FileMaker Pro (version 5.0 through version 6.0). Conservators who do not own FileMaker can download the databases bundled with a runtime version of FileMaker Pro. There are runtime versions for Macintosh System 9, Macintosh OS-X, and Windows 98 and higher.

To prevent its use by amateurs, the Modular Cleaning Program requires a serial number before it can be opened for the first time. Professional conservators may register with Chris Stavroudis to obtain a serial number. Registered users will also be notified when updated versions of the software is available.

Please note: No technical support will be provided. The software is copyright and may not be sold or distributed. Modifications made by other parties must be shared with the user community.

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SOURCES OF MATERIALS

Software:

FileMaker® Pro Developer 5.5 and
FileMaker® Pro 6.0

FileMaker, Inc.
5201 Patrick Henry Dr.
Santa Clara, CA 95054
(408) 987-7000

Supplies:

Disposable Polyethylene Pipette (1/2 ml. graduation. 3 ml draw. 7 ml. Capacity) catalog: P224

Weighing Cups (Polyethylene, graduated. Total capacity is 30cc) catalog: B482

Tri-Ess Sciences
1020 W Chestnut Street,
Burbank, CA 91506
(818) 848-7838

Chemicals (acids, bases, buffers, chelating agents, co-solvents, surfactants):

Sigma:
Bicine (N,N-bis[2-Hydroxyethyl]glycine) catalog: B-3876
Bis-tris (bis(2-hydroxyethyl)amino-tris [hydroxymethyl] methane) catalog: B-9754
Glycine (aminoacetic acid) catalog: G-7126
HPMC (hydroxypropylmethylcellulose) catalog: H-7509
MES (2-[N-Morpholino]ethanesulfonic acid monohydrate) catalog: M-3671
sodium lauryl sulfate (sodium dodecyl sulfate) catalog: L-5750

Aldrich:
Brij® 700 (POE 100 Stearyl ether) catalog: 46,638-7
DTPA (Diethylenetriamine pentaacetic acid) catalog: D9,390-2

EDTA (ethylenediaminetetraacetic acid) catalog: 25,404-5
Tris (Tris[hydroxymethyl]aminomethane) catalog: 25,285-9

Sigma-Aldrich
3050 Spruce St.
St. Louis, MO 63103
(800) 325-3010

Acetic acid
Ammonium hydroxide
Benzyl alcohol
Citric acid (2-Hydroxy-1,2,3-propanetricarboxylic acid)
Hydrochloric acid
Sodium hydroxide

Tri-Ess Sciences (see above)

Carbopol® 934
Deoxycholic acid
n-Methyl-2-pyrrolidone
Triton® XL-80N

Conservation Support Systems
Santa Barbara, CA
(800) 482-6299

ILLUSTRATIONS

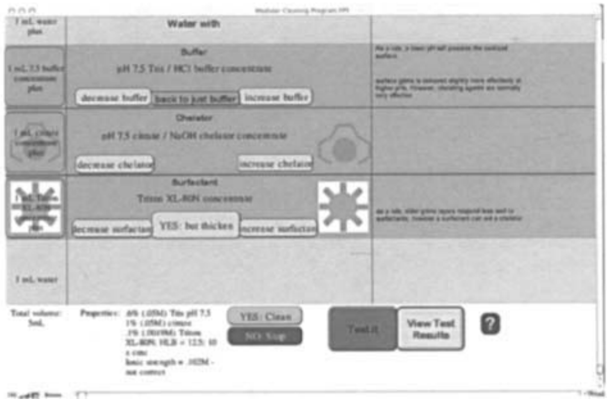

Illustration 1: The Modular Cleaning Program's aqueous test cleaning screen. Shown is a test cleaning solution consisting of water and Tris buffered to pH 7.5 with citrate added as a chelating agent and Triton XL-80N added as the surfactant. No gelling agent has been specified so the 5th component, an additional 1mL of water, indicated by the lower blue band brings the final volume of the test cleaning solution to 5mL.

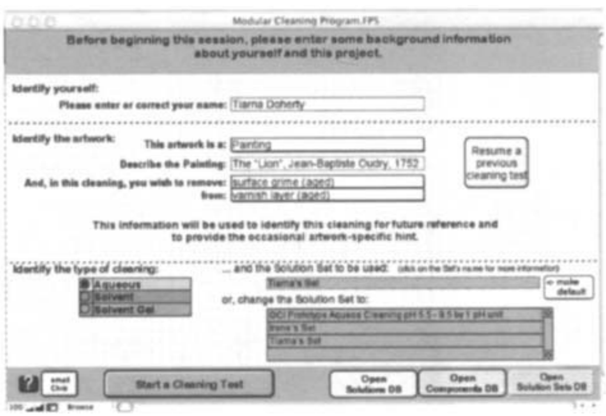

Illustration 2: The "background" page where the parameters of a cleaning are selected by the conservator.

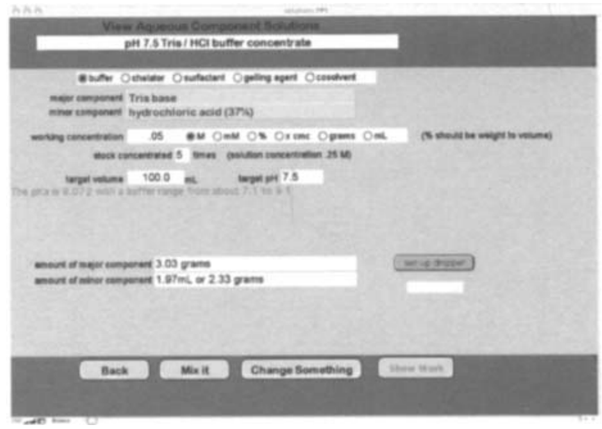

Illustration 3: The specification of the pH 7.5 Tris buffer concentrated stock solution as displayed in the "solutions" database.

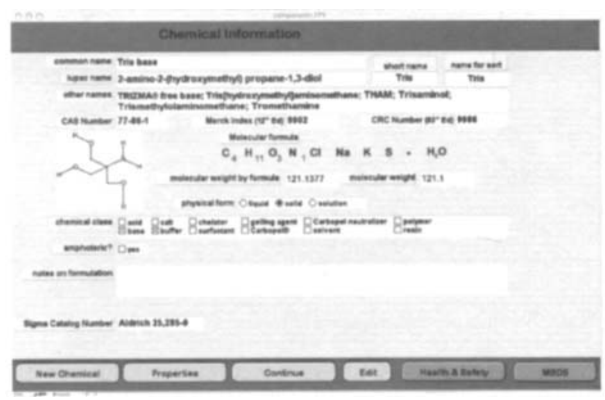

Illustration 4: The information on Tris displayed in the "components" database.

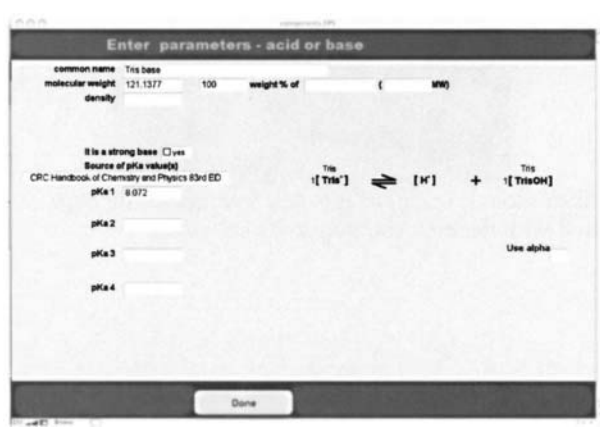

Illustration 5: The properties of Tris as displayed in the "components" database.

Illustration 6: The "Lion" by Jean-Baptiste Oudry seen on a temporary stretcher in the paintings conservation studio of the J. Paul Getty Museum in 2002, The "Lion" is from the collection: Staatliches Museum Schwerin.

Illustration 7: Picture of cart with computer laptop and concentrated stock solutions in front of The "Lion".

Illustration 8: Detail of pipettes and measuring cups used with the concentrated stock solutions.

Illustration 9: "Portrait of Elisha Caleb Dean", 1854, by Solomon Nunes Carvalho (signed and dated lower, center left). Photograph before treatment in specular light showing the uneven, leathery surface.

Illustration 10: Carvalho painting after treatment installed in its original oval-matted frame.

A WIDE OPEN FIELD OF COLOR: CARING FOR COLOR FIELD PAINTINGS AT THE HIRSHHORN MUSEUM AND SCULPTURE GARDEN

Tatiana Z. Ausema, Samuel H. Kress Conservation Fellow[1]

The care and conservation of paintings on unprimed canvas has been an ongoing concern for those charged with their care since artists first began experimenting with the technique in the early 1950's. The process of combining areas of stained fabric with expanses of raw, unprimed cotton canvas results in works that are vulnerable to a variety of damages, and that do not respond to traditional techniques of painting conservation. In order to begin to address some of the issues surrounding these works, in February 2004 the Hirshhorn Museum and Sculpture Garden began a year-long project to survey, analyze, and treat their collection of over 40 color field paintings, thanks in part to the support of a Samuel H. Kress Conservation Fellowship and the Morris Louis Conservation Fund. The goal of the project is to address the holistic care of these works—encompassing treatment, technical analysis and examination—with a long-term, collection-wide focus on how these unique paintings can be protected and preserved for future generations, as well as having them remain available for exhibition and study. At the time of this publication, the project is still ongoing, and as such this paper is only a preliminary summary of results.[1]

What are Color Field Paintings?

The term "color field paintings" is generally used to refer to works where the artist has diluted paint to a thin consistency, and then dripped, poured, or soaked it into unprimed, cotton, canvas, creating broad expanses of color. The fabric absorbs the paint, resulting in a stained effect where the color becomes part of the canvas itself, allowing the texture of the fabric to remain visible. The stained areas are sometimes offset by unpainted, raw canvas that forms an integral part of the shapes and overall tonality of the work. As oil paints take a long time to dry and may accelerate degradation of the unprimed fabric, color field artists were also some of the first to embrace new acrylic resin paints, such as Leonard Bocour's Magna.

The loosely associated group of artists known as the Washington Color Field Painters were pioneers of this stained technique. Active between the mid 1950's and 1970's in Washington DC, the group is generally regarded to include Morris Louis, Kenneth Noland, Gene Davis, Howard Mehring, Thomas Downing and Paul Reed, although others are sometimes included. These painters and their unique style gained national recognition in an exhibition "The Washington Color Painters" held at The Washington Gallery of Modern Art in 1965. Despite the fact that many of the artists had never met or worked together in any formal fashion, their similar use of paint, color, and raw canvas clearly identified and united the six artists.

From the moment they were produced, the artists, curators, and conservators familiar with this style of painting were aware of the unique preservation challenges that the color field paintings presented. Broad areas of raw canvas are vulnerable to subtle changes in texture or color from mars, scrapes, or stains. The works are unvarnished and generally intended to be seen unglazed, so the accumulation of dust and potential for vandalism or accidental damage is very high. Even transportation and storage are a concern, as the paintings are generally very large and bay be stored or shipped in a rolled fashion.

As a result of their delicate nature, many museums, the Hirshhorn included, have approached their color field paintings and other works on unprimed canvas with a "hands off" attitude, focusing instead on preventive care such as proper storage, handling, and display, with occasional vacuuming to remove surface dust and grime. While maintenance through preventive care is the ideal, the reality is as these works age, there are inherent vices in the materials used for construction that necessitate intervention in order to ensure that they remain exhibitable and do not suffer from neglect.

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Survey of Hirshhorn Works[2]

In order to evaluate exactly what types of degradation and condition concerns are present, the project began with a survey to broadly examine, photograph, and document the condition of 30 works in the Hirshhorn collection. Since files relating to condition, exhibition history, and previous treatment were stored in disparate locations around the museum, a computer database was created to store and organize information. The development of a custom, specialized database allowed inclusion of basic information such as treatment history, condition notes, storage location, and registration data, but also could track results of paint analysis (PY-GC-MS and FTIR), overall and detail photographs, and exhibition data.

The process of documenting current condition, previous restoration, and history of the work revealed a number of trends relating to the condition of the works, and helped identify some key issues affecting the long-term preservation of the paintings.

By far, of greatest concern for all of the color field paintings is the accumulation of dust and grime on the surface. This gradual accumulation occurs while on view, in storage, and in transit. In some works the grime is deeply imbedded in the fibers, but more often, it is superficially held to the surface of the work. As with any other work of art, the accumulation of surface grime is a concern as it can attract moisture, contribute acids that weaken the canvas over time, and become an attractive food source for insects and mold, in addition to the aesthetic concerns of a dirty painting. With color field paintings however, this grime is even more of a concern, as it can become imbedded in the raw canvas, becoming difficult, if not impossible to remove. Traditional methods of grime removal such as use of moisture may only serve to imbed grime further, or produce uneven results. Since broad fields of color are disrupted by even minor variations in color intensity, the ability to achieve even and subtle cleaning is extremely important. In addition to surface dust accumulated while in storage or on display, improper handling can further lock grime on the surface by adding oils, friction, and pressure to a particular area. Of the color field paintings surveyed, all had an accumulation of dust to varying degrees.

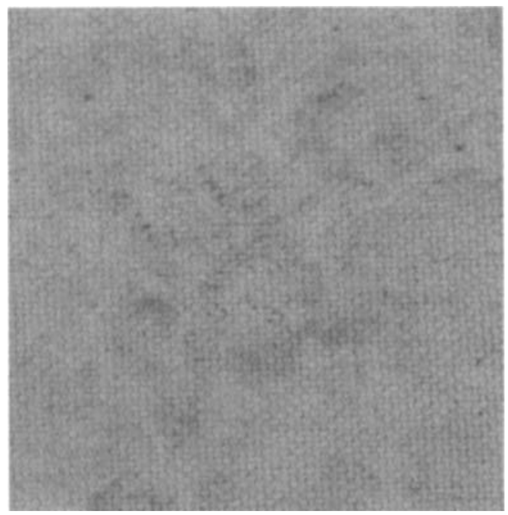

Figure 1: Detail of grime that has become unevenly imbedded in the cotton canvas

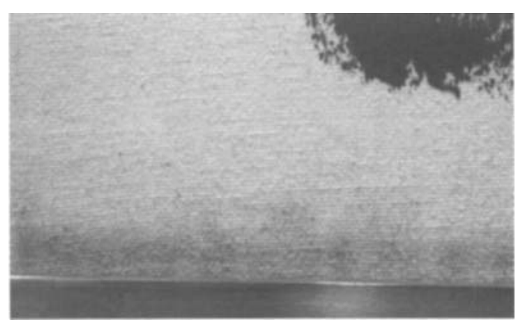

Figure 2: A severe example of stretcher bar staining resulting from acids migrating from the wood stretcher into the unprimed, raw fabric.

The survey also confirmed the frequent occurrence of light to moderate staining where raw canvas comes in contact with the wooden stretcher. Conservators that have worked extensively with color field paintings in the past have mentioned this phenomenon, but it has not been documented or studied extensively. It is presumed that the staining is caused by acids and degradation products in the wood stretcher migrating into the canvas over time, oxidizing, yellowing, and weakening the fabric where the two materials come in contact. The degree of discoloration varied widely from painting to painting, from faintly visible yellowing around the outermost edges of a work, to disfiguring brown lines that interrupted what was intended as a flat, uniform plane. It does not appear as if there is a regular pattern to predict which works will exhibit stretcher bar staining, and to what degree it will occur. As most of the paintings examined have been stored in a similar environment for the past 20-30 years, it is not likely that fluctuations in temperature or humidity play a significant role. A more likely accounting for the variance is the source and treatment of the wood stock from which a given stretcher is made, and the amount of lignin present in that particular tree. It is anticipated that in time a large number of paintings where raw canvas comes in contact with a wood stretcher bar will exhibit staining if no intervention occurs.

Canvas staining unrelated to the stretcher bar was the third common condition concern seen on works in storage. Types of staining varied widely, from yellowed areas where oils from handling which were once invisible have now oxidized and yellowed, to black or gray scuff marks from rubbing or impact with a colored object.

Within the broad category of staining a sub-category of stains with undetermined causes emerged. These stains were generally yellow in color and did not appear to be the result of a material resting on top of the fabric fibers; rather, when examined under magnification the fibers themselves appeared to have yellowed. *Bend Sinister* by Kenneth Noland, provides the clearest example of such staining. It has an array of deep yellow spotting running the entire height of the right side. Such spots may have been a result of being splashed, or local moisture treatments that redistributed sizing. Over time, the spotting that may have once been invisible has oxidized preferentially, getting yellower and more distinct with time. Conservation records suggest the damage has progressed slowly: notes made in the early 1980's indicate "faint mottling" of the support; however, the stains in their current state have hard edges and contrast sharply with the cream-colored surrounding fabric. Other works exhibit staining in much smaller areas or are more subtle, but in all cases it disrupts the broad planes of color and raw canvas that are an important part of the totality of the painting.

A final category of condition concerns arise from previous restoration of the paintings. While many color field paintings were carefully and minimally treated, others in the Hirshhorn collection were overpainted, chemically bleached, coated, or even lined in an attempt to address current or ward off future problems. Many areas subjected to treatments have aged differently than the surrounding non-treated areas: coatings have turned gray and mottled, inpainting has discolored, and areas treated with moisture are clearly distinguished as being lighter or darker than the rest of the fabric.

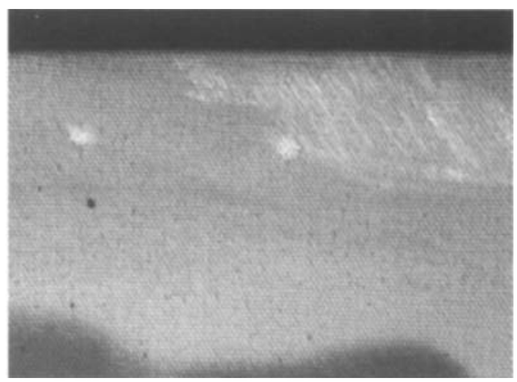

Figure 3: Previous restoration on this painting included filling and inpainting tack holes, as well as overpaint along the edges. Over time, the canvas has yellowed and discolored, and the inpainting now contrasts strongly with the surrounding fabric.

Completion of the survey of works in the Hirshhorn collection underscored the need to address some of the most pressing condition concerns during this year-long project, but also revealed that some of the condition issues would be beyond the scope of such a short project. Since the time period of examination, research, and treatment is limited, it was decided to focus primarily on surface cleaning techniques that would benefit the largest number of paintings. Surface cleaning could address dust, grime, and some staining, but it was clear that most stains would require some form of moisture application. The issue of wet cleaning techniques—including washing and local moisture treatments—is one that needs much attention and further research, but unfortunately was not within the scope of this project.

Evaluation of dry treatment techniques

Historically, ground erasers have been the first line of defense against accumulated surface dust and grime. Examination of Hirshhorn records and discussions with other conservators suggest that erasers such as Magic Rub, Opaline, and Art Gum have been used, with varying degrees of success. In 1989, Elizabeth Estabrook experimented with the effect of various erasers on cotton fabric. Her results, published in the *Journal of the American Institute for Conservation*[3], generally revealed that to varying degrees, almost all erasers she tested leave behind some quantities of crumbs and disrupt the fibers of the cotton fabric. As Estabrook's published analysis was thorough and complete, it was not necessary to recreate her experiments; however, I was interested in seeing first-hand some of the effects of using erasers, as well as comparing them to other surface cleaning techniques.

Expecting to see some residual crumbs, I examined a number of paintings in the Hirshhorn collection that had been cleaned using an Opaline, Scum-X, or Magic Rub eraser between 1977 and 1989. According to museum treatment records, treatment generally involved rubbing with pre-ground eraser crumbs only on unpainted areas of canvas, followed by vacuuming. Examination of three paintings using magnification ranging from 10x to 31x did not reveal any particles suggestive of eraser crumbs remaining in the weave. While there are a large number of factors that might contribute to the lack of crumbs remaining on the surface, one of the major differences between Estabrook's study and treatment of Hirshhorn paintings was that the latter used eraser crumbs that were already pre-ground, while Estabrook used a whole, block eraser, which might require more pressure or create smaller, more tenacious crumbs.

Erasers were tested on a small-scale reconstruction made using #12 cotton duck canvas and original Magna paint diluted with turpentine. Fine and extra-coarse grinds of Eberhard-Faber's "Magic Rub" were obtained from William Minter, who supplies pre-ground erasers to paper conservators. A Staedtler Mars Plastic eraser was also hand ground to a fairly coarse texture for testing.[4] Additionally, *Groom/stick*[5] a natural rubber-based cleaning material similar to a kneaded eraser was a tested on the panel.

In an attempt to standardize application, one teaspoon of eraser crumbs was spread on the surface, rubbed gently for approximately 10 seconds, and remaining matter vacuumed off with a HEPA vacuum set on the lowest suction setting. After cleaning, the surfaces were examined and compared to a control. Under magnification, it was clear that particle size made a significant difference in the ability to remove remaining crumbs. The Magic Rub fine grind left a large number of particles, even after vacuuming, while the extra-coarse grind left almost no crumbs after vacuuming. The hand-ground Mars eraser left a moderate amount of crumbs behind, mostly very small ones, similar in size to the fine grind Magic Rub. All three ground erasers seemed to clean with minimal disruption to the fabric weave and texture, and when used crumbs were examined under the microscope at 25x magnification, very few broken fabric fibers were found adhering to the crumbs. The Groom/Stick, however, pulled off large amounts of fibers and pigment, even when rolled most gently over the surface.[6] It should be noted that only disruption to the canvas fibers and residual crumbs were evaluated. Issues such as migration of plasticizers or other material from the eraser to the fabric—while important to consider—were not studied.

While erasers have generally been used for the cleaning of color field paintings, they are not ideal. A second method, while seeming initially unorthodox, has been used by Jim Bernstein for 22 years and has been adopted by some conservators of modern art today.[7] This cleaning technique involves baking a special loaf of "conservation-grade" bread using only flour, water, and yeast.[8] After baking, the crust is trimmed off and discarded, leaving a soft, moist, and crumbly material.

The bread crumbs are used like erasers, starting with small handfuls of bread. The bread is then gently rubbed over unpainted areas of canvas, paying special attention to the texture and feel of the crumbs in the hand. If prepared properly, the bread will naturally crumble as it is rolled across the surface, picking up surface grime. As the bread breaks into smaller pieces it looses moisture, at which time the rubbing stops and the excess vacuumed off the surface. It is extremely important to stop as soon as the crumbs begin to dry in order to prevent abrasion or undue friction on the canvas. Prior to loosing moisture, the bread is very soft, and responds well to the various textures on the unprimed canvas.

During testing of the bread cleaning technique on the reconstructed panel, some very small bread crumbs were visible in the fabric weave under magnification after the initial vacuuming, but if the same area was vacuumed again an hour later, after all the moisture had evaporated from the crumbs, they were entirely removed, and did not stick to the surrounding fibers.

Like many conservators, I was initially very skeptical about the safety and appropriateness of using a food product to clean works of art. The thought of bread immediately conjures up images of potato or onion cleanings, or other "historical" techniques that the conservation profession has spent years trying to discourage. The threat of mold growth or insect infestation seemed as if it might outweigh any potential benefits that the bread presented.

Of greatest concern was that paintings cleaned with bread might be more susceptible to mold growth, should they be exposed to a period of high humidity. In order to test this, another reconstruction was created using unstretched cotton duck canvas and Magna paint diluted with turpentine. The samples were exposed to the general dust and air of the museum for approximately three months, sitting uncovered first in the conservation lab, followed by painting storage.

The exposed fabric was cut into four equal sections. The first section was a control that would be exposed to high humidity without being surface cleaned or vacuumed. The second sample would only be vacuumed, the third would be cleaned with bread and not vacuumed, and the final sample would also be cleaned with bread but vacuumed afterwards. The samples were then placed on a mesh screen and suspended above a tray of water. Humidity was monitored regularly using a simple temperature/humidity monitor. In two days, mold began to grow only on those samples that had not been vacuumed, with no apparent difference between the one that had been cleaned with bread and the one that had not. On the fourth day, mold began to grow on the other two vacuumed pieces, again, with little to no difference in rate between the one that had been cleaned with bread, and the one that had not. The test was repeated with new fabric strips two months later, with a similar outcome. These results suggest that vacuuming, more than cleaning technique, is the major factor in mold growth, and that those works cleaned with bread are no more likely than their uncleaned counterparts to develop mold during a period of high humidity.

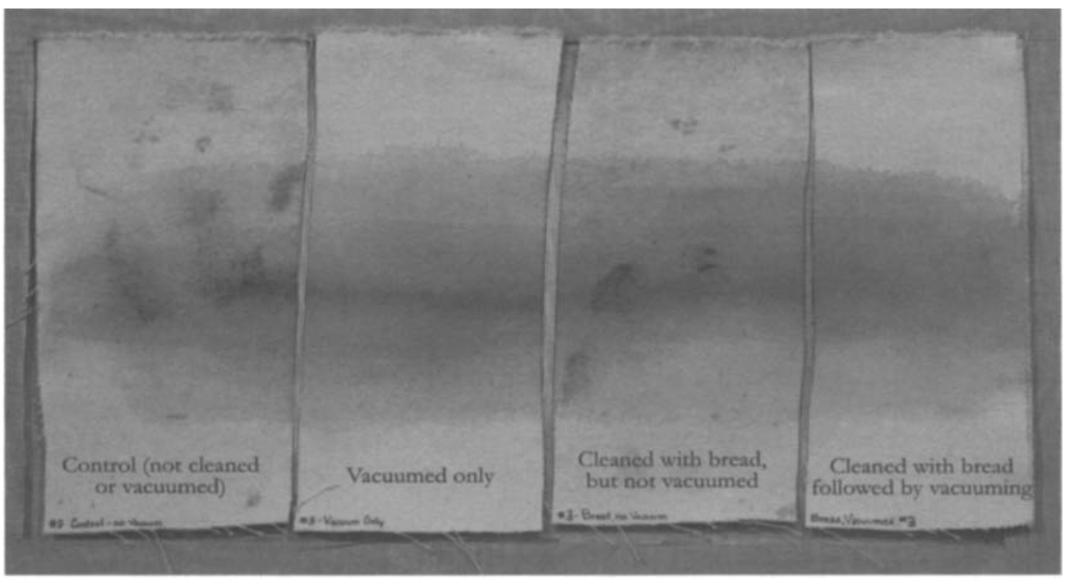

Figure 4: Results of mold test after two days. The fabric samples that had been vacuumed show minimal mold growth, while those that were not vacuumed have much more extensive mold. From these tests it does not appear as if the use of bread as a cleaning material is associated with mold growth.

While using bread to clean these paintings may not promote mold growth in and of itself, it is very important to stress the importance of choosing an appropriate location that can be cleaned thoroughly after this technique is performed. Bread crumbs that fall to the floor must be cleaned up at the end of each session to prevent attracting insects or rodents, and crumbs should be disposed of in areas of the museum normally associated with food preparation, rather than in the conservation lab. When combined with a comprehensive pest management policy, paintings cleaned with bread should be no more attractive to insects than those that have been cleaned using other methods.

When the cleaning efficacy of bread crumbs is compared to that of erasers, bread crumbs are far superior in removing grime and light staining in an even, gentle manner. While unorthodox, there are a number of potential reasons why the breadcrumbs are such a successful material for cleaning works on unprimed canvas. One potential reason is the amount of irregular surface area that a bread crumb has compared to an eraser crumb. While erasers have a generally smooth surface, the bread has numerous voids and "arms" that can hold grime and cover more of the canvas weave. While fresh, the bread is extremely resilient and flexible, bending around textures without abrading or grabbing at loose fibers. In addition, the bread has some inherent moisture. This moisture aids in pulling the grime off the surface and reducing light stains, whereas the erasers have no associated moisture content. Unlike small eraser particles, the bread generally does not break into pieces small enough to get trapped in the fabric fibers, and any particles that do adhere are easily removed when the moisture is lost and they shrink in size.

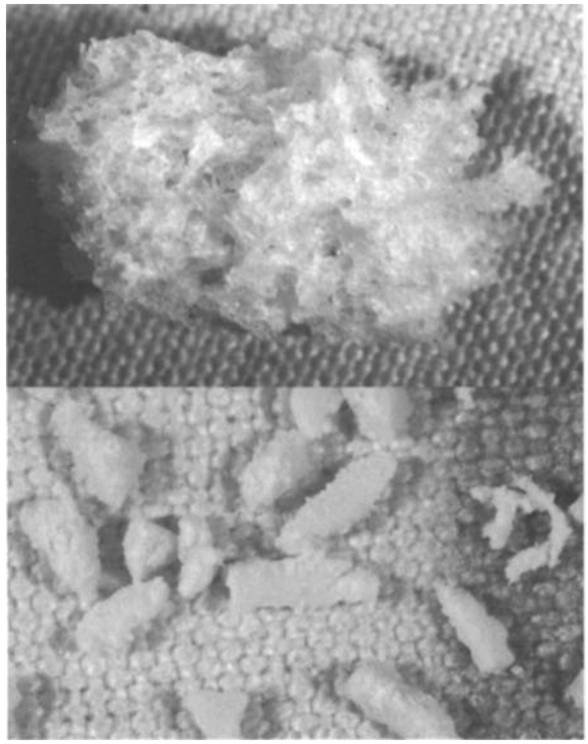

Figure 5: Comparison of a bread crumb (top) with coarsely ground eraser crumbs (bottom). One of the reasons that the bread is highly effective at removing grime is that it has a lot of surface area and "arms" that can remove grime from in between canvas fibers. The eraser crumbs have much less surface area and are not as flexible.

Since it is likely that the presence of moisture is an important factor in the success of bread cleaning, alternative techniques involving the use of polymer gel systems are also being explored. Carbopol or methylcellulose based polymer gels, like bread, could crumble, hold some moisture, and be soft and flexible. Unlike bread, a gel could be more standardized and incorporate other beneficial elements, such as chelating agents, solvents, or buffers to maintain a specific pH. Cellulose-based gels mixed in the lab have shown promise, but to date none has been able to meet the requirements for full removability without adhering to or being absorbed by the fabric fibers.

Working with Glenn Gates, Andrew W. Mellon Post-doctoral Fellow in Conservation Science at the Straus Center for conservation, the use of commercially available hydrogels was also explored. These cross-linked, non-ionic, methacrylate-based gels are used for making contact lenses, and as such are chemically pure and do not contain unreacted material that might adversely affect the raw canvas. The gels are purchased pre-made in their dry, dehydrated form. When crushed to increase surface area, and rehydrated with water, they could be used in the same way as breadcrumbs or erasers. In initial tests, after cleaning no significant differences were observed in the cleaning efficiency of the hydrogels as compared to the breadcrumbs, and it was decided that they hydrogels were too expensive and difficult to obtain to justify this application. Less expensive ionic hydrogels are currently being explored as an alternative.

Treatment strategy

Treatment of works in the collection is one of the most important elements of this project, but is also one of the areas requiring the most care and caution. As the survey indicated, some color field paintings have been irreversibly damaged by previous conservation treatment, however well-intended. After the detailed study of surface cleaning techniques, it was decided that enough was known about the materials to begin basic cleaning of the color field paintings in the Hirshhorn collection, but that testing of alternatives would continue. The treatment phase of this project is now in its formative stages, and will continue through the completion of the fellowship in March 2005. Although treatment of each painting will be individualized, some basic principles and techniques will be used.

As suggested by the mold test, gentle vacuuming to remove accumulated dust and grime is an important step in caring for works on unprimed canvas. When appropriate, each color field painting will be vacuumed using a designated brush attachment on a HEPA vacuum. Generally, only unpainted canvas will be cleaned; however, on particularly dusty paintings it may be necessary to vacuum the painted areas as well. For some of the paintings in the collection, this is all the treatment that the work will require, while other works will also be cleaned with bread to remove more tenacious grime or to achieve a more even result. Cleaned paintings will be covered prior to returning to storage to prevent new accumulations of dust.

Works that exhibit migration of acids from the wood stretcher to the canvas, will be considered candidates for a loose lining to prevent further damage. The loose lining process would involve removing the work from the stretcher, priming a secondary lining canvas with acrylic gesso, sealing the stretcher with a polyurethane or similar coating, and restretching the painting on the original stretcher. In evaluating paintings for this treatment, the benefits of reduction in staining will be weighed against the invasiveness of removing the work from the stretcher, and the potential strain on the painting. As the process of loose lining has the potential to significantly change stresses within the painting, alternatives to the loose lining process will also be explored and tested in the hope that a less invasive and potentially damaging alternative might be developed.

Of most importance, the treatment phase of this project will provide preventive care for those works already in good condition by updating written and photographic documentation of condition, evaluating storage, and establishing a baseline for monitoring future changes.

Future Work

Although this project is a beginning, there is much work that still must be done before conservators fully understand the aging process of color field paintings and other works on unprimed canvas. Staining of the canvas support, cleaning of the painted areas, deterioration of the paint binding medium, and examination of canvas sizing are all important in understanding how to care for these works, yet little—if any—work in these areas has been done.

It should be emphasized that the cleaning techniques and treatment strategies presented here are not the only methods for approaching these works of art, or even necessarily the best. Instead, the goal is to better understand what materials are available, what the pros and cons of each material might be, and to introduce new possibilities and treatment options. It is hoped that with future research, an even clearer understanding of the effects of treatment on color field paintings will be known, and new, even more innovative approaches to caring for these works can be developed.

Acknowledgements

The author would like to thank the Samuel H. Kress Foundation and the Morris Louis Conservation Fund for their financial support of this project. In addition, Hirshhorn conservation staff Susan Lake, Clarke Bedford, Roni Polisar, Lee Aks, and Bruce Day have been invaluable in moving these large paintings, arranging working space, and supporting my interest in this project. I would also like to thank those conservators in private practice an at institutions all over the country that have offered photographs, reports, and stories of color field paintings in their collection, as well as treatment experiences.

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Endnotes

[1] It is anticipated that full results of the project, including more detailed analytical data, conclusions, and charts will be published in the *AIC Journal* at a later date.

[2] Because of the Hirshhorn's strong collection of paintings by Washington Color Field artists, this project focused exclusively on works by Noland, Louis, Mehring, Davis, Reed, and Downing. Of course, many other artists throughout history have also painted on unprimed canvas, and the condition concerns and treatment techniques applied to color field paintings would be equally valid for them. Had the survey included all works on unprimed canvas in the Hirshhorn collection, it would have included over 25 different artists and over 100 paintings.

[3] Estabrook, Elizabeth. "Considerations of the Effect of Erasers on Cotton Fabric" in *Journal of the American Institute for Conservation.* 28 (1989): 79-96

[4] Magic Rub and Mars brand erasers are both commercially manufactured Poly (vinyl chloride) based block erasers with a variety of fillers and additives. Magic Rub is produced by the Eberhard Faber company located in Lewisburg, Tennessee, and Mars is produced by the Staedtler company in Nuremburg, Germany. Both are commonly used by paper conservators for surface cleaning and have been reviewed multiple times in conservation literature.

[5] Groom/Stick Molecular Trap is described as an "Unique non-abrasive, absorptive long-life cleaner for paper and many surfaces." It is made by Picreator Enterprises Ltd. 44 Park View Gardens, Hendon, London NW4 2PN, England.

[6] Since the presentation of this paper at the AIC annual meeting, a number of other materials, such as Absorene, Wishab sponges, and chemical sponges have also been tested. Results of these tests will be presented in a future publication.

[7] I was introduced to the technique of bread cleaning by Jay Krueger, conservator of modern and contemporary paintings at the National Gallery of Art, Washington.

[8] I have been using a commercially available breadmaker to prepare the bread, using the company's basic white bread recipe and omitting all salt, sugar, butter, milk, etc. It could be done without a breadmaker by simply following proportions of flour, water, and yeast in a traditional bread recipe and baking according to directions. Different brands of flour give different consistencies of bread—it is important to experiment until you find one that gives the proper texture. Baking at different temperature and humidity levels, as well as altitude all affects the quality of the final loaf of bread.

CONTROLLED LASER CLEANING OF FIRE-DAMAGED PAINTINGS

Abstract of paper given in AIC Painting Specialty Group Session, June, 2004

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Summary

New technologies can offer valuable tools to support conservators and restorers in their work. The Dutch company Art Innovation has developed an innovative laser restoration tool for non-contact cleaning of painted artworks. This laser workstation has proven to be a valuable tool to solve the problem of fire-damaged paintings. In cases where a thin layer of soot is deposited on the surface, the dirt can easily be removed using only very low laser energies. Hence the effect of the UV laser light on the surface is minimal. The ability to gradually remove the damaged top layers of a painting with minimal influence on the remaining material opens new possibilities for conservators. European research supports the viability of the UV laser technique as an additional tool in conservation practice.

UV lasers in painting conservation

In the last twenty years the application of laser-based techniques as a restoration tool has received more and more attention from both conservators and scientists. The utilisation of lasers obviates the use of various chemicals, and provides a method to remove layers that cannot be removed using conventional methods.
The feasibility and advantages of laser cleaning techniques for surfaces like sculptures, stone and marble have been demonstrated by several research institutes. Application of lasers for conservation of painted artworks is more demanding, due to the high sensitivity of paint layers (different pigments and binding media) to light. Researchers at the Foundation for Research and Technology-Hellas (FORTH) in Greece carried out pioneering work on laser cleaning of paintings and icons.

Using the Greek expertise on this subject, the Dutch company Art Innovation has developed a professional laser cleaning station for the restoration of paintings. The laser cleaning station consists of a UV excimer laser (248 nm) and a spectroscopic detection system (Laser-Induced Breakdown Spectroscopy) for on-line control of the cleaning process. An 'optical arm' and XY-frame were designed for accurate manipulation of the laser beam, in order to keep both the laser and art object static. In the framework of the research project "Advanced workstation for controlled laser cleaning of artworks" (ENV4-CT98-0787, funded by the European Commission), a multidisciplinary team of conservators, scientists and engineers collaborates to apply and improve this innovative laser restoration tool for non-contact cleaning of artworks. The research objectives of the project focus on definition of the boundary conditions in which laser cleaning can be safely applied. Molecular changes in pigments and binding medium induced by UV irradiation are evaluated on the basis of a series of test systems.

It is very difficult to define a general cleaning procedure. Hence, each restoration case has to start with a feasibility study to establish the laser parameters and define a specific data algorithm for process control. In many cases, a combination of laser cleaning and conventional techniques offers the best solution for a conservation problem. For example, with the removal of varnish from a paint layer, often a thin layer of varnish is left on the surface to protect the sensitive paint layers from the UV light. This very soft layer of organic material can subsequently be removed using mild solvents.

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[4] Hesterman Restauratie Atelier voor Schilderijen, Postbus 1004, 1398 ZJ Muiden (The Netherlands) Hesterman@zonnet.nl
[5] Foundation for Research and Technology-Hellas (Fo.R.T.H.), I.E.S.L. Laser and Application Division, Heraklion, Crete (Greece) zafir@iesl.forth.gr

Fire-damaged paintings

The UV laser technique was successfully applied to solve the problem of fire-damaged paintings. Thin layers of soot, especially when deposited directly on the painting surface, can cause serious problems for conservators. The grime does not easily dissolve in solvents, and rubbing when using a cotton swab causes the particles to disperse into the surface. However, when using a UV laser, only low energy fluences are needed for the removal of these particles. A bright spring landscape (1942, oil paint on hardboard) was severely damaged in a fire. The combination of high temperatures and soot has largely obscured the original image. Conservators feel that it is very difficult to restore this kind of damaged paintings using conventional conservation techniques. Already the first trials with the UV laser workstation show that the laser can help to solve these difficult conservation problems. Using a moderate amount of energy (0.38 J/cm2), only a few laser pulses are needed to remove the very top layer of the painting. The cleaned area beautifully reveals the original painting colours. With the limited amount of UV light reaching the painting, the original paint layers are not discoloured by the light. Under the microscope, the painting surface shows that the laser has removed the discoloured layer while leaving the paint surface texture intact.

Another example concerns the painting "Lamentation", which originates from a small pilgrim chapel (Kappel Genooij; Parochie St. Martiuskerk) in the south of the Netherlands. It consists of a panel support with overlying ground and paint layers, covered with a thick varnish layer. The surface has been entirely covered by soot, obscuring the complete image. The soot deposits have built up over many years as a result of pilgrims and visitors lighting candles and (oil)lamps. The removal of non-original material using traditional techniques can, in this case, be extremely problematic and potentially damaging to the underlying original material. The soot layer was removed using the laser cleaning station at Art Innovation. A moderate amount of laser energy (0.3 J/cm2) and only one laser pulse per spot was needed to remove the thin soot layer from the surface. The focused beam area was 2 mm x 14.8 mm. An overlap of 0.4 mm was used in the x-direction and an overlap of 7.4 mm was applied in y-direction. The cleaned painting revealed the image of the "Entombment of Christ".

Acknowledgements

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FIRE, WATER, AIR, AND MORE THAN 1000 SQUARE METRES OF SOILED SURFACES TO BE CLEANED

Gunnar Heydenreich, Ph.D., Conservator of Paintings

The effect of fire, water and air pollutants on the collections of the museum kunst palast Düsseldorf and the necessary surface cleaning, have put a stamp on the activities of the Restaurierungszentrum for more than a decade. This article deals with the causes, kinds of damage and measures, reflects on the experiences and proposes various strategies to counteract this interplay of forces [1].

1 Nam June Paik, *Fish flies on sky* (1974/85), Video installation after the fire of September 11th 1993.

Fire

In 1993 a video installation with 88 monitors by Nam June Paik was destroyed by fire (Fig. 1) and a total of 760 paintings, sculptures and art objects were damaged by fire by-products.[2]

Fish flies on sky is one of the earliest and artistically most important video installation in a museum. Paik designed this artwork for a central room on the first floor of the collection. He arranged 88 colour televisions on the ceiling to form one large screen. The monitors were suspended in a frame made of steel girders with the screens facing downwards.

On the 11th of September 1993 at about seven in the evening the installation was destroyed by fire in just a few minutes time. The fire brigade was able to extinguish the fire before it spread to other rooms, the fumes however filled the adjoining galleries. In addition soot was spread to more distant parts of the building by the air conditioning system. The ventilation system had been equipped with heat detectors and fire dampers, but the temperature of the fumes which filled the pipes was too low to set these off. There was no link between the fire alarm based on smoke detectors and the air conditioning. The pieces in the direct vicinity of the fire were damaged the most. The air which contained particles of soot condensed on cooler surfaces causing black drips (Fig. 2).

The soot consisted above all of the burned plastic from the 88 monitors and its wiring. When PVC burns, the chlorine can split off and become dispersed with the fumes. When dissolved in condensing steam hydrochloric acid may be formed. Within a few days the acids caused strong corrosion on numerous metal surfaces.

Under special circumstances the burning of synthetic materials containing chlorine can also produce highly toxic dioxins and furans. The backs of the Korean monitors had been supplied with polybrominated biphenylether as a flame retardant. These belong to the so-called predioxines that by virtue of their production contain traces of polybrominated dibenzo-p-dioxines and dibenzofuranes. These materials can form additional

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poisons in a fire. The analysis of the soot showed that the concentration of the so-called Seveso-dioxines exceeded the double amount, and in the case of other dioxins up to 94 times the permissible limit of the safety regulations.[3] Disposable overalls, protective gloves and complete facemasks with P3A2-filters were employed for human protection during the investigation and salvage.

2 Enzo Cucchi, *il muro* (1985), Soot deposit and drips caused by condensation, Detail

The extent of the damage could only be estimated after some days: 325 paintings and contemporary objects, 68 sculptures, 22 furniture items and 345 arts-and-crafts objects showed clearly visible deposits of soot. Curators and conservators decided to transfer all moveable objects to two provisional stores which were set up in galleries with less contamination. As much of the loosely adhered soot as possible was removed before moving anything, using special vacuum cleaners supplied with appropriate (class H) filters. Later observations confirmed the importance of this measure: even one fingerprint or a longer period of deposit could cause a stronger adhesion of the soot particles to the surface.

3 Evacuation of works of art by Joseph Beuys after the fire

The transport of some modern and contemporary works of art proved particularly difficult (Fig. 3). Protective masks restricted communication, rubber gloves reduced sensibility to delicate objects and shortage of oxygen reduced concentration during extensive dismantling. Leaving large and very fragile objects in place also proved problematic, because in the first few days nobody could tell if intermediary levels and air ducts with deposits of soot needed to be opened and renewed. We decided to protect these works with transit frames placed in front of the object, secured to the wall and covered with polyethylene foil. The objects were cleaned in the galleries after the building measures were completed. The evacuated works were cleaned in the workshops of the Düsseldorf conservation centre over a period of four years. Because the damage was covered by insurance we were able to temporarily employ 22 additional colleagues.

Numerous materials and methods were used for dry and wet surface cleaning, because of the different surfaces and forms of damage and because of different experiences in the various departments involved. The adhesion of the soot varied depending on the artwork's materials and the way they had been used as well as the deposit of old dust and the distance from the fire.

• The wishab-cleaning sponge[4] (today akapad and akawipe) was used frequently in the initial phase to remove loosely adhered soot particles. The disadvantage was that occasionally glossy residues and small particles that flake off the sponges could be observed. Although we took meticulous care to vacuum these particles they recurred in fabrics or between stretcher and fabric even after several years. Resent research shows that the new wishab-paper sponge (akapad 1030) leaves behind less residues[5] and according to the manufacturer it also contains less sulphur.[6]
• Vulcanized cis 1.4 polyisoprene rubber, known for example by its brandname Groom/Stick is suitable for the removal of soot but because of the often greater pressure applied to the painting's surface it was less frequently used. In addition, the occasionally visible separation of oil components reduced the possibilities for application.
• Vulcanized rubber sponges, like the Wallmaster Drychem Sponge have been increasingly used in conservation for about ten years.[7] The wallmaster sponge is filled with calcium carbonate and contains traces of aluminum, zinc, silicon, iron and sulphur as well as less than 1% oil.[8] With this product soot particles were successfully removed from many surfaces. Because of its sulphur content, it was not applied to photographs.
• In the case of individual objects – for example silk paintings by Marianne Heske or a cloth picture by Palermo – every rubbing movement led to an effacement and a consequently stronger adhesion of the soot particles on the surface. Here the removal by dabbing with adhesive pads based on styrene-butylacrylate copolymers in differing adhesive strengths proved suitable.[9] Residues of these were not detectable under laboratory conditions.[10] However, the pre-condition for the use was the stability of the support and paint layers. When the adhesive was melted and applied in thin layers with foam, or even foam rollers, larger areas could be cleaned effectively as well.
• Gomma Pane is a kind of bread traditionally used in the cleaning of wall paintings. It is made of wheat, sodium carbonate, water. Because of possible residues this material was only used in individual cases.[11]

The spectrum of dry cleaning materials was extended amongst others by different erasers and eraser powder, soft leather and micro fibre dusting cloths. The wet surface cleaning involved the use of chelating agents – quite frequently Tri ammonium citrate.[12] The surfactants tested were found to have comparatively less successful effect. Additionally and depending on the surfaces various white spirits and polar solvents were used. In some cases we successfully applied cellulose compresses and solvent gels.

On the mural object by Enzo Cucchi the fire products formed a substantial coherent black layer. Dry cleaning was followed by application of compresses of natural cellulose. These compresses were wetted with a mixture of ethanol and water, with Japanese paper as a separating layer. Afterwards the compresses were removed from the painting surfaces with the paper and the soot.[13]

The cause of the fire was never completely resolved. Different surveyors came to different conclusions and named among other things a jammed cable and also a defect TV set as possible reasons.[14]

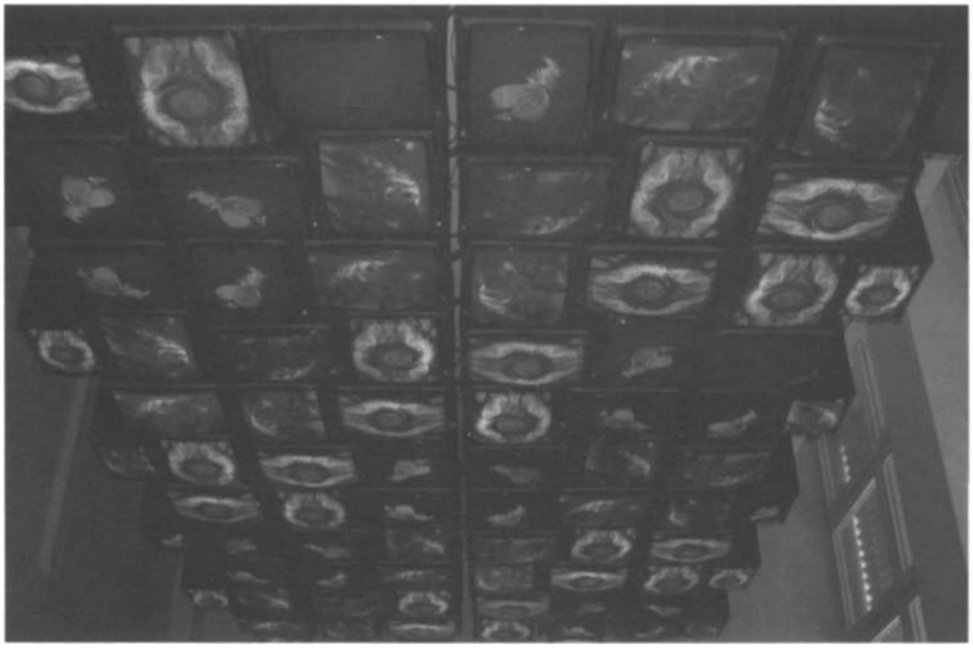
Statistically the most frequent causes of fire are:
• Defects in electrical circuits
• The overloading of heating apparatus (2004 Mount Athos)
• Lightning
• The overheating of air conditioning units and lamps (1992 Windsor Castle)
• And last but not least: insufficient care when undertaking welding and repairs.

All these factors can be avoided or at least damaging consequences could be limited by the observance of corresponding safety precautions. In Düsseldorf we had a special problem: Electric and electronic works of art can in themselves represent a fire danger. Conservators together with artists and other specialists occasionally are faced with the problem of calculating the danger and reducing the risk of fire by appropriate means. These interventions can influence the authenticity of the works. Our experiences give reason not to underestimate the potential danger of electronic works of art and necessitate in particular a reassessment of the position in the museum.

For artistic and political reasons and above all in the interest of Paik who showed himself very concerned about the effects of the fire, the museum decided to reconstruct the installation (Fig. 4). It was reinstalled in co-operation with the artist in the same room with new monitors and with the preserved video.

The reconstruction has taken into account the following seven safety measures which should contribute to avoid a new fire catastrophe happening and, in case of a fire, to avoid damage to personnel and art by toxic fumes.

1. Instead of the usual synthetic cover all monitors received a perforated metal housing, which changed the appearance of the installation.
2. The electrical installation was carried out with halogen free cable material i.e. without PVC isolation.
3. Protecting switches turn off the whole system if there is an increase in current in one apparatus.
4. Temperature sensors automatically interrupt the current if a monitor's temperature exceeds 55°C.
5. Smoke detectors and a smoke suction system were placed above the monitors.
6. If the alert system is activated the fire dampers in the air conditioning are automatically closed.
7. The adjacent rooms are protected by new fire protection doors with an automatic closing mechanism.



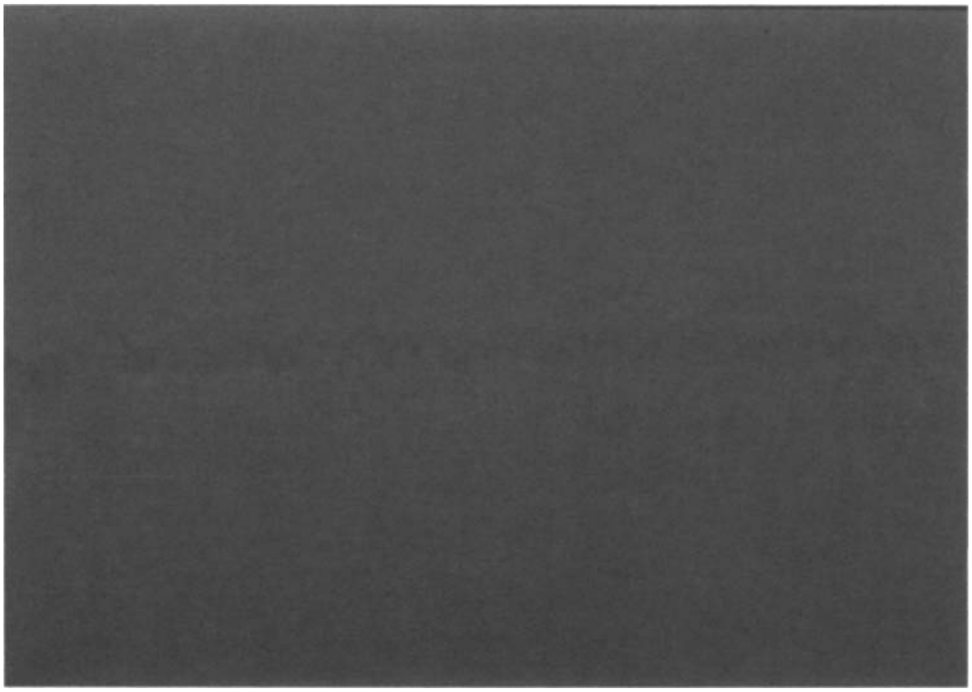
4 Nam June Paik, *Fish flies on sky* (1974/85/95), reconstruction of the video installation

Looking back we can also record some positive results:
• The investigation and documentation of about 760 cleaned objects gave us a more accurate knowledge of the state of preservation of the collection.
• Urgent conservation and extensive preventive measures could be completed during the cleaning treatment.
• Paintings were more adequately framed and received a protective backing. In a large number of cases we decided to apply protective glass, reducing the effect of air pollution and the frequency of cleaning.

Air

During the cleaning process we found that some paintings showed considerable soiling after a relatively short time, therefore we examined the entry of dust particles and monitored air pollutants in various stores and galleries. The results showed high proportions of dust and corrosive gases, above all sulphur compounds, nitrogen oxides and chlorides. In the framework of the Dutch Delta plan recommended values were in some cases exceeded by 125%.[15] Because these pollutants accelerate the deterioration of works of art and can lead to costly surface cleaning, the installation of suitable particle and gas filters was investigated.
As the short period of amortization was justified by a lower devaluation, the first Purafil air filtration unit could be put into operation in the paintings stores in 1999.[16] These units contain two special filters for the chemical absorption of corrosive gases. An online system registers the concentration of corrosive gases.[17] This instrument measures the rate of corrosion i.e. residue, which are formed on the surface of a copper and a silver plate. The available data prove that the Air Purity Class recommended for archives under the Dutch Delta Plan (less than 120Å silver corrosion in 90 days) was reached.
Although the effects of relative humidity and temperature on works of art have been studied for a long time, European museums pay comparatively little attention to the effects of air pollution. Until 2002 only 3 out of 105 institutions contacted in Switzerland, Germany and Austria undertook regular monitoring of air pollutants.[18] Half of these museums install filters, but most of these filters remove only particles.

Particles and gaseous contaminants reacting to temperature and humidity greatly influence aging and the need of surface cleaning of works of art. The mechanisms of deterioration and critical concentrations need more research.[19] By monitoring and filtering air pollutants, various measures for surface cleaning can without doubt be pursued more actively in the future. In collections of contemporary art these measures are becoming increasingly more important as traditional forms of glass protection and cleaning cannot be applied because of the structure of the surfaces or cannot be reconciled with artistic intention.



5 Blinky Palermo, *no titel* (1969), With water damage, Detail

Water

In August 2002 more than 200 objects in the storage of the museum kunst palast were damaged by water. The cause of the flood was a burst water main outside the museum. The leak occured in an area where the supply to the building branches off so the water could penetrate unhindered into the cellars in the early morning. The guards on duty were alerted when an electrical circuit break set off an alarm as the flood level reached about 20 cm. At this time the water had flooded several stores, altogether about 2000 m².

With the help of the fire brigade the flooding was stopped relatively quickly and the water which had penetrated was pumped out within a few hours. Consequently however all the affected stores with several thousand objects had to be evacuated because of the high humidity, the wooden floor being badly damaged and the considerable growth of mould. The water had damaged paintings, drawings, photos, kinetic objects, sculptures, furniture and design objects. This damage consisted of dirt, deformation, loss of strength and adhesion, corrosion, microbe attack and colour changes.

The fabric picture by Blinky Palermo from 1969 illustrates the various problems and treatments. It is a work from a series the artist made out of three differently dyed pieces of cotton fabric.[20] The picture was considerably damaged by the effect of water. Parallel to the lower edge a watermark formed with dark and light deposits (Fig. 5). In cooperation with the textile conservation department at the University of Applied Sciences Cologne we succeeded in removing the water stains successfully by wet-cleaning. In order to reach the back of the fabric, the tacks along the lower edges of the painting were removed. A wooden frame served as a temporary support for the loose material. This construction was necessary, because the original loose lining did not allow treatment from the back.

The deposits of dirt and calcium salts were removed in the following way:

• On the front of the fabric WypAll cleaning tissue and blotting paper served as absorbent pads.

• The watermarks were wetted several times from the back with cotton swabs and a 1% solution of Hostapon T (methyl-oleoyltaurine sodium salt) in demineralised water at about 30°C (Fig. 6). Thus a large percentage of the dirt deposits washed into the WypAll tissue.

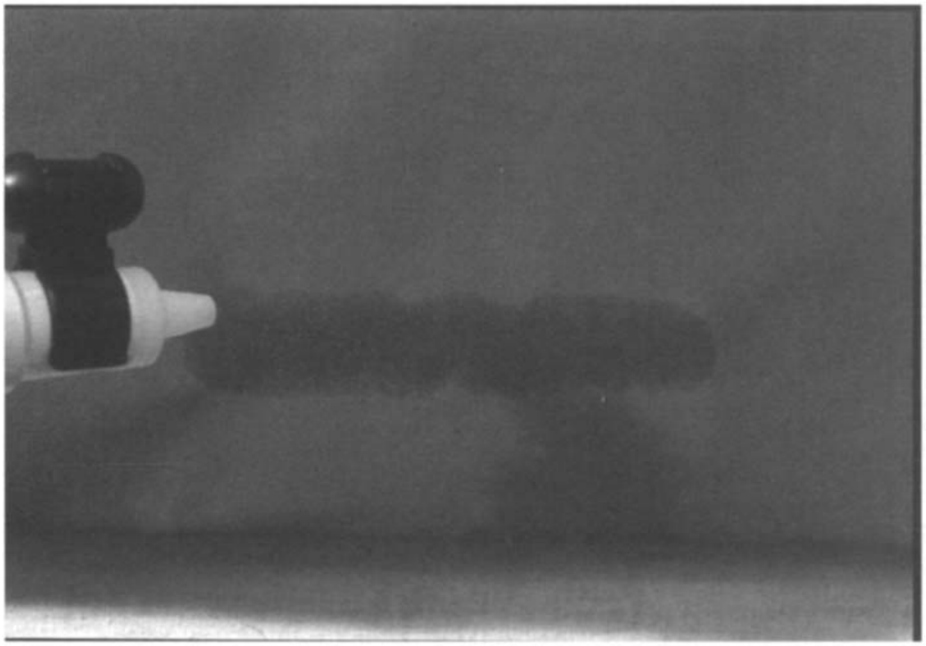
• To avoid the formation of new stains the edges of these areas were kept moist. Steam dispersed by a ultrasonic mister showed to be most suitable for this.[21]

• After several treatments the fabric was blow-dried from the back to draw any remaining dirt to this side. Depending on the degree of soiling this whole procedure was repeated several times (Fig. 7).

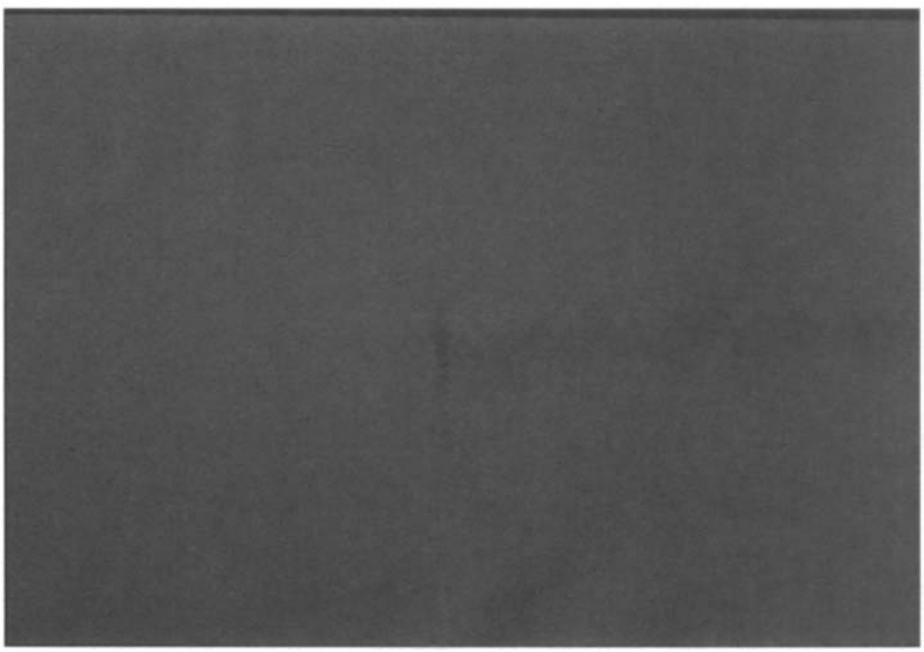
• In some areas Tri ammonia citrate (2%) and citric acid (10%) were used to reduce the deposits of calcium salts.

• Finally the treated area was washed once more with demineralized water.

The treatment resulted in a clear reduction of the watermarks and a slight loss of colour only visible on the backside. The cleaned areas appeared bluer than the non treated i.e. dirtier parts. To reintegrate these effects a retouching by means of an Aqua Sporca with dry pigments in water without any binding medium proved successful. Wet cleaning of the complete fabric was not considered an option because of the local damage and the potential danger of a change in colour in the area bordering two differently dyed fabrics.



6 Blinky Palermo, *no titel* (1969), The reverse during cleaning, Detail



7 Blinky Palermo, *no titel* (1969), The front during cleaning, Detail

The water damage lead to preventive measures. Electronic monitoring devices close to the floor will immediately report any flooding. Objects will be stored higher from the floor, on shelves or racks, and when planning a new storage area the placement of water-carrying installations will be watched closely.

In conclusion

Fire damage, air pollution and the effect of water have determined the activity of the conservation centre in Düsseldorf for more than a decade. Because of the various forms of damage a rich spectrum of materials and methods for cleaning has been applied. These measures directed our view increasingly towards preventive damage control. It remains a daily challenge to carry out surface cleaning without damaging the artworks, acting with due regard to economic considerations and preventing pollution at the same time.

Limiting damage and successful restoration was the result of the cooperation of many colleagues and experts. We owe them our special thanks.

Notes

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All images from the Restaurierungszentrum Düsseldorf.

CLEANING BY THE YARD: VERMONT'S HAND-PAINTED THEATER CURTAINS

Mary Jo Davis, Paper Conservator in Private Practice
Emily Gardner, Conservation Assistant

Introduction

The surface cleaning issues facing the Vermont theater curtain project are based on the need to adapt conservation techniques to on-site conditions. "Cleaning by the Yard" takes place in rural Vermont town halls, Grange halls, and opera houses that are not air-conditioned in the summer and are often not heated in the winter. The sheer size of a 100-year old painted theater curtain presents challenges of handling as well as determining the degree of reducing surface soiling, mending, and stabilizing that can be accomplished within budgetary constraints. The project objective is basic stabilization of the curtain structures with minimal interference to the fabric support and distemper media. In order to address the diverse requirements of a curtain, a conservation process has been developed to deal with tears, stains, overall aesthetics, and the challenges of continued use.

The project is a collaborative effort between conservators in different specializations. Paper conservator MJ Davis, painting conservator Suki Fredericks, and textile conservator Michele Pagan all bring a variety of ideas and experiences that have helped to create innovative treatment methods. Every site poses different challenges and the "curtains team" is constantly learning, modifying, and progressing for the next site. As this process occurs, *Guidelines for Practice* associated with the project is continually being written, reviewed and modified.

A Brief History

The Vermont Hand-Painted Theater Curtain Project began in 1998 as a statewide program of the Vermont Museum and Gallery Alliance (VMGA). Thanks to a grant from the Cynthia Wood Mitchell Fund of the National Trust for Historic Preservation, MJ Davis, then Project Director for VMGA's Collection Care Program, and Vermont historian Michael Sherman, started work on an initial survey of known curtains. Having started with roughly 20 curtains that number quickly grew to 80, and as of today over 150 curtains have been located throughout Vermont. The collection of curtains as a whole has been designated a "National Treasure" through the Save America's Treasure program. Thanks to grants from the National Endowment for the Arts, Save America's Treasures, the Vermont Legislature, and a variety of Vermont foundations, the stabilization project began in November 2002 under the guidance of project director Christine Hadsel (former executive director of VMGA). To date, over 75 curtains have been treated.

The hand-painted curtains, which were created between 1885 and 1940, can be found in local Vermont town halls, Grange halls, and opera houses. They are at the heart of the communities and have been a part of town gatherings, stage entertainment, and local Grange meetings for many years. The curtains can be classified in a variety of ways, such as by type of curtain – Grand Drape, backdrop or advertising; overall aesthetics – local or romantic scene; or by artist – known Vermonters, anonymous or still unknown painters, or studio production from companies in Boston, New York, or Chicago.

The first type of curtain and probably the most striking is the Grand Drape, noted for the decorative, painted fabric framing the central image. It is placed at the proscenium, and dominates the stage, usually providing a romantic castle or mountain scene that the audience can escape to before the curtain is drawn up for the show. Occasionally a local scene is used, but only if it is sufficiently romantic in its own right. Moving towards the back of the stage, one finds a variety of different back drop curtains, ranging from a street scene, a woodland scene, or formal interior. Some sites have a collection of stage pieces that work together with the curtains to complete the stage set. These pieces range from overhead "teasers" used to block the stage lights, to a collection of "ears", "tormentors", or "legs" that create depth on the stage and provide entry points for the actors.

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Grange curtains are in a category by themselves, and are characterized by local advertisements. Part of the interest of this curtain type is the crossover between a Grand Drape and the prosaic nature of the advertisements around the perimeter of a small central scene. Grange curtains are an early example of businesses sponsoring the arts!

The artists fall into several categories, the first being known Vermonters. One of the most accomplished and prolific was Charles Washington Henry (1861 – 1917). He and his extended family of 17 people traveled throughout Vermont and the neighboring states, often boarding out six months at a time with local families. He painted curtains from about 1885 until 1915, when he settled down to become the manager of a small opera house. The family traveled in a caravan of horse-drawn wagons and then Model T Fords and carried with them costumes, paints, play scripts and all their personal belongings. The Henrys all played musical instruments and produced vaudeville-like evenings. Henry's curtains have common characteristics such as his style of drapery, palette, and his inclusion of horses in almost every Grand Drape.

Another artist with Vermont connections was Robert Naves, who worked out of a barn in neighboring New Hampshire, but who traveled throughout Vermont selling ads and painting curtains in Grange and village town halls. Noted for creating the logo for his Flying Tigers Air Force unit during WWII, his curtains have a completely different style from all others. He uses vibrant colors and blocks of ads to create street scenes and often includes amusing images in his scenes. Naves died in China in 1944.

Commercially produced curtains were ordered from studios in Boston, New York, Chicago and other places. Today these curtains are often in more stable condition than those painted by the itinerant artists – their paints were more professionally mixed and the primary support is often of a slightly higher quality. Towns could choose from catalogues of different images which would be adapted for size and local preference. One set of especially beautiful studio curtains was painted by a Vermonter who went to Boston to learn the scenic painting trade. The Derby Line Opera House (which straddles the US/Canada border so that the stage is in Canada, while the audience sits in the US) contains an elegant scene of Venice as well as several other professionally produced curtains painted by native son, L. L. Moss.

A final group of artists remain anonymous. This was an age of traveling sign painters, as well as self-taught artists who created scenes on the sides of barns. Some of these curtains are extremely well executed and it may only be a matter of research before we are able to attribute them to scenic studios.

Objectives and Working Methods

The cleaning of a painted theater curtain requires extrapolation from several conservation disciplines. As previously mentioned, the team working on this project includes a textile, painting, and paper conservators with an objects conservator on the project advisory committee. The combined knowledge and skills of the four conservation areas provides a multi-disciplinary approach to the issues and techniques of cleaning.

The project objects are as follows:

1. Reduce surface soiling and disfiguring stains.
2. Stabilize primary support (fabric) through the mending of rips and tears and compensate for large losses through the insertion of similar fabrics. Stabilize raw or damaged edges to prevent vertical or horizontal rips.
3. Provide minimal consolidation of paint layer when loss of media is localized and urgent.
4. Provide minimal in-painting and toning of fills and stains to improve overall aesthetics.
5. Prepare curtain for reinstallation or safe storage.

To prepare for the removal of accumulated surface dirt and grime, the curtain must be placed on a flat surface. Each site must provide enough tables of equal height to create an "island" large enough to accommodate a curtain, its roller and top support. The tables are padded with 100% polyester blankets followed by a layer of cotton muslin and a final layer of Tyvek ®. If necessary, a treatment roller is then constructed on site using corrugated, galvanized downspouts. The sections are screwed together and the roller is then padded with polyester batting and covered with stockinette, giving it the friction needed to keep the curtain on the roller. The curtain is then handled as a scroll during the cleaning process allowing each area to be accessible. The treatment roller will be used to install the curtain later on if the original roller is missing or is too badly warped to be reused.

Due to the shear size and numbers of artifacts, budget, time, and workforce, the project team depends on local volunteers to assist in almost every aspect of the project. Once trained, our "Curtain Caretakers" become critical to the future care and handling of the curtains after the project team has gone. Project participation, under the supervision of project staff, builds appreciation and understanding of the fragile nature of these 100-year-old artifacts. By working one-on-one with the volunteers, the project team teaches them a variety of techniques and procedures they can use to later maintain their curtains. Starting with surface cleaning, the volunteers learn the proper vacuuming techniques needed for the curtain, how to hold a brush, use a screen and adjust a rheostat. They are quickly impressed and instantly gratified by the visible surface dirt removed. Along with vacuuming, volunteers are taught to surface clean using dry, vulcanized rubber sponges. This allows them a more intimate view of the paint layer and a realization of just how delicate their artifact is.

Stain removal has been most successful when using damp blotters placed on the recto of the stain, followed with a warm tacking iron to help wick discoloration upward. However, if the media becomes too damp, tidelines may form. In cases in which stains are in need of solvent treatment, a suction table has been employed carried out by the site conservator. Some stains also respond to mild enzymatic solution applied with cotton swabs and still others can be mitigated by careful use of a scalpel to break up a hard edge. Most stains can later be judiciously in-painted to improve the aesthetics of the curtain's overall appearance.

Surface cleaning is challenged by the friable nature of the media which is a distemper made from dry pigments and an animal glue binder. As most of the paints were made on-site by the artists, they vary widely in their stability even within a given curtain. Surface cleaning of areas most sensitive are avoided and a decision is made whether to consolidate locally or not depending on the degree of instability.

Finally, a curtain is either reinstalled in its original location on the verso of the proscenium or rehung as a backdrop with new hemp ropes, pulleys and cleats. If old hardware is workable, it is reused. Different locations have allowed for a variety of dust covers to be fabricated to help with long-term in situ storage. If the original building has disappeared or was lost to fire, curtains have been relocated to another public building with the stricture that they in will be unrolled only a few times a year.

A final treatment report includes the special needs and considerations for each curtain and site. If the extent of consolidation or required cleaning is beyond the scope of the project, additional conservation recommendations are included in the treatment reports and owners are referred to conservators who specialize in the required treatments.

Conclusion

Many of the 100-year old painted curtains were taken out of use because of physical damage to the primary supports or to the mechanical systems used for raising and lowering. Also, the introduction of motion pictures to rural Vermont saw the removal of the curtains and the addition of movie screens. Putting the curtains back into working order does create a potential for overuse, and is a topic of continued discussion for project staff. However, it is hoped that local volunteer participation in the stabilization process will raise the level of concern and care. Without intervention, the present condition and storage of the curtains would have lead to continued damage or possible loss.

RECOVERING THE APPEARANCE OF AN UNVARNISHED SURFACE

abstract of presentation

Jim Coddington* and Jay Krueger **

The history of 20th century art is replete with examples of paintings that were never intended to be varnished. Turning away from the rich, saturated look of a varnished surface was increasingly common with avant-garde artists throughout Europe by the end of the 19th century, with many artists exploring the aesthetic possibilities of fresh, light coloration, unencumbered by a traditional natural resin coating.

Through ignorance or unfamiliarity with art of this period, paintings that were never intended to be varnished have been visually compromised by the application of surface coatings and other traditional conservation methods and materials. Subtle nuances of color, tone, and variations in surface gloss are lost beneath the homogenizing layer of varnish, and alterations such as these, no matter how well intentioned have a serious and negative impact on paintings.

For conservators involved with the care of modern and contemporary paintings, a significant amount of time is devoted to removing surface coatings in an attempt to regain some semblance of the original surface. While not always successful, significant improvements are often achieved. A brief presentation of issues and case histories will illustrate how decisions have been made in regard to what a surface should look like, combined with a review of various approaches to attenuate physical changes and recover an unvarnished appearance. A discussion period with the audience will follow the presentations.

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THE CONSEQUENCES OF CLEANING THE MUMMY PORTRAITS FROM THE PETRIE MUSEUM OF EGYPTIAN ARCHAEOLOGY

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Introduction

The encaustic mummy portraits in the Petrie Museum of Egyptian Archaeology are an important part of the teaching collection at University College London (UCL) and since the 1970s have been particular favourites of conservators trained at the Institute of Archaeology (IoA), which is now a department of UCL. In 1976, IoA student Brian Ramer set a precedent for cleaning the encaustic portraits with solvents, a process that was wholly modified nearly a decade later by Helena and Richard Jaeschke, who employed only mechanical methods. Due to their collective efforts the majority of the 38 portraits and nine fragment groups have been cleaned in order to prepare them for travelling exhibitions, for handling and for museum display.

A recent survey of the encaustic portraits, which date from the Roman era in Egypt between the first and fourth century AD, focused on the use of both organic solvents and mechanical cleaning methods in an effort to determine the impact of cleaning on archaeological wax-based paints (Streeton 2003). The conservation records for the Petrie Museum collection were examined as were the mummy portraits themselves and a small number of portraits were viewed under magnification, some of which had been analysed in the past. The long-term effects of solvent use were of particular interest – specifically, the recurrence of surface 'bloom' – as was the materials research associated with the various cleaning campaigns. Overall, the project has led to a better understanding of the nature of the encaustic surface and, given the burial history, the cleaning processes most appropriate for it. However, many questions remain unresolved.

Of course it could be said that, with the benefit of hindsight, assessing the consequences of cleaning the Petrie Museum portraits will bring to light some cautionary tales. But considering the remarkable legibility (see Figure 1) and relative stability of the majority of the portraits in the collection today, their current state is a tribute to the forethought of the British Egyptologist, Sir William Matthew Flinders Petrie (1853–1942) and to those who have spent many hours at the microscope, regardless of the cleaning method employed. The purpose of tracing the treatment of the mummy portraits over 30 years has been not only to look at the ways that cleaning has affected their current condition, but also to take stock of the myriad advances in materials research since the 1970s and the changing perceptions of best practice in conservation over this period.

Figure 1. Portrait of a woman, UC14692, which had been 'rewaxed' by Petrie in the field *(photo: reproduced by kind permission of the Petrie Museum of Egyptian Archaeology, UCL)*

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Previous stratigraphy

No pre-treatment cross-sections have been retained from the 1976 project of Brian Ramer, who was the first to record his work on the portraits (Ramer 1977; Ramer 1979)[1] and no samples that had been taken by the Jaeschkes have been available for this study. In lieu of a well-defined cross-section through all the layers as they existed prior to treatment, the line drawing in Figure 2 should give some indication of the previous stratigraphic structure of the portraits[2]. The ancient, wax-based paint (the uneven layer labelled 2) was typically fractured and sometimes missing, in which case the underlying panel was exposed. Burial accretions of varying sorts, e.g., sand, mummification fluid and mineralised organics, were embedded in the paint layer and exposed panel (labelled 3) and in many instances, all of this lay encased in a discoloured and uneven coating of modern paraffin wax (the upper-most layer labelled 1).

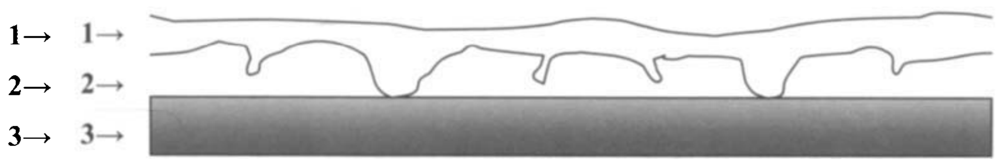


Figure 2. Line drawing of the layered structure prior to cleaning: 1) paraffin wax; 2) distinct paint layer with cracking and areas of loss; 3) wooden panel. Note that the drawing does not indicate the presence of burial accretions and 'dirt', which would have been encrusted in the ancient and modern waxes, nor does it indicate the ways in which the support has been distorted

Petrie's field treatment

Paraffin wax had been applied to a proportion of the portraits in the field by Petrie, who discovered hundreds of portrait mummies while excavating a Roman-period necropolis at Hawara in the Fayum oasis in 1888 and 1911 (Petrie 1889; Petrie 1911). The application of the wax coating often involved the dripping of molten paraffin wax onto the ancient wax paint and although Petrie intended this to be a protective measure – one which was to be used only when absolutely necessary because 'it was of course of great importance to show the surface as unaltered as possible' (Petrie 1889, 19) – it is not surprising that this highly invasive practice attracted criticism from his contemporaries (Petrie 1904). Far from causing extensive damage, however, Petrie's actions have been justified by history. Petrie's wax secured those areas of the paint film that had been damaged in antiquity or during interment in dry, sandy graves and also played an important role thereafter. Despite warping and cracking of the wooden support during transport out of Egypt and during years of unsuitable storage in London, Petrie's wax had prevented the paint film, as it existed at the time of excavation, from flaking, separating and disappearing altogether from the archaeological record.

Petrie recalled in 1931 that 'many of the portraits were injured by damp but, by putting a coat of fresh beeswax over them, the old colour was revived and safely fixed, so that it would not drop away' (Petrie 1931, 84). Despite his recollection, his 1889 and 1911 publications most often cite the use of paraffin (candle) wax, which at the time was a reasonably new product that had been developed in the 1860s in the United States (Gettens and Stout 1966). Paraffin wax was valued for its inert nature and was useful to Petrie because of its relatively low melting point in comparison to beeswax or the ancient paint media.

According to Petrie, the condition of the panels varied enormously at the time of their discovery and in response he devised four methods to protect and/or adhere flaking paint to the wooden support (Petrie 1911). For some, like the portrait shown in Figure 3, isolated areas of flaking paint were secured by 'remelting', which was performed on this portrait of a woman by holding a candle close enough to heat the surface (Petrie 1911, 6). When the entire paint layer was at risk, as was probably the case with the portrait of a woman, UC14692 (Figure 1) and portrait of a man, UC38315, Petrie reportedly flooded the painted surfaces with molten paraffin wax in a process that he called 'rewaxing' (Petrie 1889, 19; 1911, 6). The applied layer was anywhere between 1 and 4 mm thick and one can only assume that the risks of dripping molten wax onto ancient wax were accepted and justified because of the lack of a feasible alternative. His solutions were perhaps the most sympathetic ones available to him in that location at that time.

Figure 3. Portrait of a woman, UC19611, which had been 'remelted' by Petrie in the field (*photo: reproduced by kind permission of the Petrie Museum of Egyptian Archaeology, UCL*)

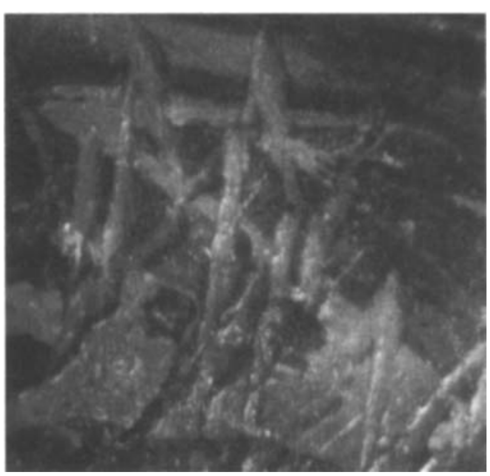
Another method similar to rewaxing involved a coat of paraffin 'butter', which was a soft admixture of paraffin wax, benzene and petroleum-jelly extracts (Petrie 1911, 6). The mixture was spread over less damaged surfaces and when the benzene evaporated out, a protective film remained. Those portraits that were treated with paraffin butter are more difficult to identify, not least because those that received this treatment are poorly documented, but it is likely that those with wax still filling the splits (such as portrait of a woman, UC30081) were treated in this way. Finally, the most friable fragments were faced with paper using rice-starch paste (Petrie 1911; Jaeschke 1997).

Of the 38 portraits and nine fragment groups in the Petrie Collection, it appears that more than three quarters were treated at least minimally with one of these methods and, as with many invasive treatments, the benefits have been tempered by undesirable side-effects. The modern wax had discoloured over the years, obscuring the image beneath, and although the paint layer had been preserved by the boundary and adhesion of the modern wax, it must be said that Petrie's wax coatings complicated cleaning efforts, primarily because burial dirt had become firmly embedded during the heating and softening of the ancient paint.

Additionally, Petrie and his team removed all of the Petrie Museum portraits from their mummy cases and predictably, many of the lime-wood panels, which measure between 1 and 3 mm thick, have warped and split.

A note on the encaustic technique

Although the history of the mummy portraits and Roman Egypt is quite colourful, it is beyond the scope of this paper to provide anything more than a note on the encaustic technique. The interested reader can consult the British Museum conference proceedings, *Portraits and Masks* (Bierbrier 1997), the exhibition catalogue for *Ancient Faces* (Walker 2000), *The Mysterious Fayum Portraits* (Doxiadis 1995), *Ancient Egyptian Materials and Technology* (Lee and Quirke 2000), *A History of the Arab Peoples* (Hourani 1991) and *Egypt after the Pharaohs* (Bowman 1996) each of which contains an extensive bibliography.



Fayum artisans painted the portraits on thin panels of wood with warm pigmented wax, using a lancet-shaped metal spatula called a *cestrum* (see Cros and Henry 1884, 10) and/or a brush stiffened in congealing wax. If the surface texture of the Petrie Museum portraits is an indication of common practice then both brush and a metal implement were commonly employed. Irregular ridges made by a stiffened brush as it passed through cooling paint are present, as are spatula marks and delineations made by a sharp instrument, perhaps the sharpened handle of a brush (see Figure 4).

Figure 4. Detail of ringlets of hair on the forehead of portrait UC19611 (Figure 3) showing brush strokes underlying marks made by a sharper instrument, perhaps a brush handle or a spatula (*photo: Libby Sheldon/Noëlle Streeton*)

Most scholars would agree that the technique, known as encaustic, originated in Egypt where extreme temperatures combined with the low melting point of untreated beeswax would have made the application of wax-based paints 'perfectly simple', or at least less complicated than in cooler climates (Smith 1889, 37; Gettens and Stout 1966, 23). For Greek painters who adopted the technique around the fifth century BC and in whose hands encaustic reached its greatest artistic development (Lucas and Harris 1962) hot palettes were necessary to keep the medium in a workable state. It is little wonder, then, that the Greek word *enkaio* – to burn in – refers literally to the process of melting or burning and expresses the characteristic feature of the Greek process (Smith 1889; Doxiadis 1995).

The encaustic technique depends on the solidification of the binding media, which have been variously identified as beeswax or Punic wax – which is beeswax that has been saponified, probably with the addition of naturally-occurring sodium carbonate, also known as natron (Na_2CO_3). The differences between the two waxes bear mentioning. While beeswax is a naturally yellow and rather brittle biogenetically determined substance (Mills and White 1994) Punic wax is white and more workable when made to a particular recipe (Masschelein-Kleiner 1995; Colinart *et al.* 1999). Clearly the ancients had discovered that the action of natron, which is a caustic alkali, could produce a saponified mineral wax – or a soap – that mimics the desirable qualities of beeswax while improving its colour, workability and durability. It is significant that artificially produced Punic wax has a much higher melting point than untreated beeswax. Whereas the melting-point range for beeswax is between 63.4° and 65° C, that for Punic wax is above 85° C (Ramer 1979; Mills and White 1994). Punic wax would therefore be more durable in the extreme heat of the Libyan Desert and would prove more resistant to accidental melting. This is an important difference, considering the ways in which portraits in both media were protected by Petrie. The modern wax could not have had a melting point much above 62° C, otherwise it would have melted the ancient paint on contact.

The first documented cleaning

The absence of a precedent or substantial point of reference for cleaning encaustic portraits meant that Ramer was obliged to determine the specific nature of the archaeological material at hand before proceeding. Ramer's research and subsequent cleaning of two encaustic portraits is described in an unpublished dissertation, submitted in 1977, which is the earliest record for cleaning any Petrie Museum portrait and also the sole resource for their treatment histories during this period.

Ramer, with the help of Raymond White at the National Gallery in London, did much to establish firm conclusions on the nature of the material constituents of two portraits, UC19611 (Figure 3) and a portrait of a man, UC19612. Ramer was working at a time when he was able to refer to Hermann Kühn's influential work, 'Detection and identification of waxes, including Punic wax, by infra-red spectrography', published in *Studies in Conservation* in 1960, while making use of more up-to-date investigative methods. For instance, Ramer and White endeavoured to fingerprint the characteristics of wax media using gas chromatography (GC), which was then being developed by White (White 1978).

Ramer's work on the encaustic portraits contributed directly to the debate between chemists and art historians on the sorts of waxes used by ancient painters to bind pigments (Encaust 1984; Colinart *et al.* 1999; Wunderlich 2000; Nadolny 2003). At least since the nineteenth century, historians had been fond of citing Pliny's recipe for Punic wax (Book XXXI, ch. 46) while chemists/researchers such as Donner von Richter (1890), Berger (1904), Dow (1936), Laurie (1937) and Burdick (1938) were increasingly able to refer to analytical data. Due to the transformational advances in instrumentation since the 1930s and the development of applications for conservation, Ramer and White were able to use GC to determine conclusively that the paint of one portrait – UC19611 (Figure 3) – was bound in beeswax while the medium for the portrait of a man, UC19612, was most likely Punic wax (Ramer 1977).

Armed with the knowledge that the wax media differed and with contemporary data on the behaviour of animal and mineral waxes, Ramer elected to borrow a cleaning method from painting conservation and went on to establish a precedent for cleaning the mummy portraits. He chose to dissolve the discoloured paraffin wax with an organic solvent called Shellsol T®, which is a commercial blend of aliphatic hydrocarbons (Petrie Museum 1983). Deposits of dirt that were difficult to dislodge were loosened with a 5% solution of Vulpex®, a potassium oleate soap containing Sextol, which was applied only in isolated areas (Ramer 1979).

Working with the aid of a stereo microscope at low magnification, Ramer applied Shellsol T® with one sable-hair brush and mopped up paraffin wax and burial matter with another. This 'dissolve and mop' process also removed salt precipitates that had formed prior to excavation and perhaps since, as well as three-quarters of a century of museum dust. The aim of using Shellsol T® in particular was to completely remove the paraffin wax layer (Ramer 1977) which, because of its low melting point in comparison to both beeswax and Punic wax, would have sat in a reasonably discrete layer on the ancient surface. Shellsol T® was chosen because, like paraffin wax, it is also a petroleum distillate that was shown to act slowly (Ramer 1977), thereby enabling Ramer to control its action to the extent that this would have been possible. In addition, paraffin wax is composed entirely of hydrocarbons (as opposed to 14% in beeswax) and because it is less complex than either beeswax or Punic wax, Shellsol T® would, in theory, only act on the paraffin wax.

However, in isolated areas where Petrie's wax had damaged or fused with the ancient paint, the complete removal of the paraffin wax would have been difficult, if not impossible, without affecting the ancient surface. Bearing in mind that the paint was buckled, blistered and broken as the result of ancient damage or cycles of deliquescing salts, it is not likely that the solvent was prevented from reaching the ancient surface in all instances. In addition, unlike volatile solvents like white spirit and Stoddard solvent, which would have evaporated quickly, Shellsol T® contains a proportion of less volatile agents, which means that these could potentially remain on the ancient surface as a residue. Furthermore, it is now recognised that the high pH of Vulpex® is unsuitable for cleaning alkaline-sensitive surfaces like these (Woodcock 2004).

It seems likely, therefore, that solvent residues have remained in isolated areas, particularly in pits and on broken edges where the solvents, paraffin wax and ancient wax had inevitably interfaced.

At the time of Ramer's cleaning project there was no evidence of surface blanching or crystallisation, but by the early 1980s a surface 'bloom' had developed on at least eight portraits, all of which had been treated with Shellsol T® (Streeton 2003) and perhaps with Vulpex® as well, but the use of Vulpex® is less well documented. Bloom refers to the white or bluish-white crystalline precipitate that forms on some waxy surfaces due to fatty acids or individual constituents migrating out of the wax medium (Koller and Burmester 1990).

No full-scale analysis of the affected portraits has been carried out to date, not least because more samples would be required. It would therefore be unwise at this juncture to attribute the formation of bloom solely to solvent use. But because it would have been impossible to prevent the aforementioned solvents from reaching the ancient paint in all instances, and equally impossible to remove all residues from a highly fractured surface, it is likely that solvent residues – particularly those from Vulpex® – have been part of the problem.

Bloom or hydrolysis

Some of the portraits had, according to Petrie, already suffered bloom or hydrolysis in the grave. He said that, '…the surface of the wax was decomposed and whitened; I then brushed it with a stiff brush and spirit to remove the altered film, and remedied the whiteness and dullness which almost obscured the colour, by spreading a thin coat of wax and ether over it…' (Petrie 1889, 19). After excavation and subsequent treatment with wax, it seems unlikely that hydrolysis of the wax media would have continued in the same manner as in the grave[3] and the volatility of ether would mean that it would evaporate off very quickly and completely, although ether could possibly blanch the surface (Price 2003). In addition, any moisture that would have seriously affected the wax medium over the centuries would have destroyed the panel first. As the panels of the portraits affected by bloom are in a reasonable condition, and seem not to have suffered biodeterioration, hydrolysis caused by damp burial conditions would seem an unlikely source of the problem.

Hydrolysis in storage, however, is likely. In 1986, portions of the Petrie Museum underwent building work and according to the Jaeschkes, a number of portraits that had been previously cleaned with solvents were affected by elevated relative humidity (RH) (Jaeschke and Jaeschke 1990). Although hydrolysis can occur naturally at room temperature at modest RH, it is possible that the elevated RH level in the museum had accelerated a process that had begun in the grave (Mecklenburg and Tumosa 2004). Pearlstein suggests that temperature influences the mechanism of the formation of surface bloom and apparently long chain fatty acids, esters, alcohols and paraffins, which are stable at certain temperatures, are all able to assume different crystal forms (Pearlstein 1986, 89). Therefore, temperature levels would, according to Pearlstein, dictate the polymorphic transformation of waxes and if this is accepted, then at least part of the cause of bloom formation on the portraits could be temperature related because the speed of diffusion has been increased.

However, because the portraits would have been exposed to extreme temperatures for the majority of their history, presumably without significant whitening of the wax media, it would seem that there must be another factor to explain the formation of isolated bloom patches. This factor must be either an unknown component in Shellsol T®, perhaps catalysed by damp and warm conditions in the museum, or even more likely a component in Vulpex®.

Mechanical cleaning

In the late 70s, the possible consequences of using solvents were not immediately apparent and therefore the 'dissolve and mop' method was used consistently by a number of other student conservators, including Helena Jaeschke, until Helena and Richard Jaeschke developed mechanical means for cleaning the portraits in the early 1980s. If the conservation documentation held at the Petrie Museum is any indication, it appears that neither Shellsol T® nor Vulpex® were used again after 1985.

Between 1984 and 1999, all but three of the portraits and one group of fragments were consolidated, cleaned and in some instances re-cleaned by the Jaeschkes, both of whom trained at the Institute of Archaeology. After a short period of using the solvents, the Jaeschkes sought another method because they found that solvent cleaning presented several problems (Jaeschke and Jaeschke 1990). Apart from the lack of control in general, they discovered that Shellsol T® in particular would lead to the softening of the wax paint, making it more susceptible to abrasion, while the texture of the ancient surface would be smoothed by the physical removal of Petrie's wax. Also, the solvent slurry could become lodged in fine cracks, making it impossible to remove (Jaeschke 1997).

On portraits with intact paraffin-wax layers, the Jaeschkes observed that Petrie's wax tended to separate from the dirt layer overlaying the encaustic paint (Jaeschke and Jaeschke 1990). They therefore devised a method for mechanical cleaning that used the separation, and cavitation, to their advantage. With a scalpel under low magnification the blade could be drawn through softer areas but where this coating was harder or there was concreted dirt, the paraffin wax had to be carved down to the encaustic paint layer (Jaeschke and Jaeschke 1990, 18).

One would assume that this method of cleaning would have been far more complicated for portraits that had already been solvent cleaned, which indeed was the case with a portrait of a woman, UC14692 (Figure 1). The portrait was first cleaned in the 1970s and re-cleaned in 1990; and in Richard Jaeschke's 1997 article in *Portraits and Masks*, a photograph of the half-cleaned portrait taken in 1990 shows the degree to which residues from Petrie's wax had continued to obscure the image (Jaeschke 1997, Plate 13/2).

It must be said that mechanical cleaning has produced outstanding results without the unpredictability associated with the former solvent cleaning. Using mechanical methods, Petrie's wax and burial dirt were removed (to the extent possible) from 21 portraits, while 13 were re-cleaned, removing from at least eight the first occurrence of bloom. However, of those that had been previously cleaned with solvents and mechanically re-cleaned, at least four have developed patches of bloom for the second time.

The survey

In light of the different approaches to cleaning and the unexplained recurrence of bloom, as part of this author's research (for which no new samples were taken) all the existing conservation records for the encaustic portraits and fragments in the Petrie files were surveyed (Streeton 2003). Of these, none begins before 1977 and of the 47 sets of records, only around 20 were detailed enough to allow for conclusions or reasonable assumptions to be made about how the cleaning treatments have affected the current state of the portraits.

From this survey, three categories emerged, which are set out in the Table here. Portraits in Category I are those that were remelted or rewaxed by Petrie, then cleaned in the 70s and 80s with Shellsol T® and possibly also with Vulpex®, and then re-treated by the Jaeschkes thereafter. Portraits that were cleaned only with solvents, perhaps up to 30 years ago, are listed in Category II. Those that were cleaned using mechanical methods only are listed in Category III.

	UC number	*binding medium*	*Petrie treatment*	*bloom?*	*notes*	*wood sort*
Category I						
All treatments	14692	Punic wax	rewaxed	bloom	uneven haze	lime
	19609		rewaxed	bloom		lime
	19610		rewaxed	bloom		lime
	19611	Beeswax	remelted	bloom	pitting	lime
	19612	Punic wax	rewaxed	bloom		lime
	30088		rewaxed	no		lime
	30089		?	bloom	textile pattern	lime
	36348		none	possible		lime
	38060		rewaxed	possible	salt blisters	
	36215		p. butter	no	tool damage	lime
Category II	19607		rewaxed	bloom	blanching	lime
Solvent(s) only	19608		rewaxed	bloom	blanching	
	19613		?	no		
Category III						
Mechanically	38059		p. butter	no	blanching	lime?
cleaned only	38102		rewaxed	no	pitting	lime
	38103		rewaxed	no		lime
	38314		none	no	Fungal mycelia	lime
	38315		rewaxed	no	pitting	lime
	40698		rewaxed	no	blanching	lime
	45002		none		blanching	

Table. Results of the survey of conservation files on the encaustic portraits reveal that there is indeed a correlation between solvent cleaning and the occurrence of surface 'bloom'. Key: pitting = bubbles and pits; p. butter = paraffin butter

From this survey, it has also been possible to draw two conclusions. Firstly, and in general, the present state of the collection as a whole is exceptional. Considering the delicate nature of these panels – which are on average 2 mm thick – and the long and complicated history of this particular group, it is quite astonishing that so many images are intact and legible. Secondly, and less positively, it would seem that there is indeed a correlation between solvent-based cleaning and the recurrence of surface bloom. The portraits in Categories I and II stand in stark contrast to those in Category III that have no recorded solvent exposure. None of these exhibit similar symptoms.

However, the current bloom formations vary, taking three identifiable forms, which means that this ongoing problem might not be traceable to a single cause. The portrait of the 'brown youth', as Petrie called him (see Figure 5), was both solvent and mechanically cleaned and now a bluish-white powder has formed in the impasto crevices between the eyes (see Figure 6). In the portrait of a woman, UC19611 (Figure 3), which was treated similarly, there is a recurrence of efflorescence in the pitted surface in the hair area (see Figure 7), a problem that was first reported in 1991 and at that time was identified as ammonium sulphate (Petrie Museum 1991). This efflorescence has a different character from the previous example, appearing less powdery and more crystalline.

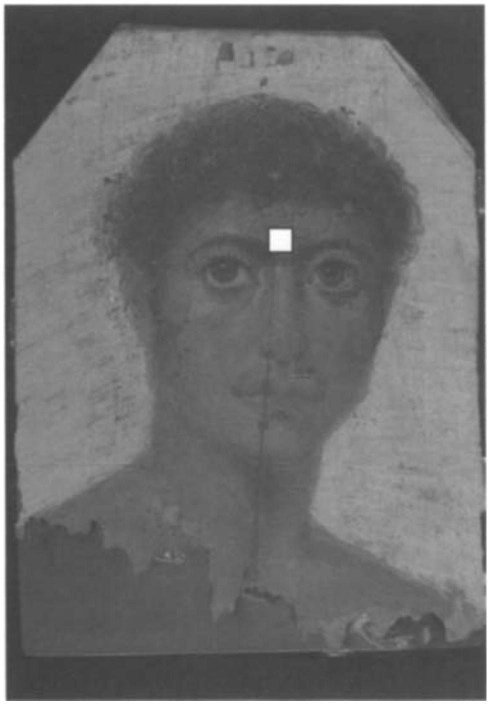


Figure 5. The 'brown youth', UC19609 (*photo: reproduced by kind permission of the Petrie Museum of Egyptian Archaeology, UCL*)

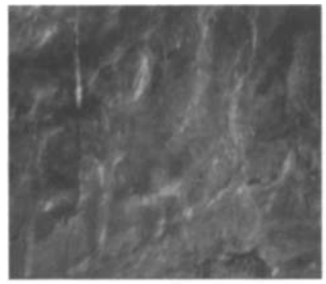


Figure 6. Photomicrograph (× 500) of the highlighted area on UC19609 (Figure 5) showing a bluish-white powder in the impasto crevices between the eyes (*photo: Libby Sheldon/Noëlle Streeton*)

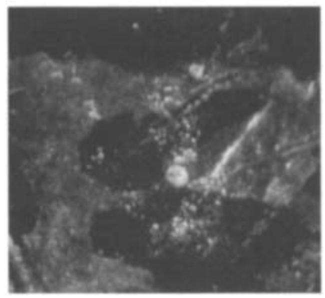


Figure 7. Photomicrograph (× 500) of UC19611 (Figure 3) showing crystalline efflorescence in the hair area, proper left (*photo: Libby Sheldon/Noëlle Streeton*)

Before moving on to the third type of bloom, the pitting in the light-coloured paint areas of UC19611 (Figure 3) in the hair parting (see Figure 8) is noteworthy. Similar pitting has been observed in a small number of other portraits in the collection, such as in the white (perhaps lead white) area of the collar on the portrait of a woman, UC14692 (Figure 9).

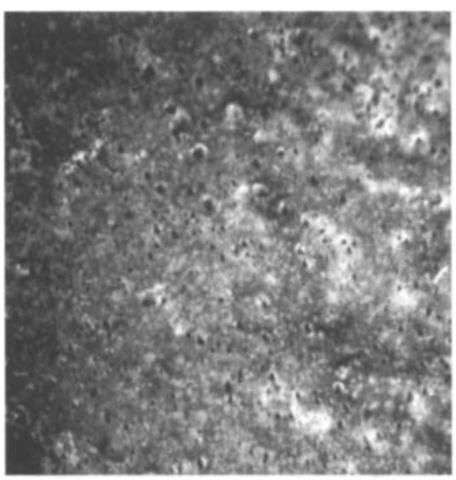


Figure 8. Photomicrograph (× 900) of UC19611 (Figure 3) showing pitting in the area of the hair parting, which would have complicated cleaning (*photo: Libby Sheldon/Noëlle Streeton*)

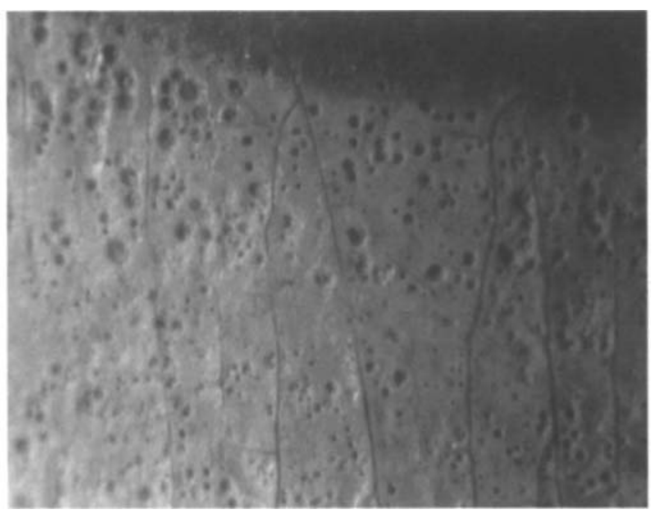


Figure 9. Photomicrograph (× 900) of UC14692 (Figure 1) showing a pitted white area of the collar (*photo: Libby Sheldon/Noëlle Streeton*)

The pitting became apparent under the microscope but is also visible to the naked eye. Its cause is, as yet, unclear. It could be that the pitting is the result of super-heating at the time of paint application, or it could be the result of Petrie heating the surface with molten paraffin wax. It would be worth questioning too whether the pitting is the result of metal-soap aggregate formation, of the sort that has been the focus of so much recent research being carried out in the Netherlands and in the UK on the deterioration of lead white and lead-based paints (Noble *et al.* 2002, Boon *et al.* 2002, Higgitt *et al.* 2003). Aggressive cleaning generally decapitates the protruding mass, which is the tell-tale sign of metal-soap formation, but depending on its solubility, some residual matter is left behind in the pits. Mechanical cleaning would have removed any protruding aggregates, if they existed at all, but as the pits seen in Figures 8 and 9 appear perfectly round and there appears to be intact residual material, FTIR (Fourier transform infrared) analysis of the pit could confirm the presence or absence of metal soaps (Noble 2004).

Returning to the issue of bloom, the third instance appears as a powdery and uneven white haze in at least one area of the garment of portrait of a woman, UC14692 (Figure 1), seen in the photomicrograph shown in Figure 10.

Suffice to say, if the various forms of bloom that currently affect the mummy portraits are indeed caused by individual solvents or by a combination of products, some basic but essential analysis using FTIR and SEM/EDX (scanning electron microscopy/energy dispersive X-ray spectroscopy) would allow conclusions to be drawn. For example, SEM/EDX analysis would determine if sulphur were present, hinting at the reformation of ammonium sulphate, which has been identified in the past on portraits UC19611 (Figure 3) and UC19610 (Petre Museum 1983a; 1991). Perhaps leached components could also be identified. The localised and isolated nature of the efflorescences points to the lack of control over solvents, and perhaps to the intermittent use of Vulpex®, but only with instrumental analysis can the consequences of cleaning these already fragile paintings be understood.

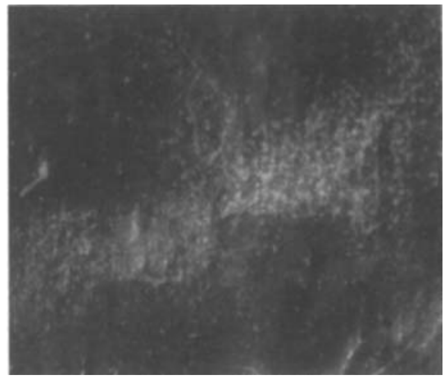


Figure 10. Photomicrograph (× 500) of UC14692 (Figure 1) showing hazy bloom (*photo: Libby Sheldon/Noëlle Streeton*)

Materials research

It must be said that this account of ancient objects, which now have 'problems' that could be directly linked to recent treatment, ought to be a sobering one for a conservator. However, looking closely at cleaning techniques and their consequences has spurred the reassessment of recent materials research, which could surely benefit emergent scholarship on the portraits. For instance, work done by Charles Tumosa, Marion Mecklenburg and their colleagues at the Smithsonian Center for Materials Research in Washington DC on oil paint films has shown that the removal of 'leachable' or volatile components would be of little consequence for film strength (Tumosa *et al.* 1999, 349). Therefore, it may be that the strength of the encaustic film is little affected by the bloom formation. However, more investigation into the specific properties and ageing of wax-based paints, which contain fewer volatile organic components than oils to begin with, would have to be carried out.

Furthermore, the analyses associated with the cleaning projects over the years have provided an inroad to complementary research on ancient painting techniques and the nature of encaustic materials themselves. In 1991–92, Marianne Odlyha at Birkbeck College, University of London, and Libby Sheldon at UCL, both of whom were actively involved in this study, were involved in a joint project and confirmed the presence of particular materials in the portrait of a woman, UC14692 (Figure 1). Odlyha, working in consultation with Raymond White and using the standard FTIR spectra established by Kühn, determined that Punic wax was the encaustic medium for the portrait (Odlyha 1992) while Sheldon carried out pigment analysis. According to contemporary notes, the range of pigments in the portraits that had been examined seems to be limited to 14. These include mineral earth pigments, such as ochres, and artificially prepared mineral compounds, such as lead white, minium and Egyptian blue. A pigment prepared from madder root was also identified (Sheldon 1992). The paint cross-section in Figure 11, which shows a sample taken by the Jaeschkes in the early 1990s from the necklace near the purple garment of portrait UC14692, shows yellow ochre, overlaying red iron oxide, overlaying Egyptian blue mixed with madder lake.

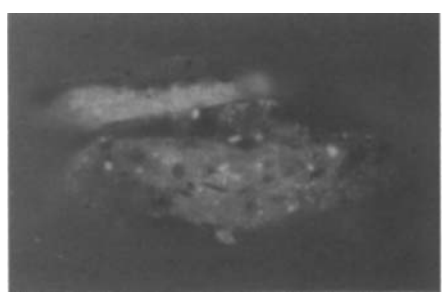


Figure 11. Cross-section, photographed in reflected light, × 200, from the garment of UC14692 (Figure 1), showing yellow ochre above red iron oxide and Egyptian blue mixed with madder lake (*photo: Libby Sheldon*)

As for the paint film itself, Sheldon determined that encaustic paint of these portraits tends to be thick and is usually composed of a number of layers containing both finely- and coarsely-ground pigment particles (Ramer 1977; Sheldon 1992). In the cross-section in Figure 12, which was taken from the neck of portrait UC14692, the paint-layer structure appears to consist of successive passages and indicates that the painter produced layers of different tones from a select number of pigments. Red layers overlay white layers that have been mixed with yellows and reds in varying proportions, which is to say that the resulting optical effect is derived either from trial and error or from an advanced knowledge of the effects of layering one colour over another.

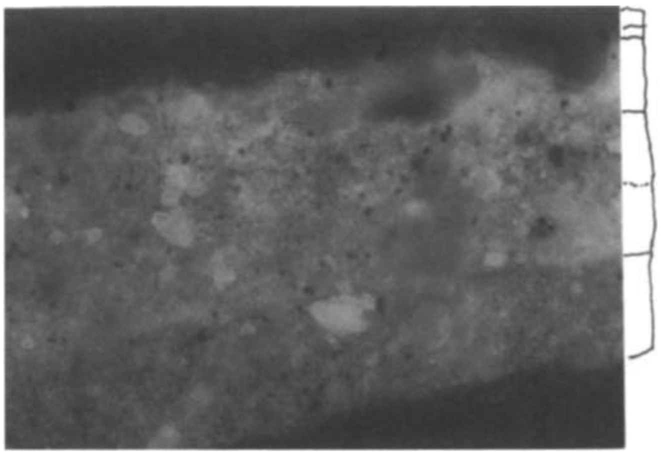


Figure 12. Cross-section, photographed in reflected light, × 500, from the neck of UC14692 (Figure 1), showing the build-up of colour (*photo: Libby Sheldon*)

Analysis of encaustic cross-sections has also provided evidence that pigments are dispersed in the emulsion and remain fixed, rather than settling as the wax cools. Because pigments appear to remain fully dispersed in the samples examined, it would be worth comparing samples taken from those portraits known to have been damaged by Petrie's 'rewaxing' or 'remelting' treatments. It would also be worth comparing the Petrie Museum portraits with recently cleaned portraits in other collections, such as the collection formerly owned by the Viennese businessman, Theodor Graf, now in Stockholm (Freccero 2000). The results might indicate whether or not the stratigraphy has been altered significantly by the application of modern paraffin wax and whether the uppermost layers have been diminished by cleaning, thereby revealing lower layers of colour that initially had been hidden.

Concluding remarks

To conclude, the mummy portraits continue to arouse immense curiosity, not simply because of what they expose about the distant past but also because of what they reveal about more recent developments in conservation practice. The cleaning projects, combined with materials analysis, have together lead to a far better understanding of cleaning methods that are safe and effective for objects of this type.

This paper has emerged from MA research at the Institute of Archaeology and is by no means exhaustive or complete. In particular, the questions that have been posed about the causes and character of recurring bloom require further investigation. Because the mummy portraits constitute the only remaining physical evidence of portraiture on panel from classical antiquity – and indeed, they are the most convincing renderings of humanity before the Renaissance portraits of van Eyck and Bellini – the long-term effects of cleaning will continue to be important.

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[1] No formal conservation records were retained from Ramer's work. His unpublished dissertation of 1977 is the primary source for information on his research and cleaning methods. The earliest conservation records on the portraits at the Petrie Museum date to the mid 1980s.

[2] The line drawing could be compared, for instance, with three portraits with intact paraffin-wax coatings at the Fitzwilliam Museum, University of Cambridge.

[3] Although the presence of any moisture from any source can cause hydrolysis, it is likely that hydrolysis would have occurred early in the history of the portraits and that the process rate would taper off over time (Mecklenberg and Tumosa 2004).

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A PILOT STUDY OF THE EFFECTS OF TRI-AMMONIUM CITRATE SOLUTIONS USED FOR SURFACE CLEANING PAINTINGS

Aviva Burnstock and Klaas Jan van den Berg[1]

Surface cleaning unvarnished paintings may have an aesthetic impact on the appearance of the painting, and the process involves direct contact with the paint surface. The method chosen for surface cleaning – and the evaluation of risks involved – makes it one of the most critical of all conservation interventions.

The choices for removal of surface dirt are influenced by the nature of the dirt or accretions to be removed, by the material and surface characteristics of the painting and its response to the chosen system for removal of the surface material. Choices for surface dirt removal from significantly aged cross linked paint bound in drying oil media typically include dry methods employing erasers, saliva, water, water at slightly elevated pH, addition of a low percentage of non-ionic surfactants and/or chelating agents.

The present study was limited to an assessment of the effects of surface cleaning unvarnished paint surfaces using tri-ammonium citrate (TAC). The choice of this reagent is based on its current widespread use by conservators for surface cleaning, since its introduction by Carlyle et al in 1990 (Carlyle 1990). This pilot study aimed to explore the potential for a wider investigation of the effects of a range of surface cleaning agents used to remove dirt from unvarnished paint surfaces, and to evaluate the risks associated with the methods. The approach combined study of the surface of samples from paintings taken before and after treatment, using light microscopy (LM), scanning electron microscopy (SEM) combined with analysis of organic materials and residues of reagents using GCMS and related techniques, to assess the effects of the reagent applied in a range of concentrations applied in a characteristic practical manner used by conservators, using a cotton wool swab for removal of surface dirt.

There are a small number of published studies that have investigated the effects of TAC and other chelating agents used for surface cleaning varnished paintings. Phenix and Burnstock (1992) proposed a combined chelating and surfactant action of TAC in dirt removal from paintings derived from data from literature from detergent industry and from two case studies of dirt removal from varnished paintings. The paper includes data on stability constants for metal ions for different chelating agents, which could be useful for selection of an appropriate agent reagent for cleaning, in particular to where specific metal ions are present in pigments that might be preferentially chelated. SEM was used to examine samples from two varnished paintings before and after surface cleaning with TAC, suggesting that this method is useful for characterizing the effects of the reagent on the varnish surface, although the effects on the paint beneath was not investigated.

Mansmann (1996) looked at the effects of TAC on unbound pigments and selected artificially aged paint films. She found that unbound lead based pigments, copper pigments, chalk gypsum and green earth changed on immersion in TAC solutions of between 1-10%, while only chalk and malachite bound in oil immersed in TAC solutions yielded their metal ions to the reagent. The chalk containing paint films exhibited both crystal formation (not further characterized) and an irreversible yellowing of the binding medium.

Hilfrich and Weser (2003) examined the effects of TAC on freshly made paint films coated with oil and found no surface changes. The authors acknowledge the likelihood that the reagent may come into contact

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with the paint via capillary penetration, although the effects on the underlying paint surface or layer structure was not investigated.

The present paper discusses the effects of cleaning of the surface of two unvarnished paintings, *Girl Cleaning a Kettle* by Frank G. Heath c.1929 and *Landscape* by Herbert Cecil Drane d. 1901. The influence of conventional cleaning tests with solutions of TAC on the surface of the paint is examined. A methodology for the analysis of residues of TAC on the surface is described and a model for possible interference of the ammonium citrate with the oil paint is presented.

Experimental

The two paintings included in the present study were undergoing treatment in the Department of Conservation and Technology at the Courtauld Institute of Art. They were selected because they provided a range of unvarnished surfaces for investigation, including well bound, porous and paint surface with smooth and impasted surface, and in both instances, the surface dirt responded to TAC in aqueous solution applied using a swab.

Solutions of TAC in distilled water in a range of concentrations from 0.5% to 10% were applied using cotton wool swabs for one minute or less, using a typical rolling motion used during cleaning by conservators. The paint surface was 'cleared' from residual citrate by swabbing with saliva.

Surfaces of samples taken from passages of paint before and after treatment were examined using SEM/SED using a Philips XL30 FEG SEM, which employs a field emission electron source, low acceleration voltage (kV) and high vacuum (10^{-9} mBar) to produce high resolution topographic images. Samples were coated with 20 nm of gold palladium (Au (80%)/Pd (20%)) using a Cressington sputter coater 208HR.

GCMS analyses were carried out on a ThermoQuest GC8000 MD800 GCMS combination, using split injection. GC conditions: ZB5 column (0,25 mm id., 0,25μm film thickness), helium carrier gas, flow 0,8-1,0 ml/min. Temperature programme: 50 °C (4 min), 6°C/min to 320°C, 320 °C for 10 min. MS: Linear quadrupole. Electron impact ionisation (70 eV); mass range m/z 45-480. Data were acquired and processed with Excalibur 1.2.
Preparation of the sample: Grind dry paint sample with reagens, sonicate for 30 min at 60 oC. Reagent: Reactasil (Aldrich): $ClSi(CH_3)_3$ / $(CH_3)_3SiNHSi(CH_3)_3$ / pyridine: 1/2/10.

Analysis of surface dirt

Dirt from the painting by H.C. Drane was characterized from cross sections using SEM/EDX and by GC-MS. Fig. 1 shows a cross-section from the foreground in incident (a) and UV (b) light highlighting the thick layer of oily and particulate dirt uppermost in the interstices of the impasted surface of the paint film. c) and d) show the SEM/BE image of the sample and e) is an EDX spectrum gathered from the dirt layer (highlighted in d). Elemental analysis was carried out on carbon coated samples embedded in polyester resin as paint cross sections, using an Oxford Instruments Inca system with JEOL S100 scanning electron microscope.

Surface dirt as analysed for the Drane painting comprises inorganic material, particles both loose and embedded in a yellowish non-drying oily material. Inorganics here indicated by elemental analysis included C, Si, Fe, Al, Ca, Pb and K. Analysis of the oily material associated with the inorganic component on this painting suggested the presence of non-drying oily material characteristic, for example of domestic cooking by products (van Keulen 2003), consistent with the location of the painting over a fireplace near the Arga stove in a private house.

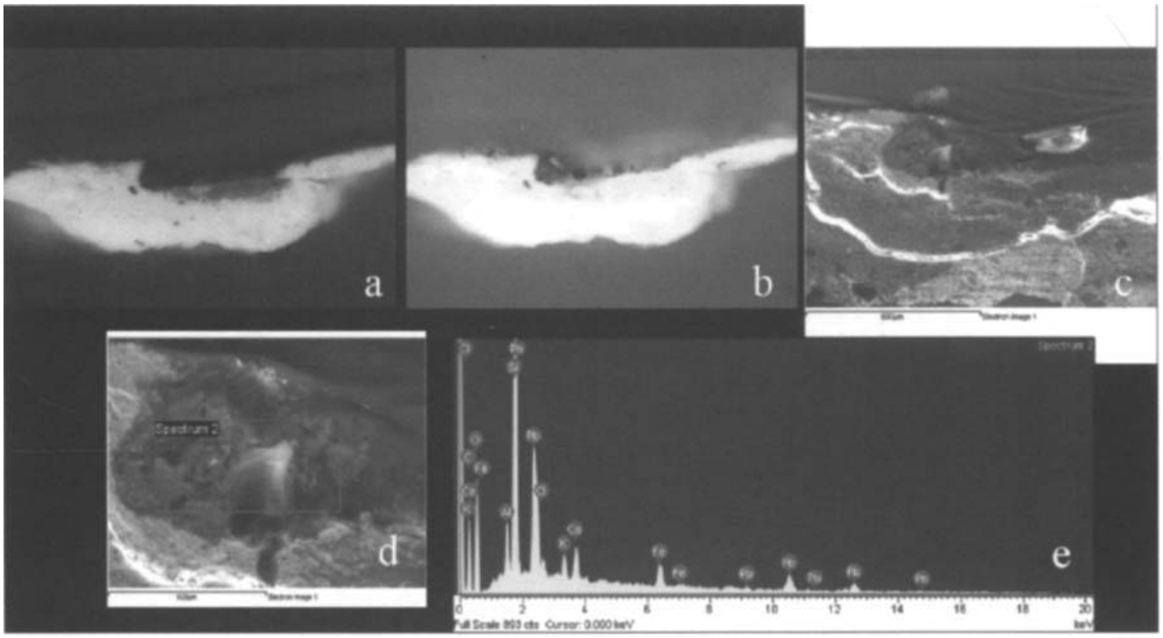

Fig.1 a-e: Characterisation of dirt from a cross section from H. C. Drane *Landscape* using LM & SEM/EDX

The elements suggest a combination of organic with inorganic materials associated with fuel- burning and iron oxide and sillicaceous particles in the local environment. The presence of lead might have an external source (such has petroleum products) or alternatively might be the result of migration of mobile ions from the oil paint. Analysis of surface dirt from other paintings, including the work by Heath included in the present study suggest that inorganic component of the dirt layer is similar for paintings made and located in domestic interiors southern England from the early part of the 20th Century to date.

Surface characterization using SEM

Fig. 2. shows SEM/SED images of samples from the well-bound pink paint from the background of F.G Heath *Girl Cleaning a Kettle*, after treatment with saliva (a, b) and 1% TAC solution (c, d). All images are magnified 650x, and are therefore comparable with light microscope images at similar magnification. Small-scale surface alterations on this scale would be just visible to the eye, and if changes were characteristic of the overall surface, the effects would be fully evident to the viewer. The surface of the sample form the area treated only with saliva illustrates the characteristic effects of this method on the dirt layer- failing to effectively remove the particulate dirt and smearing the oily dirt, with imbibed particulate material across the surface of the paint. The residual dirt is evident in both images, on the paint surface (a) and the tilted view (b) shows the dirt in a trough in the paint film. After treatment using a 1% solution of TAC, much of the dirt is removed to reveal the smooth well-bound paint film beneath. Small etched lined in the organic material on the paint surface are characteristic of surfaces cleaned using aqueous solutions in general, suggesting the small scale removal of polar material in the paint by polar solutions, effected by the mechanical swabbing of the surface (Burnstock and White 1990).

Fig.3 shows samples from leanly bound lead white and chalk in oil commercial priming from the F.G Heath painting, imaged using SEM. 3.a shows a thick layer of surface dirt that renders the very porous paint film invisible at 2500x magnification. After saliva cleaning the dirt is smeared over the surface although some loose particles are removed (3.b), and 3.c after cleaning with 1% TAC solution, that thinned, but did not remove the oily nor the particulate dirt entirely. 3.d) shows the porous commercial priming, dirt free, from a corner fold. At 15,000x magnification the unbound particles of lead (large hexagonal shaped)

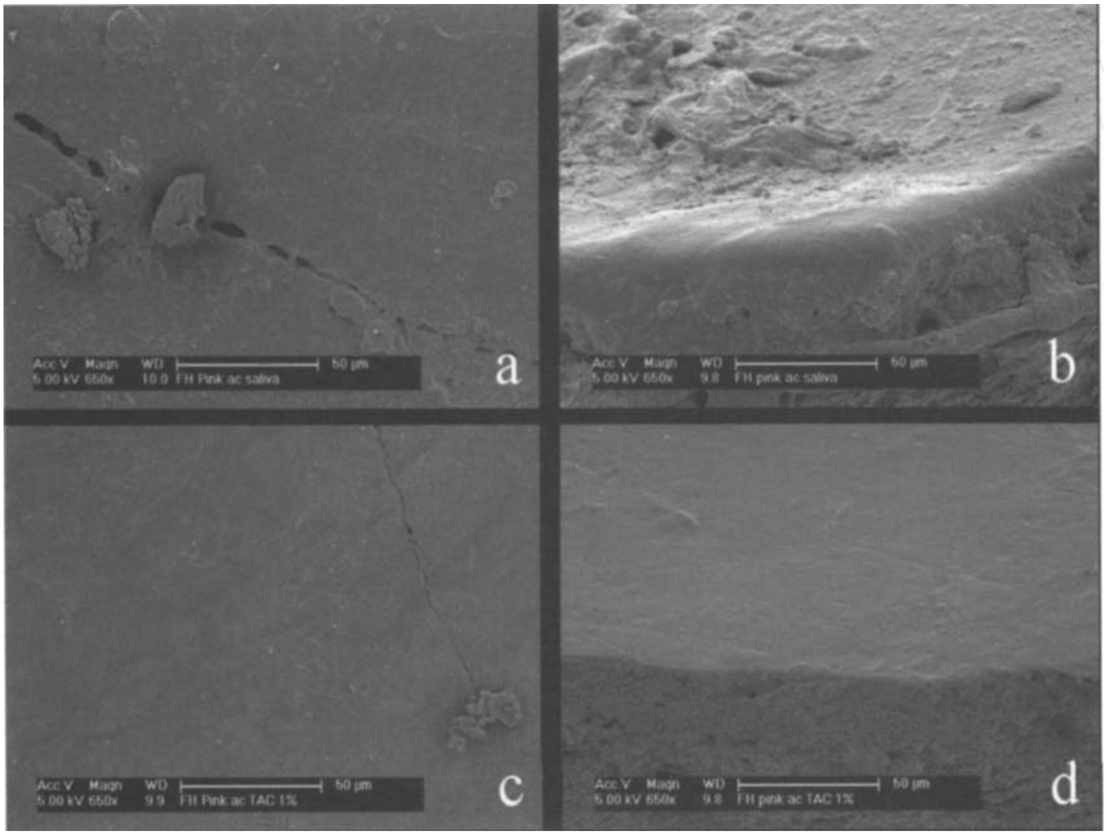

Fig.2 a-d F.G Heath *Girl cleaning a kettle*: SEM images from paint from background; well bound in oil medium, after treatment using saliva (a&b) and 1% TAC solution (c&d). All magnified 650x.

and calcium carbonate white (smaller particles) are evident. This demonstrates the porosity of the canvas that might readily absorb both dirt and cleaning reagents.

Fig. 4 are SEM images from samples taken from the H.C. Drane *Landscape* before and after surface cleaning, all magnified at 2500x. The characteristic oily particulate surface dirt is evident on the surface before cleaning in 4.a. 4b shows an image taken from an area after saliva swabbing, that shows that removed some of the loosely bound particulate dirt. A 0.75% solution of TAC wetted the surface better than saliva and removed some surface material (Fig.4.c) while a 2.5% solution removed dirt slowly but more effectively, without visible damage to the paint surface beneath (4.d). A 4% solution of TAC removed the dirt more rapidly, but the binding medium at the surface of the paint appeared to be affected by the treatment (Fig. 4.e). Use of a 10% solution of TAC (4.f) evenly removed the dirt, however the surface of the paint appeared to be etched, with removal of the organic coating over pigment particles leaving a matt surface. This is evident in the SEM images where the pigment particles are clearly visible on the paint surface after treatment using 10% TAC solution, and partly visible, in the sample after treatment using the 4% solution. In this sample the smooth material is the organic part of the paint medium at the surface that has not been removed by the reagent.

Fig. 5 is an SEM image of a sample from the porous priming from the painting by Heath after cleaning using a 10% solution of TAC. The structures on the surface are atypical of the surface of other samples from the painting after treatment, nor do these structures resemble alterations to the paint film that might be incurred by erosion of the paint that was evident in other samples. It is possible that these structures represent residual reagent, or may be the effect of residual reagent on the paint surface.

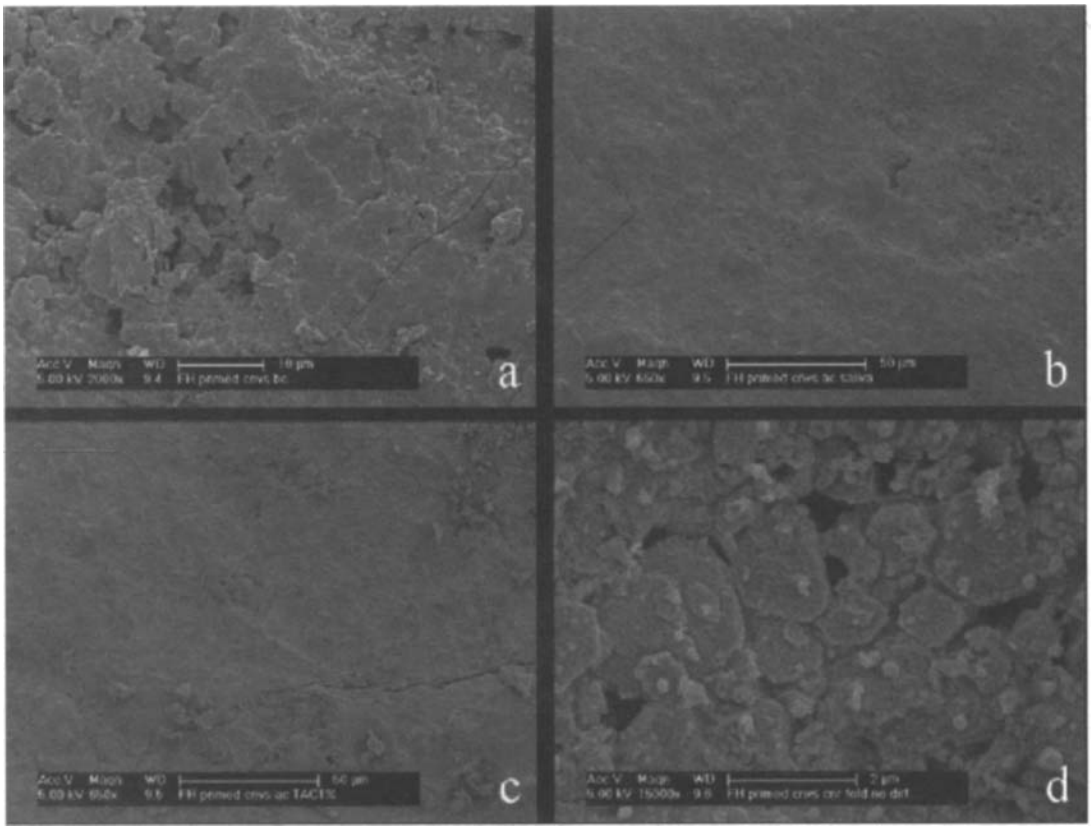

Fig.3 SEM images from samples taken from F.G. Heath *Girl cleaning a kettle*: Leanly bound lead white and chalk in oil commercial priming; a) thick layer of surface dirt over priming before cleaning 2000x, b) after saliva cleaning, 650x, c) after cleaning with 1% TAC solution 650x, d) commercial priming from a corner fold, 15000x.

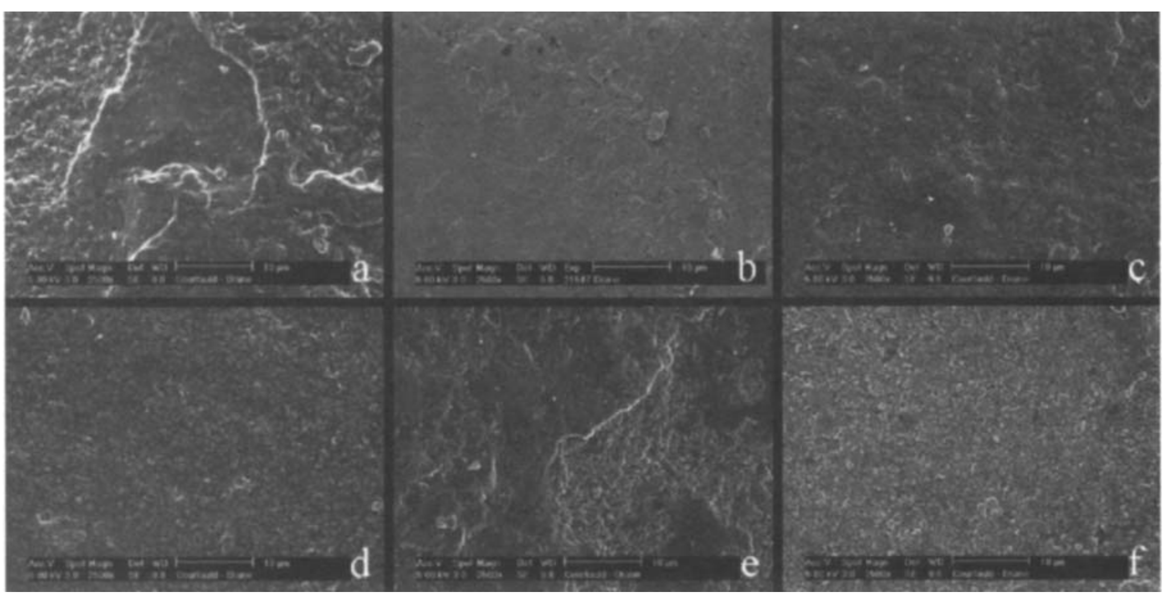

Fig. 4 SEM images from samples taken from the H.C. Drane *Landscape* before and after cleaning, all magnified at 2500x; a) surface before cleaning, b) after saliva cleaning, c) after cleaning using a 0.75% solution of TAC, d) after cleaning using a 2.5% solution of TAC, e) after cleaning using a 4% solution of TAC, f) after cleaning using a 10% solution of TAC.

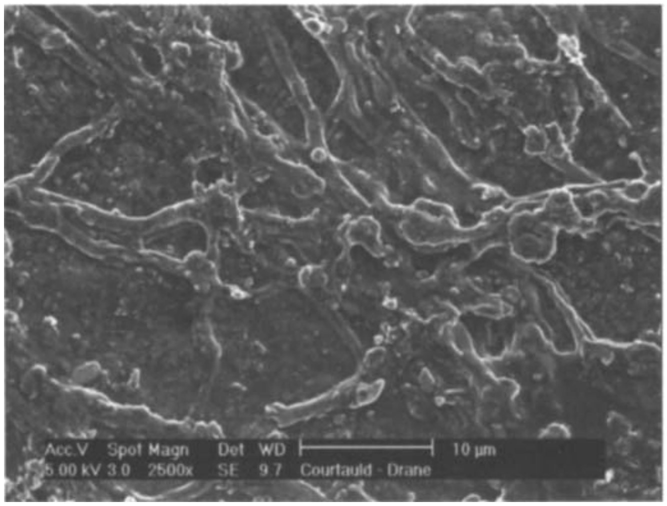

Fig. 5. SEM photograph of sample F.G. Heath *Girl cleaning a kettle*, after 10% TAC 2500x.

Analysis of residual TAC

One of the aims of the present study was to find a reliable quantitative method for detecting residual TAC in the paint after cleaning. Then it would be important to know whether the citrate is in a 'free' form, such as triammonium citrate, or in a complexed, perhaps passified form (see fig. 6). To analyze citrates in low concentration, Gas Chromatography Mass Spectrometry (GCMS) is at present the method of choice. It was established that derivatisation, regardless in what state of the citrate, with a trimethylsilylation agent proved most sensitive (See Experimental section). In fig. 7, the derivatisation reaction and the resulting mass spectrum of the trimethylsilylated citrate are presented. The spectrum is very specific for the product, and the low number of peaks especially compared to citrates derivatised with other methods such as methylation makes it specifically suited for quantitative analysis.

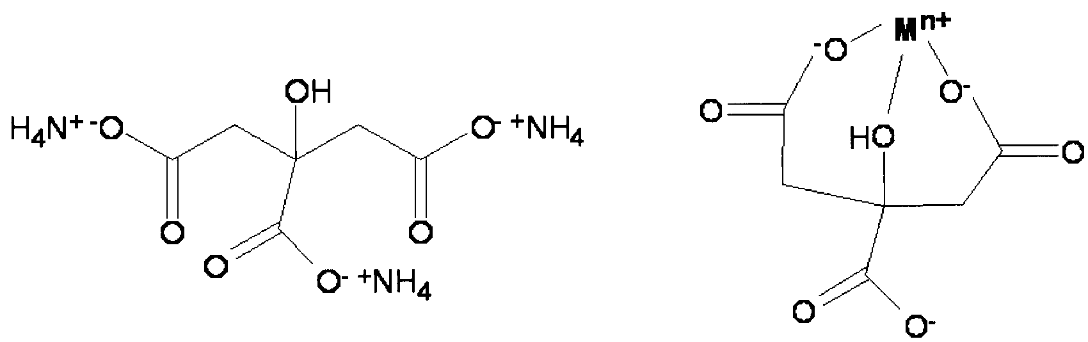

Fig. 6. Molecular structure of a) TAC and a metal complex form b).

The total ion gas chromatogram (TIC) of analysis of a mixture of TAC and lead white oil paint, for example, shows a clear peak for the citrate (Fig. 8a). If the TIC is recalculated to a single ion gas chromatogram, the signal to noise ratio of the peak of 200 results in a clear detection limit below 1 ng for a typical paint sample of about 20 µg with the present GCMS setup. As a result, citrate detection is possible on the ppb level. (Fig. 8b). Ion monitoring, a technique commonly used to obtain quantitative data in microanalyses, even leads to a higher sensitivity.

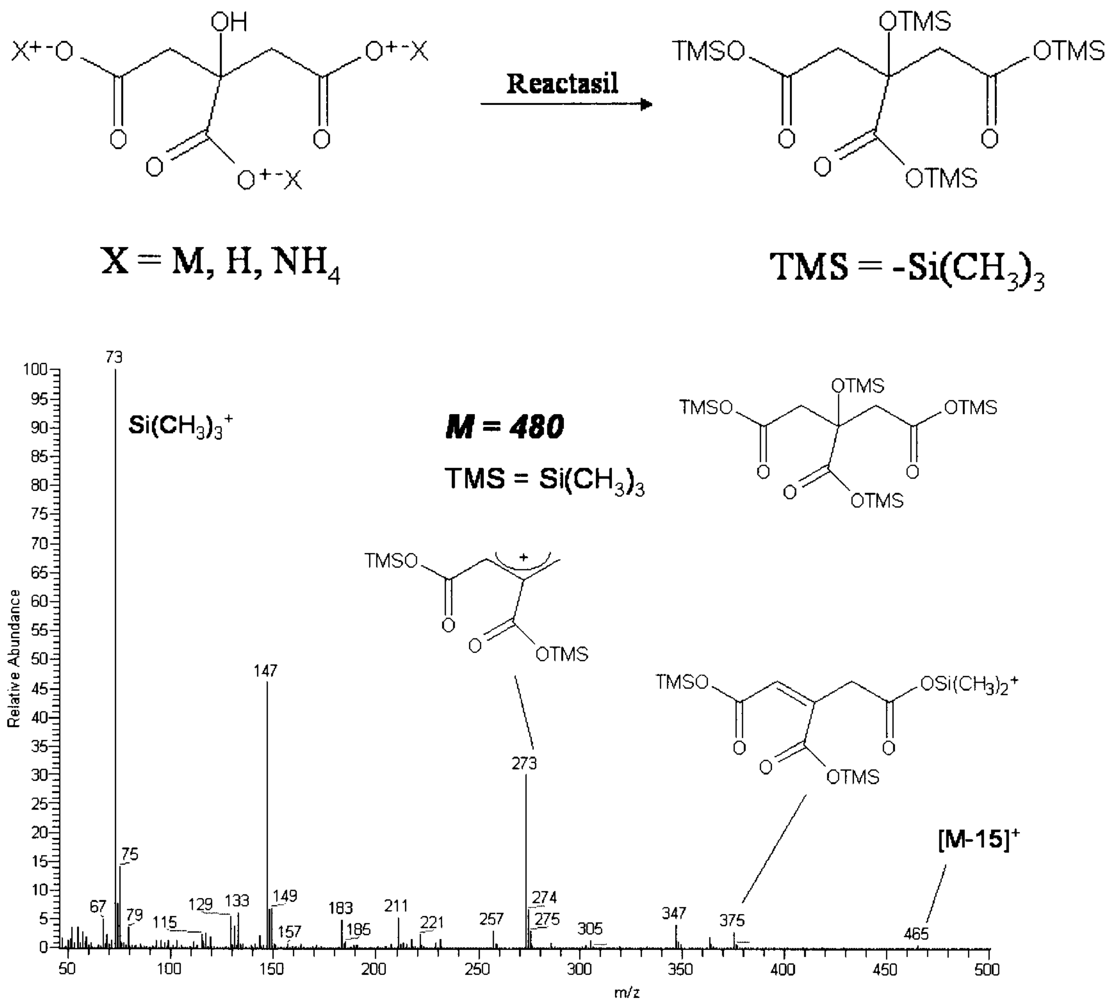

Fig. 7. a) Derivatisation reaction of citrates; b) the resulting mass spectrum of the product.

Discussion

The results of SEM/EDX studies reinforced empirical observations from cleaning studies of two unvarnished paintings from the late 19th Century, that suggest that the activity of the reagent is affected both by the composition of the dirt, and the adhesion of dirt to paint. The concentration of reagent is critical both to its activity and to the risk of surface change in paint after treatment. Metallic elements and non-drying oil characterized in the dirt layer may potentially form metal carboxylates that respond to the reagent more readily than linseed oil – bound original paint, a difference that could be exploited by conservators in criteria for selection of TAC for surface cleaning. However, the margin of safety is related to critical concentration of the reagent, with solutions of more than 5% affecting well-bound paint. Reagent application time may also be important.

Analytical pilot studies show that it is possible in principle to trace residues of TAC in or on the paint surface with GCMS in combination with trimethyl silyl derivatisation. It is difficult to establish threshold values - these also depend on the method of sample taking, the porosity of the paint and the sensitivity of the instrument. Alternative sample taking methods and analytical preparation methods may yield lower detection thresholds.

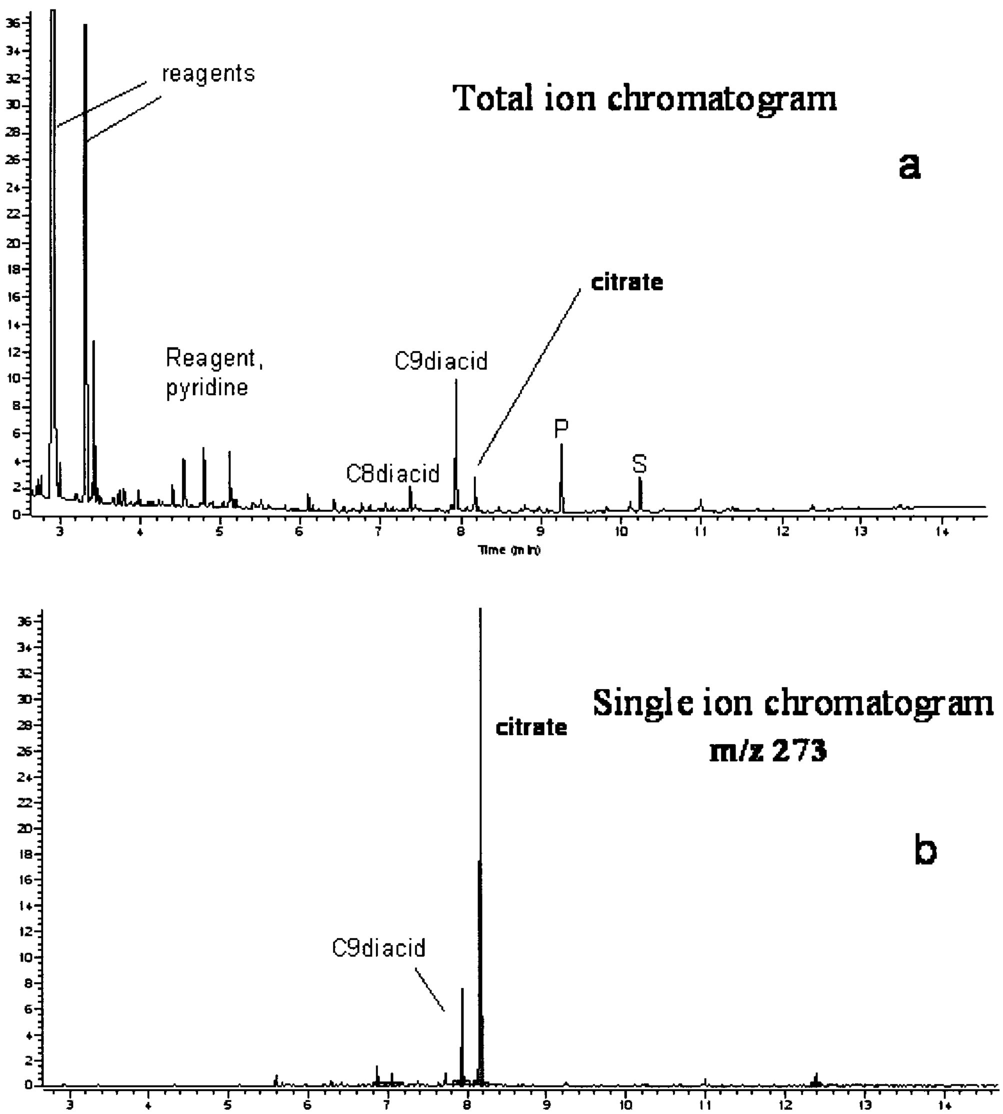

Fig. 8. Molecular structure of a) TAC and a metal complex form b).

Risk assessment based on concentrations of residue might usefully include data on the presence of free ammonium citrate and citrate that may be complexed with pigment particles. The present analytical method does not allow for distinction between free and bound citrate.

The present study focused on efficacy of a combination of surface study using (SEM and LM) combined with organic analysis using GCMS of paint treated using TAC solutions. Only one method for application of the reagent was used, that is, by swab rolling – other methods for applying reagents, such as the use of intervention layers nor other alternative methods that might reduce the mechanical action on the paint surface have not been tested, and require further study.

Future study might usefully consider the effects of the reagent at different concentrations; the effects of pH, and methods of application of the reagent for surface cleaning naturally aged unvarnished oil paint. Study should include the mode of action, clearance and potential effects of residues on paint. A comparison of the effects to other surface cleaning agents (saliva, water elevated pH, dry methods, other chelating agents) is essential for the development of criteria for evaluation the best method for surface cleaning. The potential for longer-term activity of residual chelating agents on paint might be considered.

Conclusion

Tri-ammonium citrate solutions up to 2.5% were effective in enhancing the removal of remove oily/particulate surface dirt from unvarnished paintings without visible damage to the paint surface. Higher concentrations affected the paint surface, on a micrometer scale and using 10% solutions the effects were visible by eye. Surface structures were evident on the surfaces of paint treated with high concentrations of the reagent that could be residual complexed citrate. A method for detecting residual citrate in the ppb range was developed using GCMS. The characterization of residual citrate in paint after treatment was not confirmed in the present study, and needs qualification using organic analytical techniques developed in the present study. Future studies are proposed that examine and compare other methods for applying the reagent, other chelating agents and surface cleaning agents for unvarnished paintings.
In addition, analytical techniques will be developed to distinguish between complexes of citrate and free ammonium citrates.

Acknowledgements

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THE USE OF THE ER:YAG LASER IN CLEANING PAINTED SURFACES: THEORY; APPLICATION; LABORATORY MODELS

abstract

Adele deCruz, Myron L. Wolbarsht, and Paula Bracco

An analysis of surface ablation of painted surfaces by laser exposure as part of the conservation process indicates that heat diffusion from the site of laser exposure may be minimized by proper selection of wavelength and exposure duration. A model using a laser for unwanted material has been developed taking account of the threshold phenomenon of ablation as a function of wavelength. The exposures at 2.94 µm by an Er:YAG laser with short duration pulses is compared with those from a Nd:YAG (1.064 and 532nm), CO2 (10.6 µm) and the ultraviolet excimer laser at 193 nm. Thermal diffusion is minimized by taking advantage of the large amount of heat removed by the phase change of water into steam. This model suggests that for bulk removal at strongly absorbed wavelengths, many short pulses are better than continuous exposures. The selection of the Er:YAG laser allows the use of hollow glass waveguides of high flexibility which are commercially available as delivery systems.

A cleaning method based on an Er:YAG laser system at 2.94 µm, highly absorbed by O-H bonds, was tested for removal of overpaint, varnish, and patina top-layers from various painted surfaces of laboratory paint models as well as old paintings. The purpose was to evaluate the comparative efficiency, selectivity, and safety of the laser cleaning method using various pulse energies and various OH containing wetting agents. A large number of paint models with known characteristics (type and number of layers, thickness, and composition) were prepared to simulate old master techniques. In addition, a set of diagnostic controls was designed to study the effects of the laser radiation on the surface components. The testing process consisted of morphological, optical, and chemical examination, and analyses of the effect of laser radiation of the surface components. Thereafter, the results of the testing permitted a comparison of the safety, efficiency, and the limits of penetration of the laser pulse as opposed to the use of traditional solvent-based procedures. The thresholds of safe energy were determined for each type of surface layer, including varnish and overpaint. The results confirmed the suitability of the Er:YAG laser when used by qualified and expert conservators, especially in combination with traditional chemical and mechanical cleaning methods.

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Myron L. Wolbarsht, Duke University
Paula Bracco, Opificio delle Piertre Dure

HERE WE GO 'ROUND AGAIN: CLEANING LINSEED OIL FROM CAROUSEL ANIMALS AT THE SHELBURNE MUSEUM

Richard L. Kerschner, Director of Preservation and Conservation
Nancie Ravenel, Objects Conservator

History of the Museum and the Dentzel Carousel

Shelburne Museum is an art and outdoor history museum with some of the country's finest and most diverse holdings of folk art, decorative arts, European Impressionist and American Paintings, and artifacts of everyday live in 18th and 19th century New England. The Museum was founded in 1947 by Electra Havemeyer Webb, the daughter of Louisine and H.O. Havemeyer, "The Sugar King" who was head of the American Sugar Refining Company. The Havemeyers, two of the most important and passionate collectors of the Gilded Age, amassed an extensive collection of Impressionist paintings guided by Mary Cassatt, a close friend of Mrs. Havemeyer. Young Electra truly appreciated European painting, but she was particularly drawn to American Folk Art and, to her mother's dismay, purchased her first cigar store figure for $15 at the age of 18.

"At first, Electra Webb thought that a carousel would be out of place with the historic buildings at the Museum. She decided to sleep on it and later recalled, 'I had a really wonderful dream – music playing, my husband, my children and all the grandchildren riding the merry-go-round animals, laughing and reaching for the gold ring. Laughter filled my soul and on waking, I felt refreshed and full of life and ambition and was convinced a carousel would become part of Shelburne Museum'" (Hewes and Oliver 1997, 57). This statement must be from about 1948 since a round carousel building appears in plans and models for museum expansion after that date. Around 1950, Electra purchased an outstanding carousel made by the Gustav Dentzel Carousel Company in Philadelphia in 1902. The Fonda, Johnstown and Gloversville Railroad originally commissioned this carousel for a 750-acre end-of-the-line Sacandaga Amusement Park on the Sacandaga River in Northville, N.Y. In 1907, the park had 90,000 visitors and was called the "Coney Island of the North." Around 1930, the land on which the park was located was needed to create a reservoir, and William B. Abrams purchased the carousel and moved it to his campground on the north end of Piseco Lake, near Speculator, New York. Around 1947, Mr. Abrams sold the campground land for development and the carousel was sold to a firm named Jones & Irwin, who sold it to Mrs. Webb shortly thereafter.

Dentzel Carousel Tiger

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Dentzel carousel animals are considered to the most realistic of the American carousel animals produced. In Dentzel's large workshop, several carvers worked on different parts of an animal, but the master carver of this group, Daniel Muller, usually carved the head and did much of the detailed finishing work. Muller, who trained at the Pennsylvania Academy of Fine Arts, was the most gifted of Dentzel's carvers and designed and drew the patterns for many figures (Dinger 1983). He and his brother left Dentzel's employ in 1905 to establish their own carousel company (Fried 1982). The Shelburne carousel was a three-abreast machine, which means that the animals were placed in groups of three around the platform. The menagerie included twenty-nine horses, three goats, three deer, three giraffes, a lion, a tiger, fourteen lion's head shields, and four chariots. There were also sixteen painted rounding boards and seventeen large paintings on canvas that surrounded the operating mechanism in the center of the carousel. The original carousel organ is also in Shelburne's collection. Like animals were grouped together, with the largest and fanciest animal on the outside and the smallest and plainest on the inside of the circular platform. Since the carousel moved in a counterclockwise direction, the right sides of the animals, called the "romance" side, were more highly carved and decorated. The right sides were also exposed to more light and wear from riders, so the paint is normally more degraded on the right side of the animal.

Electra Webb's intention had been to assemble and run the carousel, but the animals and painted rounding boards were originally displayed in the attic of the Stagecoach Inn. Mrs. Webb died in 1960, without seeing her dream of an operating carousel at the Shelburne Museum fulfilled. Even after Mrs. Webb's death, plans continued to reassemble the carousel. Blueprints drawn in 1962 show the carousel in a newly designed building, positioned in the center of the semi-circle created by the Circus Parade Building. Although the Circus Parade Building was completed a couple of years later, the Carousel Building was never built. Following his mother's death, Mrs. Webb's son, James Watson Webb, Jr., ran the Museum for seventeen years and did much to leave his own mark on Shelburne. In his own words, he was "cutting and polishing the diamond his mother created" (Webb 1989). Museum legend has it that Mr. Webb did not share his mother's vision of an operating carousel at Shelburne Museum. Sadly, the wood frame and platform, operating mechanism, and metal fittings were stored outside, eventually deteriorated, and were discarded. Although this was an unfortunate loss historically, the mechanism and frame did not deteriorate in vane, but were sacrificed to save the best parts of this extraordinary carousel. A unique and exciting feature of Shelburne's carousel is that all the animals, rounding boards, and paintings are in original paint. Although there are appropriate signs of wear and some smaller animals and areas such as selected hooves show evidence of overpaint, cross-section analysis confirms that none of the animals have been stripped and repainted, and the original paint is in very good condition. This is very rare for an operating carousel, since it was common practice to maintain and freshen up the animals by routinely repainting them every few years. Individual carousel animals that are not in "park paint" are difficult to find. An entire forty animal carousel in original paint like Shelburne's is extremely rare and may be unique.

In 1982, the museum director initiated efforts to fulfill Electra Webb's dream of having an operating carousel at Shelburne Museum. Had the mechanism for the Dentzel carousel been available and restorable, there would most likely have been pressure to restore the Dentzel carousel so that visitors could ride on it. This would have been the beginning of the end for the original paint, and hence, this unique assemblage of carousel art. Since using the Dentzel carousel was not an option, a smaller "carni" merry-go-round made in 1921 by the Herschel-Spillman Company in Buffalo, NY, was located and purchased. This merry-go-round was constructed to be easily assembled and disassembled so it could move with seasonal carnivals to state and county fairs. Since the Herschel-Spillman animals had been stripped and repainted with several coats of park paint long before it was purchased by the museum, these carousel animals could be maintained in the same manner. Indeed, the horses require structural repair and complete repainting about every 4 years. With these two very different carousels, Shelburne has the best of both worlds: one carousel to enjoy and preserve as a work of art, and one to use and enjoy as an historic amusement park ride. Both are quite popular with museum guests.

Caring for the Carousel Animals

Mrs. Webb was very proud of the fact that her museum was built and run by local folks. Although she consulted with museum professionals, she did not hire any. Her team did amazing, wonderful things, like moving a 220-foot double paddlewheel steamboat *Ticonderoga* two miles overland to the museum grounds. But they also took some ill-advised actions, like "feeding" the painted wooden carousel animals with a mixture of linseed oil, turpentine, and driers every year from the 1950's to the 1970's. Since the linseed oil temporarily saturated the colors when first applied, it may have temporarily improved the appearance of the animals. Not surprisingly, the linseed oil coating has darkened significantly over the past fifty years to the point that the paint colors are almost completely obscured. In some areas, the linseed oil was so thick that it is still tacky after 30+ years.

Funding Conservation Treatments

When Richard Kerschner was hired in 1983 as the first conservator at Shelburne, he realized that the conservation of the forty carousel animals would be a huge undertaking and immediately thought of the student summer work projects that were an essential part of the graduate training curriculum at the Cooperstown Graduate Program. When three animals were selected for Shelburne's first traveling exhibition sponsored by the National Gallery of Art in1985, the opportunity to begin cleaning the animals was at hand. Funding for the first three animals came from the National Gallery Exhibit project budget.

Tara Hingston Cederholm, Cary Beattie, Jennifer Baker
and Barbara McMurray Rathburn cleaning Dentzel Carousel animals.

The initial carousel animal cleanings impressed members of the museum board's Collection Committee, and a patron stepped forward to donate $5000 a year for several years to supplement the meager Conservation Department budget. This helped to fund conservation summer work projects, and from 1985 to 1987, the museum offered interested conservation graduate students a $1000 stipend plus free housing and an 8-week working "vacation" on Lake Champlain in Vermont. In 1989, an endowment was established as a memorial to Museum President Electra McDowell, granddaughter of the Museum's founder. Since Electra McDowell was a champion of the growing Education and Conservation Departments, the best way to honor her was to support an educational conservation project. Income from the endowment and continued donations honoring Mrs. McDowell have supported an average of one summer internship for conservation and one for education each year since her death. However, at that rate, it would take fifty years to clean all the animals and accoutrements.

Even though cleaning carousel animals in a prominent location on the museum grounds became a popular summer attraction for Museum visitors, efforts to start and "Adopt a Carousel Animal" campaign in the early 1990's failed to attract any donors. By 2002, Richard Kerschner's 20th year at Shelburne, ten carousel animals had been cleaned. In an effort to speed up what had clearly become a life-long project, Kerschner proposed a renewed attempt at the "Adopt a Carousel Animal" project to Executive Director Hope Alswang. She suggested that he give an entertaining presentation at the next Board meeting to solicit support. At the end of the presentation, he asked board members to help him reach a personal goal to have all the animals cleaned by the time he retired in 2016. Four board members paid $2000 each to adopt an animal, and several others have expressed interest. Now the problem is finding and scheduling interns to keep up with the demand for treatments.

Contracting work to private conservators has been considered to move this project forward faster, but the cost for a still struggling museum is prohibitive. From experience, we know that it takes about five to eight weeks for a student to clean an animal. A professional conservator could probably do the job in four weeks, but this would still cost about $10,000 per animal. It is doubtful that even one animal would have been adopted at half that price. In addition to being cost effective, the summer work projects have added benefits for Shelburne. One aspect of Shelburne's conservation mission is to serve as a training institution. The conservators at the Shelburne Museum enjoy teaching, working, and interacting with the students, and they look forward to working with new interns each summer. To date, the interns have had such good experiences that they become excellent "ambassadors" for Shelburne Museum in the wider conservation and museum community.

Removing Linseed Oil from the Carousel Animals

It is worth noting that over the past 19 years, the maintenance linseed oil has always been tacky in summer time, particularly where it is thick. Though the animals have been moved from an attic to a purpose-built structure, they have never been housed in a climate-controlled space. The conservation lab at the Shelburne Museum is moderately climate controlled, with humidifiers keeping the relative humidity in the lab around 40% in winter. In summer, humidity was not controlled in the conservation lab until an air conditioner was purchased for the space in 2002.

In the summer of 1984, Richard Kerschner performed test cleanings on one of the horses and found that acetone and a mixture of 20 parts acetone, 10 parts diacetone alcohol, and 70 parts petroleum benzine (Keck Solvent Mixture #2) would remove the linseed oil, safely exposing the original paint. However, when he attempted to remove the linseed oil layer in the lab during the winter, it would not respond to the solvent mixture or stronger solvents. In the summer of 1985, second-year Cooperstown conservation student Valerie Reich cleaned a tiger generally using acetone and an ethanol/water mixture on the more sensitive blacks. In her report, Reich surmised that the linseed oil was easily removed due to a layer of shellac between the paint and the linseed oil (Reich 1985, Hunt 2004). Although recent examinations of the tiger's painted surface indicate that it was varnished with the same material as the others, probably a spar varnish, and not shellac, no other carousel animal has been cleaned so easily to date (Fried 1987). Though retaining the varnish was not a goal of the treatment, the old varnish remains as islands in depressions in the painted surface, observable in cross sections taken from the more gently cleaned black painted areas.

A second animal, a goat, was successfully cleaned in the summer of 1986 using Keck Solvent Mixture #2 (Schopes and Newman 1986). Valerie Reich returned to Shelburne in the fall of 1987 as project conservator for the National Gallery exhibit, and began cleaning tests on a giraffe during the winter months. Kerschner and Reich both were surprised to discover that the solvents that had been used to clean two animals no longer worked. While discussing what could possibly be different from the previous cleaning situations, Reich suggested that perhaps relative humidity was a factor, since it was cold out and the heated lab was now quite dry, whereas the previous animals had been cleaned during the more humid summer months. After experimenting with a poultice of cotton wool dipped in hot water and applied to the linseed-oil covered surface for several minutes, she found that the linseed oil could be safely removed from the area pretreated with the poultice using a mixture of 15 parts acetone, 7.5 parts diacetone alcohol and 77.5 parts petroleum benzine (a 1:1 mixture of Keck solvent mixtures #1 and #2) (Walmsley 1987). It was indeed the moisture that made the difference. When Cooperstown conservation students Annette Rupprecht and Elizabeth Wamsley continued the cleaning of the giraffe the summer of 1987, they were able to remove that linseed oil coating using the same solvents without the use of the water poultice.

Certainly, the late 1980's were an interesting time for those interested in cleaning painted surfaces. Richard Wolbers started talking about altering pH, and using enzymes, emulsions, or solvent gels for breaking apart grime layers and removing undesirable surface coatings in workshops in 1987 (Wolbers 2004). Attempts to adopt some of Wolbers' concepts were made in the summer of 1988 on a prancing pinto. Reich and University of Delaware/Winterthur Museum conservation program (WUDPAC) student Catherine Anderson attempted to prolong solvent contact with the surface by applying a layer of Acryloid B72 in toluene to the romance side and allowing it to dry for 4 hours prior to removing it with an emulsion of 30% ammonia, 30% lacquer thinner, and 40% water with a little Soilax, and a small amount of Aresol OT in it (Anderson and Reich 1988a). The non-romance side was cleaned with the emulsion alone. From the treatment report, its not clear if the linseed oil on the romance side was more intractable than on the non-romance side. Reich recalls that the use of B72 as a poulticing material was more of an experiment than anything else (Hunt 2004). A deer was also cleaned that summer using the same mixture of ammonia, lacquer thinner, surfactant and water (Anderson and Reich 1988b). While this method is not advocated for health reasons, it is interesting that the technique lead to a result similar to straight solvent cleaning.

Another outgrowth of Wolbers' ideas that worked its way to Shelburne was the use of cross sectional samples to understand the layers of paint that lay under the linseed oil prior to cleaning. Although there was a research microscope with a polarizing light attachment and a separate fiber-optic light source in the conservation lab, it was not common practice to take and examine cross sections prior to cleaning painted surfaces. Speculation of the presence of toning layers was based on presence or absence of pigment in cleaning swabs. It was on furniture conservator David Bayne's arrival at Shelburne in 1991 to work on an IMS sponsored folk sculpture conservation project, that the research microscope began to be used on a regular basis. Fresh from an internship at the Winterthur Museum, Bayne routinely used cross sectional samples to examine painted surfaces. He also explored aqueous cleaning techniques. Although the conservation lab at Shelburne still did not have an ultraviolet light source for their microscope, Reich and Bayne forged a connection with the University of Vermont that allowed Shelburne conservators use of an ultraviolet microscope in one of their forensic biology labs. One important aspect of viewing cross sections under ultraviolet light is to be able to visualize the presence or absence of a varnish layer between the maintenance linseed oil and the paint layers. Often the varnish is thin or absent due to abrasion as a result of use, but when it is present, its condition or absence following a cleaning test offers a good indication as to cleaning efficacy.

Carousel animal treatment reports by Jennifer Baker, an 1992 intern from the Smithsonian Institution's Conservation Analytical Laboratory furniture conservation program, indicate just how much our cleaning toolboxes had grown. Baker and Reich examined cross sections of the painted surfaces before and after cleaning tests, and test cleaned areas were also examined under ultraviolet light. The range of materials tested grew from simple solvents and solvent mixtures to include resin soaps, solvent mixtures gelled with hydroxymethyl cellulose; solvents gelled with Carbopol and Ethameen; and lipase. Despite the wider range of options tested, a dappled horse was cleaned by swelling the linseed oil with a hot water poultice followed by a Keck Solvent Mixture #2 (Baker 1992a). A goat was also cleaned that winter. Unlike most of the other animals from the carousel, much of the goat's painted surface had developed an extensive traction crackle. Noting that, in this case, "faster solvent action is better than more abrasion due to the unevenness of surface," Baker and Reich removed the linseed oil with a resin soap consisting of abiatic acid, triethanolamine (TEA), Triton X-100, methyl cellulose and benzyl alcohol at a pH of 8.5 (Baker 1992b).

State University of New York College at Buffalo conservation program first year student Cary Beattie and WUDPAC first year student Peg Olley, summer interns in 2002 and 2003 respectively, further investigated chelating agents and aqueous cleaning techniques. Beattie substituted a 3% solution of ammonium citrate for the hot water in her poultice while Olley found that some pigments were sensitive to the ammonium citrate on the horse she cleaned (Beattie 2002, Olley 2003). Although Olley tested ethanol gelled with Carbopol and Ethameen and the ethanol gel with more water added to it, she chose to clean the horse with a warm water and muslin poultice followed by a 1:1 mixture of ethanol and Stoddard solvent. Areas of silver leaf covered with a golden varnish were cleaned with acetone due to the broken nature of the surface. Although tests using gels and chelating agents held some promise for removing the linseed oil and leaving this toning layer, there was concern about adequately clearing the surface. Both Beattie and Olley noted that cleaning became more difficult when the air conditioner, installed in 2002, was on, reducing the relative humidity in the lab.

In 2001, thanks to a grant from the Walter Cerf Foundation, the museum was able to purchase an ultraviolet light and filter attachment for the research microscope. The ready availability of an ultraviolet microscope has allowed interns working on carousel animals over the past three summers to further explore cleaning efficacy issues. Since then, cross-sectional samples have been taken prior to cleaning and following cleaning tests to more fully understand how the animal is painted and how a given cleaning solution affects the surface. As a result, more is being learned about the painting technique within the Dentzel factory.

While the carving of these animals has been attributed to Mueller, it is not known who painted this menagerie. Typically, the painted surfaces consist of a white lead primer, topped with a thin layer of colored paint. Fur was often rendered with a wet-into-wet technique, allowing for shades to be blended subtly by stippling or sponging. A base color for the saddle and bridle lies beneath any stripes present. Gilded ornamentation was executed with a silver colored metallic flake paint or silver leaf coated with a golden varnish. Prior to 2004, it was assumed that none of the animals had been overpainted except in a few areas that had received wear. In the course of cleaning two of the smaller inner-ring horses, both were found to be heavily overpainted in the saddle and bridle areas using different colors. The similarity of colors and the lack of dirt between paint layers suggests that they may have been overpainted in the Dentzel factory workshop rather than as part of a park maintenance scheme.

In 2004, summer interns continued efforts to find an appropriate aqueous cleaning method, this time guided by the Modular Cleaning Program developed by Chris Stavroudis. By mixing various stock solutions of chelating agents, buffers, and gelling agents, interns were able to quickly find methods that would remove the linseed oil and leave the original varnish. In May and June, first year Queens University conservation student Tommie Riddolls found that a gel of 250 ml. deionized water, 16 g. TEA, and 5 g. Carbopol 934, adjusted to pH 8.5 with acetic acid, followed by an acetate/TEA buffer at pH 8, then cleared with deionized water, was quite effective on a giraffe (Riddolls 2004a). In fact, he was able to clean the carousel animal in fifteen days. For the balance of his internship he was able to clean a second smaller animal, an inner-ring dappled horse, initially using the same method (Riddolls 2004b). On removal of the maintenance linseed oil Riddolls found that the varnish over the original paint was quite yellow, altering the appearance of the black and white pattern. He reduced the yellowed varnish over the white areas with ethanol on cotton swabs.

Tommy Riddolls cleaning Dentzel Carousel Giraffe.

Using a slightly stronger TEA gel (7.5% TEA as opposed to the 6.5% TEA used by Riddolls), Sandra Hons, a second year student from the University of Applied Sciences, Bern, preferred using citric acid to acetic acid as a buffer in both the gel and the free buffer (Hons 2004). She ascribed the need to increase the strength of the chelating agents to a lower humidity level in the Conservation Lab than those experienced by Riddolls earlier that summer. Generally the air conditioner is run later in the summer since July and August tend to be much warmer and more humid than June. By testing the pH of the gel while it was on the surface of the animal, Hons and Riddolls found that the pH of the cleaning gel fell to 7 as it saponified the linseed oil. Both felt that this self-neutralizing effect resulted in a highly controllable system.

Conclusions

Despite the fact that the linseed oil remains sticky where heavily applied, it seems that it is becoming more intractable as years go by. The various reports indicate that increasingly more polar solvents and water poultices have been required to remove the linseed oil even during the more humid summer season. The aqueous systems used by Riddolls and Hons to remove linseed oil from the painted surfaces of the carousel animals were self-neutralizing, had greater efficacy, and were safer from a health standpoint than the solvent systems used in the past. However, differences between the paint schemes on the animals and the environment in which the treatments are undertaken make the use of a single cleaning method undesirable. No matter what cleaning method has been used, it is not apparent to the visitor that different cleaning methods have been undertaken on the various animals.

As the work continues, more will be learned about the Dentzel carousel itself. Overpaint found on the tack on two of the smaller inner-ring horses suggests that they may have been originally carved to be part of a different carousel menagerie. Since few carousel animals remain in their original paint and fewer full carousel menageries are extant, it may never be possible to answer all the questions that careful examination of these animals may raise.

Due to reasons of funding and other museum demands on the conservation staff, removing the linseed oil from the forty-animal carousel will likely stretch over three decades. While this might seem to be a detriment as the linseed oil becomes more intractable over the years, the project has benefited over the years from the availability of a wider range of examination options and the development of a wider range of treatment options. Conservation students working on the animals benefit from the past experiences of their predecessors by reading their treatment reports and reviewing their experience working on an animal. Because of the wider range of examination options, more is learned about the carousel with each animal treated. In our opinion, these benefits certainly compensate for the detriment imposed by time.

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PERSPECTIVES ON PATINA

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Patina is a relatively thin layer that may carry baggage and issues regarding age, history, use, authenticity, value, beauty, and condition. To the mind of the public, "patina" is apparently considered to be a positive attribute. In March 2004 more than 21,900 objects on the Internet auction site eBay used the word "patina" to attract bidders. Patina is usually considered to be an attribute of metal but was used by eBay sellers to describe antlers, a bomber jacket, and even lipstick. We are all familiar with tourist reproductions on street corners or museum gift store items that are given a haze of dirt and cracks to attract buyers. The online *Art and Architecture Thesaurus,* courtesy of the Getty Art History Information Program, defines patina as "An aged appearance caused by environmental factors, acquired naturally or artificially induced; used especially with regard to a surface layer on metal caused by oxidation or corrosion."

Patina may be artificially or naturally induced. Artificially induced patina may or may not be convincing. Elizabeth Taylor was about 24 years old when she appeared in the movie *Giant* in 1956. The role called for her to age to a wise matron by the end of the film. Even at the age of ten I was amused by the artificial patina applied to the actress that appeared to be ineffectually carried out with eyebrow pencil and gray hair spray. She remained a very slender, smooth-skinned presence. However, by 2004 we have now seen the real thing: "naturally induced patina" on Elizabeth Taylor, and in retrospect the artificial patina of *Giant* appears particularly in-authentic. However, Miss Taylor may have been fighting her natural patina. On the other hand, recent photographs of Andrew Wyeth show an accepted 80+-year-old patina on a human face. Like a human face, the surface of paintings or metals is not immobile; the natural materials age and are subjected to years of reverence or abuse. (Andrew Wyeth has painted out of doors in all weathers for more than 70 years and has also weathered attacks by the art-historical establishment; his surface reflects years of exposure to his environment.)

The patina on metal may be a goal in itself or may signal danger and need for treatment. Dictionary definitions more often refer to metals; however, the use of the word "patina" to describe the corrosion layer on metal dates from only the 18th century—1751 in France. Whereas for paintings the word was used almost a century early—in 1681, in Filippo Baldinucci's art dictionary as a term used by painters to refer to a "skin" and "that universal darkening that time makes on pictures." I will focus for the rest of this paper on the patina for painted surfaces, especially paintings.

We are now well aware that part of Baldinucci's "universal darkening" may be caused by the increased translucency of oil paint films, especially when applied over dark grounds. The 19th-century literature abounds with painters such as Washington Allston trying rather poignantly to imitate this increased translucency or the general effects of time through translucent additives to his paint films—waxes, multiple inner layers of varnish, or through what Allston called "Titian's Dirt" on the surface. (This was a mixture of asphaltum, Indian red, and ultramarine plus megilp (Stoner, 1990).) The evolution of taste for dark surfaces is often evidenced by the quip from the collector Sir George Beaumont who noted, "A good picture like a good violin should be brown." Beaumont's statement reflects the conventional view that the highest achievements in painting lay in the past and were therefore visibly baptized by time. According to recipes of his era, an instant Beaumont brown was attempted through the use of beer, asphalt, coffee, soot, saffron, extract of walnut shells, licorice, or tobacco juice. William Dunlap described landscape artist Richard Wilson dispatching a porter for India ink and Spanish licorice, which he then dissolved in water and "washed half the pictures of the annual exhibition of the Society of Painters with the glaze." Benjamin West commented, "There were all the better for it" (Dunlap 1918, 2:306).

Discussion of patina has also been muddied, if you will, over the last several centuries due to the lack of clear distinction between what was applied by the artist, and what may have been applied by the so-called "patinators." Old Master paintings, and therefore paintings that were considered to have authenticity and quality, often appeared brown in the late 18th and much of the 19th century, either through peculiar added layers or the natural oxidation of simple or complex varnishes. All varnishes known until the 20th century yellowed almost immediately and then

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became more and more brown, complicated by industrial smog and the burning of gas, coal, and candles. Whistler would have his paintings cleaned by his London restorer less than a decade after they were painted. And—until the 1880s and the Impressionists—all oil paintings were generally varnished. Charles Leslie complained that his first history picture was not allowed in the 1814 British exhibition on the grounds that it was not varnished and therefore looked "unfinished" (Leslie 1860, 22).

If brown accretions were removed, whether or not the removal was judicious, controversies often followed. There have been controversies regarding the cleaning of paintings back to antiquity, well-documented controversies at the National Gallery, London in the middle of the 19th century and again in the middle of the 20th century (Keck 1984). In the first half of the 19th century, the paintings at the National Gallery, London, had been periodically coated by a "gallery varnish" of mastic resin and linseed oil causing an overall and increasing browning effect. Many British paintings conservators believe that the 19th-century controversy was essentially due to the excessive use of this "museum gravy."

It was briefly hoped that the method patented in 1863 by Dr. Max Pettenkofer of Munich would end cleaning controversies by reversing the aging of varnish through exposure to ethanol vapors. However, Sibylle Schmitt reported at the IIC Brussels Congress of 1990 that examination of 80 paintings that were documented to have been treated in 1863 by Pettenkofer or his assistant revealed increased swelling and migration of components between the varnish and paint layers, increasing the interactive zone between the two, and profoundly complicating future cleanings (Schmidt 1990). We will return below to the interactive zone.

The Burlington Magazine discussion in the 1960s again struggled with issues of "patina." Cesare Brandi characterized the polarized sides as "the upholders of radical cleaning," essentially Helmut Ruhemann and the National Gallery, London, and a group Brandi called the "partisans of patina" who sympathized with Johannes Hell. Ruhemann, in his contribution to the 1961 IIC congress, later published as *Recent Advances in Conservation*, simplified the issue noting that in his opinion

> Patina may add charm to a building or a mediocre painting but it does nothing but detract from the quality of a fine one. The equivalent of a painting covered with patina or yellow varnish, however slight, is not a sculpture with patina, but a sculpture covered with enough mud to conceal its true form (Ruhemann 1963, 202).

Ruhemann considered "patina" on paintings to be essentially a distracting and discolored coating of varnish, whereas Paul Philippot, writing in 1966, noted that in his opinion patina is the "normal" effect that time has on a material.

Philippot considers varnish to be only one element of patina, along with the craquelure, the change of refractive index, and a surface luster that is analogous to a skin--a skin that can be pierced by injudicious cleaning. Philippot co-authored with the Laura and Paolo the book on *Conservation of Wall Paintings*. In this book the Moras illustrated a cross section with patina depicted as a very real top layer that requires its own special inpainting approach when disrupted, usually with watercolors. The Moras noted "wear of the patina causes a discontinuity of the surface which alters the luster of the painting, and consequently, the depth of the tones and the spatial unity of the image" (Mora et al. 1984).

The discussion of patina did not end in the 1960s; the interdisciplinary publication *Representations* of Spring 2002 featured three articles focusing on age in paintings, all discussing "patina," by professors of English, History, Art History, and Italian studies. English professor Eileen Cleere associated John Ruskin's preference for the bright clean colors of the Pre-Raphaelites with the 19th-century movement for sanitary reform and general cleanliness [in other words a sort of aesthetic hygiene for Victorian art]. Art Historian Darcy Grigsby quoted from *Moby Dick* and Ishmael's discussion of a large oil painting, thoroughly besmoked and defaced with unaccountable masses of shades and shadows—a "boggy, soggy, squitchy picture"—in which Ishmael could imagine he saw the sublime and supernatural chaos of the Black Sea in a midnight gale. History and Italian studies professor Randolph Starn provided a lengthy and thorough history of taste for seasoned beauty in the history of paintings and ended with the happy conclusion that he feels patina is no longer the target or trump of restoration polemics (Starn 2002). He wrote that the real subject for continued discussion is "What is known and not known about the complex systems that paintings are, and the values and choices that are brought to caring for them."

Continuing Starn's thesis, I will provide thoughts first on the values and next on the choices regarding the care of the complex system of the surface of paintings, which I shall continue to call the patina using Philippot's definition.

There is much to treasure and ponder in the *Readings in Conservation* book put out by the Getty Conservation Institute in 1996. A useful jumping off point for the value of patina can be found in the GCI *Readings* translation of Alois Riegl's "The Modern Cult of Monuments: Its Essence and Its Development," first written in 1903. In his essay Riegl listed six somewhat overlapping values; patina could be considered to have all six values:

1. **Age value** is the past for its own sake. Riegl noted this if one of the few values valid for everyone without exception writing, "even the most limited peasant will be able to distinguish between an old church tower and a new one." [Riegl was clearly an elitist.] Patina, of course, excels in "age value." Riegl noted that "age value addresses the emotions directly" and is "revealed in imperfection, a tendency to dissolve shape and color," (e.g. "boggy, soggy and squitchy") "characteristics that are in complete contrast with those of modern, i.e. newly created works."

2. Riegl's **historical value** has to do with the original state of creation; distortion and disintegration are unwelcome. Symptoms of decay should be removed to expose the historical and original state. Historical value is far more concerned with preserving the most genuine document possible. But what is "genuine" patina? Ruhemann might remove all yellow varnish to preserve what he considered "genuine," whereas Philippot would contend that Riegl's concept of the "original and genuine" state of an oil painting is impossible to re-establish or even to determine objectively.

3. According to Riegl, deliberative **commemorative value** also has to do with choosing a moment in the life of the piece to commemorate—rather than returning to an original state—such as the proverbial "blood on Lincoln's shirt." In 1974, Tony Shafrazi, a young Iranian artist (and later a trendy SoHo dealer) sprayed the words "Kill Lies All" onto Picasso's *Guernica*, as a protest against U.S. action at My Lai. A Guerilla Art Action Group came to the defense of Shafrazi, arguing that he was completing, not vandalizing, the painting. If one word of this, or say a tiny part of the red paint, had been allowed to remain on the painting—and explained on a label—this could be considered a part of the patina with "commemorative value." If the label and association with the 1974 action were misplaced and forgotten, the bit of red paint would have no meaning and no value.

4. I had considered **use value** to be a record of use, such as the wear near the key hole of a blanket chest. However, according to Riegl, "use value" is whether the masterpiece or monument—especially a building such as the dome of St. Peter's—can still fulfill its original use. A blanket chest can be used with or without a patina. A painting is to be looked at; if it is as dark as Ishmael's boggy squitchy picture, it cannot actually fulfill its original use, or we could perhaps say the original artist's intent of how it is to be seen.

5. Riegl's **newness value** has great relevance to the issue of patina. Riegl considered newness value the most formidable opponent of age value: "Unbroken form and pure polychromy that can be judged by everyone, even those devoid of education," and notes patronizingly "the masses have always been pleased by everything that appeared new." However, even the highly educated viewer probably prefers to see Andy Warhol Brillo Boxes or large color field paintings without embedded or absorbed dirt in the acrylic paint surfaces. The *Grove Art Dictionary* discussion of patina mentions wall paintings, "acquiring patina naturally with age as dirt particles are incorporated into the substance of the surface. " Yet a joint research project among conservators and scientists at the Getty, Tate, and National Gallery are currently investigating how to separate that incorporated dirt from acrylic paintings, aiming to recover the newness value of contemporary art. Discolored or faded newspaper in a Duane Hanson sculpture of a housewife at her kitchen table diminishes the impact of the piece. Perhaps many pieces of Pop Art must be patina-free to function and must be returned to a state respecting their "newness value."

6. **Artistic or aesthetic value** is the last—and thorniest of Riegl's values. He essentially threw up his hands here even in 1903 and noted that the requirements of this value are less clearly formulated and never will be because they change incessantly from subject to subject and from moment to moment. He continued, "if there is no such thing as eternal artistic value but only a relative, modern one, this will be in the hands of the contemporary interpretation." This leaves us with the question, "How do we begin to make our contemporary choices with regard to the patina?"

Philippot wrote that the patina and the varnish can serve as our tools to help achieve an equilibrium most faithful to the aesthetic unity of the original image. Philippot's interpretation was seconded by Cesare Brandi writing that restoration is "a critical moment of interpretation," and that "restoration must aim to reestablish the potential unity of the work of art, as long as this is possible without producing an artistic or historical forgery and without erasing every trace of the passage of time left on the work of art" (Brandi 1963).

How do we make our choices regarding which values we wish to preserve? Everything we do is reversible, right? However, if we choose to erase some passages of time, this is not likely to be reversible. How much age value will we choose to retain while searching for the "genuine" patina or "aesthetic unity"? Are there Commemorative Values in the surface of the works we are treating? Paintings conservator Joyce Zucker has spoken of her curator at Frederic Church's home Olana requesting that she retain Church's late-19th-century retouchings of the Old Master paintings he collected. She was asked to remove only the accretions or discolorations accumulated since Church's time; 17th-century paintings were to be returned to a specified 19th-century moment as much as this is possible.

Ernst Gombrich memorably referred to conservators as "tone engineers" and reminded us that we see through the eyes of a neon and brightly colored poster society (Gombrich 1960). We know we live in a youth-oriented botox society; how do we in our interpretive moment of treatment find a place for patina and some form of age value? Paul Philippot noted that in seeking his "achievable equilibrium," . . . "the solution must be arrived at on a case-by-case basis. The cleaning of a painting [or any other painted object] can thus never be conceived of as a purely material operation and as such, 'objective'" (Philippot 1966).

How do we develop and use the subjective skills of tone engineering and respect some number of Riegl's values appropriate to our treatments—"case by case"? Some thoughts follow.

In 1985 UK conservator and scientist Gerry Hedley spoke at the Canadian Conservation Institute following his sabbatical there investigating the cleaning of paintings and updated his concepts in June 1990, with "Long Lost Relations and New Found Relativities: Issues in the Cleaning of Paintings," for the UKIC conference held jointly with art historians and published as *Appearance, Opinion, Change: Evaluating the Look of Paintings.* Hedley defined three approaches:

1. In **complete cleaning,** the aim of the technique is to remove all of the discolored varnish and other accretions from the surface of the original paint. It is a technique best exemplified by the National Gallery in London [Ruhemann] but is one that is also widespread in North America.
2. In **partial cleaning** the aim of the cleaner is to thin the varnish uniformly so that a still visible distinct yellow layer remains on the surface. This technique is common in continental Europe and is particularly theorized at the Louvre. . . . It has the dual function of harmonizing the relationships of color and space within the painting, while acting as a signifier of the age, the antique character, of the work.
2. The third technique involves cleaning the paint differentially, removing more varnish from some areas and retaining more in others, with the intention of creating a **visual balance.** Its origins, too, are in continental Europe, though in recent years it has been most associated with practice at the Metropolitan Museum [John Brealey, Hubert von Sonnenburg, both trained by Johannes Hell]. . . . Here, the restorer constantly seeks, during the cleaning, to establish a balanced set of relationships within the work.

George L. Stout gave us the concept of the "three-legged stool" for conservation. The conservator approaching decisions with a scientist on one arm and an art historian on the other. Through art-historical work we can do our best to have respect for the visual culture of the period and the visual forebears of the artists we are treating. Washington Allston wanted to be an American Titian; art-historical sources regarding Allston warn us that we need to be on guard for forms of "Titian's Dirt" or the multiple layerings of varnish applied by that artist causing "interactive zones." We can see these interactive zones more clearly with aid from our scientist collaborators. Richard Wolbers has shown us many cross sections under ultra-violet light from the layers of paintings or furniture finishes that demonstrate layers of varnish and oil profoundly linked with one another. In 1839 Allston himself denied authorship of one of his glazed works from 25 years earlier saying that the picture cleaner had totally destroyed his conception (Johns 1979, 70).

When else might we leave a yellowed varnish untouched? What if a yellowed varnish had been left on paintings where a fugitive yellow has faded leaving a still life with blue leaves. Would the resulting faux green of the leaves be acceptable? (I think most of us would find this more acceptable than applying a yellow glaze to the blue leaves.) Would this be "achievable equilibrium"? Johannes Hell felt that leaving a bit of grime in the sensuous brush stroke of a Rembrandt passage helped the viewer enjoy the brush strokes more. However yellow varnish and grime would most likely not be appropriate over the "licked" surface of a Girodet, Ingres, or David. We now have ways to "unpack" discolored and unwanted coatings layer by layer; we can now more easily choose to retain an underlying layer while removing one or several on top. And cross-sections before and after cleaning give us more detailed documentation for the next conservator to study.

How much should we inpaint to disguise age? Wood grain showing through the surface in the sky of a Van Goyen would probably be considered acceptable patina by most conservators. However, disruptions or lighter toned drying cracks in paintings that destroy our perception of the artist's deeper shadows or the delineation of the folds in a garment would probably be inpainted by most of us.

Vision and lighting conditions also affect the way we see surfaces or conceptualize patina. As we age, our vision changes, and each generation is subject to its own visual culture and relational values. Some curators are fond of saying, "Patina is defined as the thin scale that forms over the eyes of a collector." Studies tell us how complex the process of "seeing" actually is, and how it is complicated by age, eyesight, era, contrast, lighting, and, we might add, ownership. Museum conservators and lighting designers lament the fact that safe, low, light levels are especially unacceptable to the elderly eyes of the most powerful trustees. And, as Gombrich noted, the brighter palette, the strong and even loud colors to which first Impressionism and then twentieth-century paintings (not to mention posters and neon light) have inured us may have made it difficult for us to accept the quiet tonal gradations of earlier styles (Gombrich 1960).

Another important factor is, of course, contrast. In the 1980s, the curators and conservators of the Getty Museum tried not to hang recently cleaned paintings next to those needing varnish removal as the contrast might be especially jarring. They scheduled the timing for the removal of varnishes according to the proposed hanging scheme to avoid the sort of glaring contrast that was part of the cause of the National Gallery, London controversy following World War II.

Light levels and wall color may also have significant effects. Dr. Christian Wolters noted that during the rebuilding of the Alte Pinakothek in Munich, he installed dark wall coverings and "the paintings immediately appeared brighter, and he was asked whether he had cleaned them" (Wolters 1998). Steven Weintraub of Art Preservation Services of New York City has discussed changing the color temperature of lights and has given a demonstration to our students of "cleaning Vermeers" simply by changing the Kelvin readings of the lighting. The Kimbell Museum in Ft. Worth, Texas has what Weintraub feels is the optimum lighting for paintings—a midpoint between golden tungsten lighting and bluish daylight. I have rather intentionally stayed away from discussion of the Sistine Chapel, partly because the patina on fresco has other complex and sophisticated issues. However, I visited the treatment on the scaffolding in 1985 with Andrea Rothe and saw for myself what a great difference the lighting temperature made. A recently cleaned area looked blue-ish white and overcleaned until I held up my hand to create a shadow, and it looked fine. This first choices made for lighting recently cleaned areas caused an early controversy among Italian viewers; however, according to Rothe, the complaints from local Italian groups ended abruptly when the lighting temperatures were changed from the blue to the more golden tones.

In conclusion, I propose that as we work together to continue to investigate "what is known and not known about the complex systems that paintings are and the values and choices that are brought to caring for them" (Starn's quote, 2002, above), that we keep open minds, establish open dialogues, stay flexible and calm, and continue to seek new information from all possible collaborators. Artists will continue to create materials with challenging patinas [slide of Dieter Roth's 1970 self portrait bust in chocolate with birdseed was shown in the presentation] for our future conservation treatment choices.

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ILWU UNION HALL MURAL PROJECT, HONOLULU: RESTORING A MODERN FRESCO AND ITS ARCHITECTURAL SETTING

Nora Jaso Ludviksen AIA, Principal Architect
with Rogelio Bernal Fernandez, Conservator

PROJECT HISTORY

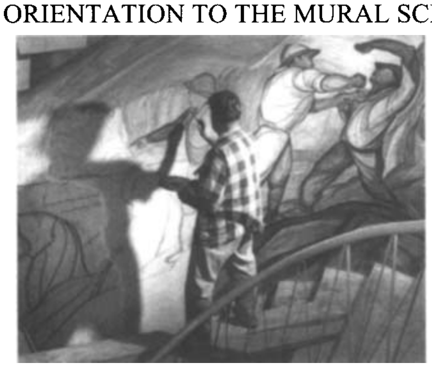
The ILWU Union Hall in Honolulu was built in 1951 following the successful sugar strike of 1948, which established a union for plantation and dockworkers in Hawai'i. The modern office building was a proud symbol of the Local's success and its forward motion, and a sign of the Union's permanence and professionalism. Designed by architect Alfred Preis, at its heart is a spectacular three-story fresco mural, "Solidaridad Sindical", painted in situ by Mexican social muralist Pablo O'Higgins, depicting the racial and labor history of the islands.

In recent decades, alterations to the modest Union Hall concealed this national artistic treasure within. Fifty years after it was built, the once-proud building had deteriorated, failing to keep up and support the purposeful work that takes place within its walls on behalf of the islands' workers. The first phase of work that the Union membership voted to support was the restoration of the mural and the renovation of public spaces around the mural. The Union established a non-profit organization, the Hawai'i Labor Heritage Council, to raise funding and conduct the restoration of the mural. In anticipating the need to protect the restored mural from damage, HLHC invited ideas from architects for a protective covering or railing for the mural. Over the years, as funds and ideas grew, the Union leadership came to see, appreciate and admire not only the international art treasure of the mural, but the elegance and utility of their building, hidden under decades of remodeling.

In the early 1990s, the Union received a Design Arts Grant from the National Endowment for the Arts and hired architects Jaso Ludviksen to begin design of the renovation of Public Spaces surrounding the mural: three levels of lobbies, meeting rooms and the mural stair itself. Working from old photographs and architectural drawings from the Union's Archives, we learned about the original configuration of the spaces that formed the setting for the mural stair.

With the design team's help, the Union leadership expanded its idea of protecting the mural from just physical protection. They realized that the mural would be protected by many measures: by restoring the architectural setting, professional lighting, adding an elevator to reduce foot traffic on the stairs and creating an educational program to expand awareness of the mural and the teaching of Hawaii's labor history. Over the years, they also recognized and appreciated anew the beauty and function of the original building and renewed their commitment to remain in the building, resisting the economic pressure of redeveloping the site.

MURAL RESTORATION AND PUBLIC SPACES PROJECT
ORIENTATION TO THE MURAL SCENES AND ARCHITECTURAL WORK



In 1950, Mexican artist Pablo O'Higgins was selected by the union to paint the mural because of his leftist leanings and profound sympathy for the working class. He spent three months traveling around the islands, sketching workers and meeting union members, discussing the mural themes. As a result, the mural reflects real life in Hawai'i in that time. O'Higgins painted the mural in true fresco ("buon fresco") style on the challenging parabolic, concave wall of the main stairway. Pigments were applied directly to wet plaster, made in "pieces"or "tareas" (giornale), frequently, but not always according to to the design's shape. The painting spirals upward three stories and dramatically beyond into a high daylighted monitor. Individual concrete steps cantilever out of the mural wall.

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Main Floor Lobby

The prominent mural section at the Main Floor shows a longshoreman on a dock in Hawai'i holding a rope that leads to the hands of a dockworker on the mainland. Between them is the blue Pacific Ocean, upon which is written the Preamble to the Union's Constitution. Below the stairs is painted the red volcanic earth of Oahu.

Architectural work:

- Removed partitions and finishes added over the years; original curving ceiling light trough found intact.
- Removed wall under the stair (required surgical and archeological skills from the demolition crew to extract stair treads and mural surfaces from the lath and plaster) revealing lost section of the mural (the Red Earth) that had been enclosed in a Janitor's closet for years.

Second Floor Lobby:

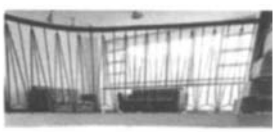
Mural depicts a powerful scene of the historic plight of sugar cane plantation workers and their families.

- Removed walls enclosing a small (added) conference room, revealing original glass block wall of office and opening Lobby and mural to the window wall.
- Restored floor opening along the windows allowing the glass to float past the floor slabs, as originally designed.

Third Floor Lobby:

A scene of the triumphant striking workers and a procession of workers and children, proudly walking upward toward the light and the future. (The stairs continue enigmatically up above the third floor, with no railing and no functional destination.)

- Removed and relocated added walls, opening the mural to the window wall and Lobby.



By recreating the original three-story window wall of the main entrance façade, we reintegrated the mural to the street and the public. This restored the relationship of the mural to the public realm as well as to the natural light.

The mural is artificially lighted by horizontal light troughs sandwiched between the floor and ceiling at each level. We restored the trough and improved the mural lighting through technological advances in lighting fixtures and acrylic lensing All architectural glass is laminated glass, which provides 99% ultraviolet light protection in the upper monitor windows and the lobby window wall. At all three floors and upon the cantilevered stairway, handrail and guardrails were modified to add a graceful reference to the cane fronds in the second floor mural. Functionally, the infill increases the code-compliance and safety of the railings.

Exterior Renovations

The urban setting for the building is far different from its beginnings and has changed dramatically in recent years with the new Convention Center next door and the renovation of the Ala Moana shopping center across the street, in a growing mid-rise apartment district. Within this vital context, the ILWU building was showing its age. The people who work there described its outward appearance as 'shameful'. In its deteriorated condition, it presented a poor public face for the Union. We completely restored the exterior, including the signature brick and mortar walls. The Union now presents a new and revived face to the public with the restoration of the main entrance façade. Restoring the glass window wall above the entry doors allows passers-by controlled views of the O'Higgins mural, opens the three-story lobbies to natural light and creates spacious public spaces for informal meeting, gathering and mural viewing.

DESIGN CONCEPT

The significance of this project centers on the mural itself, but the artwork is inextricable from its architectural setting. The mural stairway is a magnificent experiential artwork. Viewing of the mural is not a passive or static experience, but one of movement and participation. Walking up or down the stairs, you move through the art, the story and the space, ascending from dark earth and up toward sunlight.

Art is often separated from its historic context by time and place. This exceptional public artwork remains integral with the place and the purpose for which it was created. The Union mural still speaks to its members, its presence a collective conscience, always nearby while the Union conducts business, the backdrop for living negotiations.

A half-century of use and makeshift remodels damaged the mural and obscured the form and utility of the strong, sculptural building. We restored Preis' original design, most notably reintegrating the mural with the lobbies and the street, recreating the entry curtain wall. New finishes, lighting, railings, a new elevator and educational graphics and programs serve as layered protective measures for the treasured mural. A purposefully modest and practical renovation expresses ILWU's nature and members' pride of place and history.

The entire design team worked with respect and appreciation for original architect Alfred Preis' beautiful and functional modern design. The Union wanted to maintain the building's integrity and continue to offer a casual and comfortable place for members, staff and visitors. Our design approach was to be true to the character and purpose of the building and its workers.

MURAL CONSERVATION AND RESTORATION PROCESS

(This portion of the paper was written with the invaluable assistance of conservator Rogelio Bernal Fernandez of the Centro Nacional de Conservacion y Registro del Patrimonio Artistico Mueble of the Instituto Nacional de Bellas Artes, Mexico. I translated and paraphrased much of the following information from his correspondence. Statements in quotations are direct quotations of the conservator.)

After consulting with local art conservators, the Hawai'i Labor Heritage Council decided to hire Mexican fresco conservators, familiar with restoring the work of Diego Rivera and Pablo O'Higgins, to do the work. Four conservators were sent from the Centro Nacional de Conservacion y Registro del Patrimonio Artistico Mueble of the Instituto Nacional de Bellas Artes, Mexico. The Center is ruled by International Standards of Conservation and Restoration. The conservators were; Eliseo Mijangos de Jesús, Alberto González Vieyra, Rogelio Bernal Fernández, and Jacobo García Cruz. The work period ran four months, from June 25 to October 31, 2001.

Before proceeding with the conservation and restoration of the Pablo O'Higgins mural, the conservation team:

- Searched and examned historic plans, sketches and records, both in the Union archives and in Mexico. Maria O'Higgins, the artist's widow, offered access to her collection which included many studies and sketches for the mural.
- Examined the building, wall and stair structure and physical conditions which shelter the mural; checked for signs of roof leaks and wall capillarity (underground humidity absortion through the floor and lower walls).
- Observed impact of weather changes on the mural wall.
- The conservators found conditions were excellent, inside and out. The existence of 24-hour air conditioning in the lobbies had maintained uniform humidity and temperature and prevented growth of molds or other biological agents.
- Determined that there had been no previous restoration: " we started from zero , an easier way in order to justify and guarantee every single process."
- Made photographic records and diagrams of the mural
- Installed scaffolding, lighitng and climate control.

MURAL CONDITIONS

The conservators found that the causes of damage and deterioration of the mural were not from environmental or building conditions, but from "carelessness, ignorance and negligence". Before the access to the main stairs were closed to the public and the elevator was built, the stairs were one of the most common ways to access the upper floors. Frequent human contact was unavoidable, causing varied physical damage.

The conservators encountered:

- scratches, bumps, oily areas from contact with hands on the 3 lower levels
- surface erosion from constant rubbing of clothes, shoes, purses
- surface erosion from spills and cleaning products used on the stairs
- surface dust and adhered dust
- 50 years' accumulation of ambient dust, soot and cigarette smoked
- grafitti and other intentional damage
- surface compression from bumping furniture and boxes carried on the stairs
- loss of plaster and pigment at the stair level from kicks and ongoing contact of brooms, mops and vacuum cleaners

"Undoubtedly, a half century of urban soot , accumulation of dirt, grime, or cigarrete smoke residues in the walls, especially in closed public spaces , even more over rough surfaces like certain areas in the mural's plaster, dimmed its true colors."

Materials and equipment were selected and purchased in Mexico City. The conservators began with the most damaged areas first. Because of the situation where people had so much physical contact with the mural, the process of cleaning required great attention to the variety of foreign substances to be removed. The conservators experimented with different cleaning materials to find the best material and method for each condition.

The conservators did:

- an initial overall cleaning, process, using soft solvents
- spot cleaning of selected areas
- removal of floor wax residues at stair treads and walls
- removal of detergent residue, pen and pencil markings

They used different chemicals, strong enough to remove unwanted materials, but gentle and inactive to the pigment and plaster layers. The conservators estimated that the cleaning process alone restored color brilliance by 30%.

Next, individual letters of the inscription on the first floor were properly consolidated. Erosion areas and small holes next to the steps were filled up with a properly slaked lime and marble powder mixture, materials similar to the original plaster. "This was a delicate work in that again much time was required to respond to the variety of damage."

"We had the opportunity to liberate one-quarter of the mural (on the lowest level) which had been covered since the 1960s by (the wall of a janitor's closet). We also discovered that the right edge of this mural had been covered by several layers of paint. We were able to recover 100% in this zone." In this lower area (the red earth painting) there were two large areas 1.5 square meters in size (where a counter had been originally installed) that required reintegration with color to restore the unity of the mural.

Finally the "reintegration of color" on the prepared infilled areas and missing areas was performed, using a mixture of mineral pigments in a synthetic resin emulsion. Where there was minimal erosion, they used a pointilist technique. In areas of missing or infolled zones,they used the painstaking "rigattino" technique also called "divisionismo" (vibration of color based on repeated thin vertical lines), always with respect for the original paint.

MAINTENANCE

The conservators prescribed the following maintenance procatices for continuing care of the restored mural.

- Inspection by a professional conservator twice yearly.
- Training of janitorial staff in cleaning adjacent to the mural, with no water to be used.

- To prevent dust accumulation, dusting with ostrich feather duster from top to bottom, repeating the procedure without overloading the duster and without wiping the surface with an overloaded duster.
- Immediate reporting of damage or problems to the Centro Nacional de Conservacion for inspection and recommendations.
- Technical indexing and publication of the work to spread awareness of this important work of art.
- And, according to conservator Rogelio Bernal, the installation of a passenger elevator in the Union Hall Lobby was "the single most important conservation method used."

CONCLUSION

The ILWU and the Hawai'i Labor Heritage Council believe that the mural belongs to all working people and to our future generations. Its restoration and the enhancement of its setting have renewed understanding and appreciation of the mural as an important artwork and historic document of the labor movement. The Union now presents a new and revived face to the public. Restoring the glass window wall and entry allows passers-by controlled views of O'Higgins' mural, opens the three-story lobbies to natural light and creates spacious public spaces for informal meeting, gathering and mural viewing.

The renovated ILWU Local 142 Union Hall reinforces the openness and welcome of the organization, strengthens its public image and reinstates the Union's proud, visible and permanent presence in the heart of the city.

Second Story Lobby with Restored Mural

Visitors at Third Story Mural

View additional photographs of the Mural Project at www.jasoludviksen.com under the headings Workplaces and Community Places

CONSERVATION OF THE POLYCHROME CEILING AND WALL PAINTINGS AT THE SANTA MARIA DE CUEVAS MISSION

Karla Muñoz-Alcocer, Conservator of Paintings

Introduction

The Northern Mexican state of Chihuahua, located in the south border of Texas and New Mexico, includes more Spanish colonial mission sites than any other state in Mexico or the United States: to date scholars have identified 168 mission sites within its boundaries. These missions were established by Jesuit, Franciscan, and Diocesan priests over the course of the Spanish colonial period and, although some of these sites no longer include any visible evidence of their presence, over a hundred still do. Unfortunately this incomparable historical and cultural patrimony has been seriously threatened by theft and vandalism, deterioration, and damage by well-intentioned but inappropriate efforts to preserve.

Concern about the potential loss of this patrimony led the Chihuahua office of the National Institute of Anthropology and History (INAH), the federal entity entrusted with its care, to initiate a project to determine the condition of the colonial mission churches located in the rugged western portion of the State, in what is known as the Sierra Tarahumara. Between 1997 and 1999, I participated with INAH in the coordination of an interdisciplinary team to complete an inventory and conservation evaluation of 101 mission churches and the hundreds of examples of colonial art associated with them. This artwork includes, sculptures, altar screens, wall and easel paintings, and a variety of wooden architectural elements of the colonial period (doors, windows, railings) and furniture. INAH's desire to initiate projects to conserve and restore this art and architecture were stymied, however, by the lack of sufficient financial and human resources.

To begin addressing this problem, leaders of the Chihuahua business community created in 2000 a non-profit organization named *Misiones Coloniales de Chihuahua, Asociación Civil.* This non-profit has now established partnerships with the National Institute of Anthropology and History, the government of the State of Chihuahua, the Smithsonian Institution, the Catholic Church, and members of the communities where the mission sites are located to move ahead with project development. In this endeavor, it is also working closely with Mexico-North Research Network, a non-profit consortium of thirty-two U.S. and Mexican institutions that promotes collaboration on innovative projects in research, education, and outreach focused on northern Mexico and the southwestern United States.

The project of Santa Maria de Cuevas is part of a larger and more ambitious project entitled "*Una Misión para Chihuahua: Sus Misiones Coloniales*" (A Mission for Chihuahua: Its Colonial Missions). The main goals of the various programs and activities of this project are the security, research, preservation, restoration and promotion of the cultural patrimony, as well as benefits, both direct and indirect, to the communities in which the missions are located. As the title of the project indicates, its aims go beyond the conservation of monuments and works of art to also encompass the recovery of construction techniques, traditional crafts and activities, with the aim of reinforcing the cultural identity
y of the people who live at these sites, now and in the future. The project aims to establish equilibrium between the preservation of both tangible and intangible cultural wealth, without losing sight of social needs.

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The Mission

The village of Santa María de Cuevas, Chihuahua, is located in the arid foothills of northern Mexico's Sierra Madre Occidental, 60 miles southwest of the capital city of Chihuahua and 250 miles south of El Paso, Texas. It is the site of one of the most significant examples of colonial architecture in Mexico: a late seventeenth century church that has survived more or less intact. The church contains the oldest examples of colonial figurative wall paintings discovered to date in northern New Spain as well as an elaborately painted wooden ceiling that is unique in the region and all Mexico.

Figure I General view of the mission of Santa Maria de Cuevas facing East, located in the foothills of la Sierra Tarahumara, about 250 miles from El Paso, Texas. At the right, a detail of the sandstone carved façade. Note the symbol of the Virgin Mary crowned and the acronyms of Mary and Joseph.

Santa María de Cuevas was founded by the Jesuits sometime between 1651 and 1678 as a mission for Tarahumara Indians. Until the last decade of the seventeenth century, it was a mission station, or *visita*, administered by the Jesuit missionaries who successively resided at the head mission, or *cabecera*, in the town of Satebó situated fifteen miles to the east. These missionaries began the construction of the church in Santa María de Cuevas around 1678 and by 1692, the year in which Santa María de Cuevas was established as a head mission independent of Satebó, the building itself had been completed. The Sicilian Luis Mancuso was the sponsor of the mission decoration and completation.

The church consists of a single nave, a three-sided apse, a small baptistery, and a sacristy, with several notable features including a carved stone portal, cut stone architectural elements, and wall and ceiling paintings. It is flanked on the south side by an enclosed patio that formerly included the priests' living quarters. Over the centuries, rainwater filtering through the roof has damaged the ceiling, and previous modifications to the church's roof, walls, and floor have created problems of humidity and structural stress that now seriously threaten the integrity of the ceiling and the structure as a whole. Conservation actions are needed to ensure the future preservation of this church and its associated artwork.

Figure II This picture was taking in a multiple wedding around 1940's. A small antique photo exhibit and conquest was organized during the project planning, in order to obtain images of the church and people's tradition around the mission church. This shows that because of only occasional visits of the priest, multiple weddings were organized.

For more than three hundred years this church has been central to the lives of the residents of Santa María de Cuevas. Recognizing the church as the most important building of their town, they have preserved it with their own resources, most of the time unknowingly using inadequate techniques and materials. Fortunately, since the project took place, they have learned preservation techniques and have reinforced their appreciation on their heritage historical value. For all this, since their commitment to preserve their church has become stronger, they have formed a committee validated by INAH. The goal of this committee will be to protect and preserve the mission after the Conservation Implementation Project is finished.

The project

"*Mision de Santa Maria de Cuevas: Una Mision para Chihuahua*" project – administered by Misiones Coloniales de Chihuahua, A.C as a multi-disciplinary exercise, has succeeded in assembling historians, restorers, architects and other specialists to work together to gain a better understanding of the historical past of northern New Spain, through the study of this historic mission founded toward the end of the 17th century. This project was possible, thanks to a grant awarded by the J. Paul Getty Grant Program in June 2002, and for the united efforts of the local authorities and members of the community.

The Conservation Planning Project has draw upon the expertise of specialists in art and architectural conservation, archaeology, graphic design, the history of art and architecture, materials sciences, photogrammetry, Spanish colonial history, and environmental science. It also was a collaborative undertaking of a number of organizations, institutions, and individuals.

Figure III and IV. At the left, general view of the interior of the church facing the presbytery can be observed. The photo at the right, shows a detail of the construction system. Note how the tongue of the panel fits into the groove of the beam

Studies identified this late seventeenth century church as one of the most significant examples of mission architecture in Mexico. Of particular importance is its painted wooden ceiling. No other examples have been found with the same construction system, as well as painting technique: the ceiling is composed of 52 slotted beams, which support tongued, wooden tablets that are generally square in form, although not consistently equal. Within this report the ceiling is known as a tablet ceiling, referring to the name *entablado superior* given to it by an anonymous author in the 18th century (oral information contributed by Doctor Gloria Álvarez Rodríguez). The chemical and technical analyses of the painting have determined the use of gypsum plaster technique on ceiling and walls. The ceiling displays an overall floral and leaf design within which are inserted, on the longitudinal axis, large lozenges and squares containing symbols of the Litany of the Virgin. The design and the architecture follow the most strict renaissance proportions techniques.

A complete reading of the decoration of the temple was possible with the combination of studies: iconographic, design, and investigation of original wall paint in the walls. Thus it was possible to discover that in the *entablado superior* offered only a part of the story: the overpainted walls held the remainder of the narration.

Each one of the decorative elements has an iconographic significance, not only related to the Immaculate Conception, but also, geometric elements show Vitruvian theory. This theory refers to the harmony of the forms, the use of proportions and symmetry. This treatise was used by many architects and artists during the Renaissance, and was also used by the creator of this 17th century church.

This Conservation project made possible a recent and accurate documentation of the architecture, the artwork, legal land property and natural resources surveys. The chemical and technical analysis were done in collaboration with SCMRE (Smithsonian Center for Materials Research and Education), in Suitland Meryland. The results obtained by SCMRE demonstrate that the ceiling substrate was prepared using a gypsum plaster fresco-like technique over the wood and walls. The decorative layer morphology has not been completely studied, but it appears to be a more clay-enriched gypsum plaster. Since the pigment is in a distinct zone, the technique is probably similar to *fresco secco*, which is applied after the first plaster coat. Pigments and dyes were used in the decoration. Ceiling nave applied elements incorporate gold and silver leaf; however, once again, essentially no organic binder was detected. Only one sample of gold decoration had a trace amount of organic material.

In order to determine the materials, that comprise the upper tablet ceiling, as well as the wall paintings and decorations in the ceilings, 62 samples of approximately 2mm were taken, and analyzed in the laboratory. These samples were divided into various parts to be analyzed following the preferred analytical method; in this manner the organic and inorganic components present in the paint could be determined.

The ground and paint layers in the *entabaldo superior*, ceilings and wall paint in general are in good condition and follow the same characteristics. The ground is calcium sulfate or gypsum, was applied rapidly because there are big brush strokes in different directions, accumulating between the tablets and the timber strips, making a thick layer, while the finished surface remainder is applied thinly.

According to the analysis undertaken, the preparation was fresh and wet when the polychromatic paint was applied, acting as a binder. This leads us to a technique commonly known as "al fresco", nevertheless it is not possible to define it this in the true meaning of the term, because it is a calcium sulfate and not a calcium carbonate. However, SEM shows the internal structure with the features of al fresco paint. A forthcoming article will detail the analysis and interpretation.

Figures V and VI. General view of the "windows" made in the upper frieze of the nave and choir walls. Seven layers of lime and vinyl paint were found.

Paint scrapes or "windows" were undertaken in the nave, baptistery and sacristy, with the aim of determining the existence of any wall paintings. Over the years seven layers of lime and vinyl paint were applied. There original wall paint was found in the skirt area of the nave, sacristy, presbytery, narthex and choir. In addition, the windows are framed with a marbling technique. In the upper area of the nave's wall, a decorative frieze was found. There was no indication of original wall paint in the baptistery.

It is apparent that, because of its antiquity, artistic quality, and unusual method of construction, the ceiling is an extraordinary work within the context of all the art of New Spain, and it is complemented by notable pieces of religious sculpture, and easel paintings of the same period or earlier.

Parallel to the Conservation Project Planning, in November 2002, Misiones Coloniales de Chihuahua received a grant awarded by the Mexican program *Fundación para la Restauración de Bienes Muebles y Obra Artística* FOREMOBA (Fund for the Restoration of Monuments and Artworks of Federal property) from the *Consejo Nacional para la Cultura y las Artes* (CONACULTA). This fund contributed the necessary protection and work equipment, such as scaffold, ceiling tablets protection net, and materials. In addition, the fund will cover preservation actions for the historic Priest's house, since the roof was on its way to collapse. The labor was paid by the local

Figure VII. interventions in the curate with the participation of members of the community . The upper left image is the priest's house before the intervention and bottom right after restoration.

government and members of the community contributed with their time. Experts affiliated to Misiones Coloniales advised the local workers during the process that followed the traditional construction techniques.

Cleaning Treatment Proposal

The cleaning proposal treatment for the *entablado superior* of Santa Maria de Cuevas will take place in three different steps and perspectives. The proposed treatment has been discussed with members of the community of Santa Maria de Cuevas, mainly the uncovering of the original wall paint and how this could affect their use of the church. These are the following:

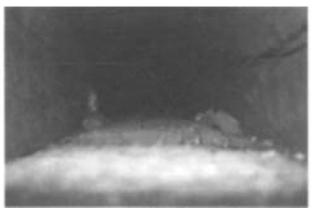


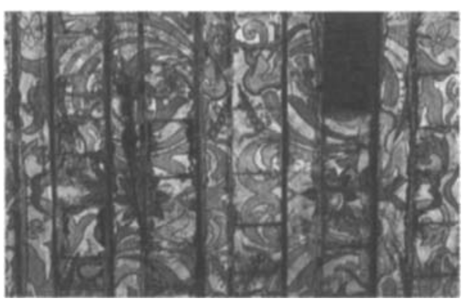
Figure VIII. Interior view from a "row" formed between two beams. There is a considerable amount of adobe material, as well as animal debris (guano, dead animals, bats, etc.) in these cavities.

1. Structural cleaning

The greatest priority will be the stabilization of loose tablets, followed by the cleaning of debris above the tablets, in the cavities below the *latillas* (wooden thin sticks that support the earthen of the roof). There is a considerable amount of adobe material, as well as animal debris (guano, dead animals, bats, etc.) in these cavities. There is only minimal access, at best to some "rows", and none in others. Some means of both access and cleaning will have to be devised.

2. Paint Layer cleaning

The cleaning of the paint layer will be minimal. Dark spots will be removed mechanically, produced by the wood resin, and humidity stain. In case, the area in general does not interrupted the reading of the design, cleaning treatment will be done. When these are disfiguring to the overall decorative schema, an appropriate cleaning solution will be determined.



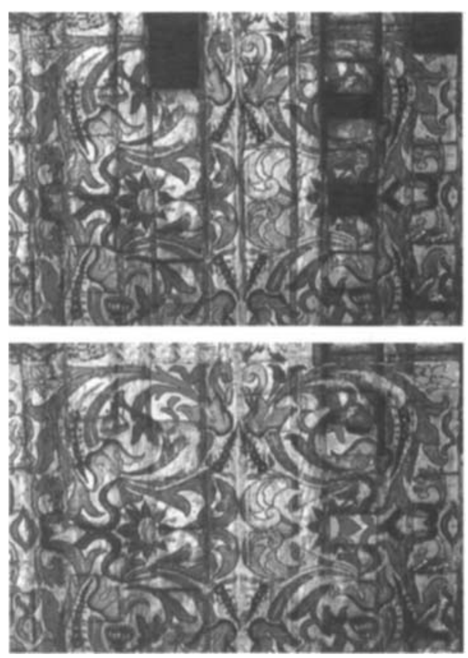


Figure IX. Botanical ornamentation from the north side of the ceiling. The left photo shows an example of dark areas that will be cleaned in order to establish the reading of the decoration. The other two photos are "digital restorations." The picture on top, panels have been put in place according to the design. The bottom photo, new painted panels have been replaced and some mimetic reintegration have been made.

3. Uncovering of the original wall paint as a cleaning process

The uncovering of wall decorative paint on the nave upper frieze, window frames, nave, narthex, presbytery and sacristy skirt area will proceed the following process:

- Documentation of the areas that will be uncovered determined realistic uncovering areas that could be done during a urgent implementation project. Though small area "windows" were uncovered during the project planning; more tests will be made in various areas with the goal of determining the total areas to be uncovered.

- Superficial cleaning of the walls with brushes to eliminate the dirtiness that is over the vinyl wall paint.

- Mechanical uncovering of the original wall paint eliminating the two layers of lime wash and three final layers of pink, blue and yellow vinyl paint. There are areas where the first lime wash application has lost its adhesion to the original wall paint; this permits easy uncovering. Conversely, there are areas that the lime wash is very well adhered to the wall painting surface. In these areas it may be found that a minimal addition of humidity applied over the yellow vinyl paint will permit a better separation of the upper layers.

Conclusions

As the investigation has progressed many elements have been uncovered that suggest that the Mission of Santa Maria de Cuevas is a treasure that stands out in the sober plains of Chihuahua. It is without a doubt a church whose creation was desired and deliberate, which is reflected in each of the architectural and decorative elements. It is possible to imagine the aspiration of its creator to construct an extraordinary and unique work in the vast territory of what was then the province of Nueva Vizcáya (New Biscay).

Figure X. Picture of the international advisory board and few members of the community. Together restoration criteria has been undertaking as well than traditional construction techniques have been thought to members of the community.

The project "Misión de Santa María de Cuevas: Una Misión para Chihuahua" would not be possible without the support of the government institutions at state and federal levels, in particular the participation of the staff at the municipal council of Dr. Belsario Domínguez, in addition to Father Ildefonso Acosta Corral, Diocese of Chihuahua, and his community. The fact that the local residents have allowed us to investigate the conservation possibilities of their unique church, has been fundamental to the preparation of the project; Their religious spirit and devotion to the church retains and renews the original sense of its creation, transcending the material wealth of the building.

The experience developed during the project planning demonstrated that conservation projects should be interdisciplinary. The community should be considered in the decision-making process: To cleaning? Not to cleaning?? Or how much?? There are questions that conservators should answer not only from the conservation guidelines perspective but also from the cultural community perspective. The conservation of an object--or as in this case--a historical monument should not be concluded without a maintenance program. I also believe that conservators, especially those that work in the field, should consider as part of the project the uniting of resources and collaborations that bring benefits to the community. These are perhaps the best guarantee of permanence of the conservation work, and of the heritage by itself.

JOHN S. SARGENT'S TRIUMPH OF RELIGION MURALS IN CONTEXT: THE RESTORATION OF SARGENT HALL AT THE BOSTON PUBLIC LIBRARY

Kate Smith Maurer*, Angela Chang*, Glenn Gates*, Teri Hensick*, Narayan Khandkar*, Philip Klausmeyer**, Kate Olivier*, Gianfranco Pocobene*

Introduction

This paper will discuss the Straus Center for Conservation's 2003-04 restoration of Sargent Hall, at the Boston Public Library (BPL), for which John Singer Sargent painted his ambitious mural cycle, *The Triumph of Religion*, between 1895 and 1919 by commission of the architects, McKim, Mead and White. The fifteen month conservation project encompassed the treatment of the sixteen murals as well as the restoration of the architectural surfaces and historic lighting of the room. The chief goal of the treatment was to re-establish the aesthetic balance between the murals and the surrounding architecture, lost due to pollution, grime and previous restoration campaigns. A 2000 AIC paper by Gianfranco Pocobene and Philip Klausmeyer presented a detailed historical discussion of the murals and their commission, as well as findings from an exploratory condition survey conducted by the Straus Center for Conservation in 1999[1]. The following builds on this earlier study and presents new findings that resulted from the treatment work.

The Condition of Sargent Hall at the Boston Public Library

The primary goal of the 2003-04 treatment was to restore Sargent Hall, approximating as closely as possible its appearance as Sargent left it in 1919. Critical to understanding the Hall was that, beyond creating sixteen murals for the room, Sargent designed the elaborate ceiling moldings, the decorative paint scheme of the ceiling and walls, and the lighting program. Supplementing natural light from three skylights, Sargent designed and installed six bronze sconces for the room. The effect of light, its direction and strength relative to different paintings in the cycle, was central to Sargent's work in the Hall and the viewer's experience of it. He further enhanced his murals by attaching over six hundred textured and gilded relief elements to the murals to create an animated gleam throughout the Hall. He envisioned the architectural space as a presentation for his paintings.

Many changes have occurred in Sargent Hall since 1919; the most notable of which was a wholesale alteration of the decorative scheme of the room that occurred as part of a 1953 restoration campaign (Fig. 1). The decorative paint was insensitively repainted without preserving color, glazing or patterning techniques. In response to public complaints about the low light levels, Sargent's lighting scheme was altered. Natural daylight from the skylights was replaced with banks of fluorescent bulbs, his sconces were rendered wall ornaments without light bulbs and additional fixtures were installed without regard for their design, location or the direction of their light. The murals themselves also suffered at the hands of well-intentioned restorers, who coated them with wax as a protective layer that eventually served to attract more soil to the surfaces. In addition to changes from human intervention, the murals deteriorated significantly from neglect and environmental pollution. The Library was ventilated through open windows and its location in a busy urban area resulted in the deposition of heavy soot, dust and grime.

2003-2004 Treatment

In November of 2003, a team of five conservators from the Straus Center, led by Gianfranco Pocobene, began to restore the murals and their surroundings. The conservators worked closely with the decorative paint firm, John Canning Studios, and the architects, Shepley, Bullfinch, Richardson and Abbott in order to make decisions about the aesthetic appearance of the Hall. Prior to beginning treatment, an advisory committee of conservators and Sargent scholars was formed to consult throughout project and encourage an open dialogue regarding treatment objectives and procedures. The committee included Ian Hodkinson, Sally Promey, Carol Troyen, Mollie Crawford Volk, and Richard Wolbers.

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**Worcester Art Museum

The mural treatment was primarily surface cleaning, wax removal and coating adjustment. There was localized flaking on two murals that had suffered previous water damage, but the paint was otherwise structurally sound and all of the canvasses, which were marouflaged to the plaster walls, were well adhered and stable. Understanding and addressing the complicated layers of surface accretions presented a number of challenges. On several of the murals, those installed below skylights, there was a discolored original coating layer. The coating's unusual material character will be discussed in more detail below. In addition, a heavy layer of soot and dust had accumulated over fifty years since the last cleaning campaign in 1953. Finally, an overall wax coating had been applied in 1940 after a cleaning campaign in order to protect the paint surfaces. This wax was discolored and had trapped grime and soot firmly onto its surface. These surface problems were compounded by the fact that Sargent often used underbound and dilute paints to achieve his desired effect. These paint films proved to be sensitive to any cleaning procedure.

The task of removing the grime-laden wax was approached with a two-step process. The wax was significantly reduced with Shell Sol 340HT® and/or Cyclosol 100® depending on the tenacity of the wax. The solvent was applied and then agitated with a hog's hair stencil brush to help dissolve the wax, which was then absorbed into cotton swabs. This left a frosty looking surface due to residual grime left behind in a film. A second step applied an aqueous 2% trisodium citrate solution to remove the grime (Fig. 2). This solution included 1% of a non-ionic surfactant, Pluronic L64®, to assist in dissolving the grime layers. Use of this surfactant in the cleaning solution was eventually discontinued as it did not significantly add to the cleaning process. In some areas, an thick emulsion of five parts 2% trisodium citrate, three parts Shell Sol 340HT® and 1 part Pluronic L64® was used on textured paint or particularly tenacious grime. Many paint passages were very sensitive to either water or solvent or both and often not all the grime and wax could be removed because the paint surface could not tolerate extended exposure to any solution.

Investigation of an Original Coating Layer

In the 1999 examination, an original coating layer was discovered in cross-sections from murals located directly below the skylights. Questions about the discolored coating's purpose and composition prompted a thorough analysis to characterize it. The material fluoresced a milky white in ultraviolet light and did not appear to be a traditional varnish. Triphenyltetrazolium chloride staining of cross-sections, performed by Philip Klausmeyer, yeilded positive results for carbohydrates in the coating layer. In 2003, Fourier-Transform Infrared Spectroscopy confirmed the presence of a carbohydrate, and also indicated the possible presence of a copal resin/drying oil mixture. Using a Gas Chromatography-Mass Spectrometry procedure developed at the Getty Conservation Institute, Glenn Gates, identified the carbohydrate component as carageenan and honey. A detailed discussion of this procedure and its findings was published by Dr. Gates in the Research and Technical Studies postprints from the 2004 AIC Conference[3]. Further analysis is currently being conducted at the Straus Center for Conservation to determine the identity of the other major components of the coating.

A critical fact about the coating was that the artist had applied it. Finishing touches of original paint were clearly applied over the coating layer. On several murals, drips of this coating material that had run down the paint surface and pooled on the cornice below the canvas indicated that it was applied after the murals were installed, possibly in response to conditions in the Hall.

The BPL's only record of a surface coating on the murals was in a 1924 letter to the library director from H.E. Thompson, the restorer from the Museum of Fine Arts, Boston, who had restored one of the murals after an act of vandalism[4]. Thompson assured the director that the mural, "was not seriously damaged" because it "was protected by a coat of 'flatting' material applied to reduce or eliminate gloss of the paint." He mentioned that he removed the varnish and the ink with it, and then replaced the coating. The letter did not describe the nature of the coating or the means by which it was removed. An artist's manual by Kurt Welte noted that flatting varnishes are generally oil varnishes, usually copal, and were lightly abraded to produce a "silky sheen"[5]. If Sargent's coating were indeed a flatting varnish, the location of the coated murals below the skylights might suggest that it was applied to matte down the painted surfaces and reduce glare.

The coating layer presented a treatment dilemma. While it was an original material, its discolored appearance contrasted with adjacent uncoated murals. After testing and discussion, it was decided to reduce the coating material during surface cleaning as it was water soluble. Any finishing paint strokes on top of the coating were noted and avoided during this step to prevent undermining them.

Varnishing the Murals

Another important issue in the treatment was whether or not to apply a protective layer of varnish on the murals. There were several arguments for doing so. First, removing the waxy coating left some weathered, frosty-looking passages that needed to be resaturated. In addition to aesthetic problems, there was the issue of protection that a varnish coating would provide. Unvarnished, the paintings would have been vulnerable to further accumulations of dirt and future cleaning campaigns, particularly as the paint was frequently underbound and sensitive. Sargent had not varnished the murals with a traditional resin varnish and he clearly wanted the murals to have a matte appearance. The murals needed to be resaturated and consolidated without significantly increasing gloss. The difficulty in applying a varnish was the irreversibility of the procedure. Sargent's paints were in many cases so porous that the applied resin could not be removed in the future without causing damage to the murals. However, it was decided that the protection provided by a stable resin application outweighed the difficulty of reversibility. After testing an array of resins in various concentrations and considering the eventual historic lighting in the Hall and its effect on surface gloss, it was decided to brush apply a 4% solution of B-72 in Cyclosol 100, cutting around the applied relief elements. This successfully saturated areas of weathered and frosty paint without increasing gloss. Tests indicate that the most fragile pigments now hold up to cleaning solutions.

Reassessing the condition of the murals based on new evidence

Over the course of treatment, archival research and continuing analysis altered and refined many earlier assumptions about the state of the murals. Until the 2003-4 conservation treatment, public opinion, based on published criticism, held that several murals had in fact been irreversibly ruined during the1953 cleaning. This has turned out to be a significant exaggeration. What was previously interpreted as damage was in many cases reassessed as artist's technique.

A lack of documentation left many unanswered questions about the materials and techniques used to clean the murals in past restorations. The presence of a wax layer on the murals was previously surmised to be a residue from a highly alkaline wax emulsion that might have been used in the 1953 restoration. However, newly discovered correspondence[6] suggested that the wax was intentionally applied as a protective coating over a decade earlier in 1940. The Boston Arts Commission, which directed the work, recommended coating the paintings with "some preparation of wax...(that)... would make the removal of dust and dirt...very much easier in future while protecting the paintings against damage." A 1938 letter from Arcadius Lyon to the Library director stated that the murals were cleaned in the 1920s with Castile soap and water, and he recommended that this procedure be repeated in 1940[7]. Apparently these cleanings were very cursory: a good deal of grime was left behind under the applied wax coating.

In 1977, Ives Gammell, an art critic and teacher, publicly deplored the 1953 treatment, declaring it had damaged the murals "beyond all possible repair.[8]" He stated that the restorers had removed paint and gold leaf and, by neglecting to varnish the murals, had allowed their pigments to "continue to powder off" so that "more of the decoration is disappearing." Gammell also referred to archival images taken of the paintings at the time of their installation in the hopes that Sargent's original "sense of splendor" could be recaptured through them. Current understanding of black and white photographs from the late 19th century suggests that Gammell may have misinterpreted the visual evidence. The spectral sensitivity of film emulsion from that time was imperfect and tended to be "blue-sensitive", rendering blue tones very bright white and red tones overly dark[9]. This imbalance distorted a true perception of contrast and strength of line in the images of the murals, particularly as Sargent made frequent use of a red paint to outline compositional elements. Using these photographs to assess modern condition could contribute to a misunderstanding of the degree of damage done and it seems that Gammell could have done just that.

Some of the assumptions made by the Straus Center conservators at the time of the 1999 study with regard to the level of damage present were re-evaluated during the course of treatment. Initially, the abraded appearance of many paint passages seemed to confirm Gammell's worst fears. In many places, the canvas weave was clearly visible as a white pattern and there appeared to be a great deal of abrasion and loss in glaze layers throughout the Hall. Sargent's underbound paints combined with the possible use of an alkaline cleaning solution in 1953, suggested that previous restorers had "scrubbed" the murals. The new evidence regarding the wax coating indicated that it had been applied nearly a decade before this cleaning. Therefore, the retention of the wax layer and the grime residues trapped beneath it signifies that the 1953 campaign was not the cause of all the abrasion and thinness. In fact, it became clear over time that much of the abraded appearance of the paint was not damage, but the result of Sargent's very dilute paint application that sank into the canvas interstices, exposing the weave. Plaster reliefs originally applied over painted canvas that were removed for treatment revealed that never-before exposed paint surfaces were identical to the exposed paint surfaces adjacent to them: both appear "abraded" (Fig. 3). In addition, archival photographs, carefully interpreted with an understanding of their limitations, revealed that a certain amount of damage was incurred during installation and was tolerated by Sargent. A photograph of one of the murals taken just before installation showed a yet unsigned, intact mural. A second photograph taken just after the painting was installed revealed significant abrasion and a scrubbed appearance in the dark glazes. The mural was signed in this second image, indicating that Sargent saw and was willing to accept this level of damage.

Re-Glazing *Frieze of Prophets*

A primary goal of this restoration project was to re-establish the aesthetic balance between the murals and their surroundings. A dramatic example of this effort was the reglazing of a gilded background on *Frieze of Prophets*. When first installed in 1895, the background of the frieze was painted a neutral gray. In 1903, during while installing murals at the opposite end of the Hall, Sargent decided to gild over the background behind the prophets on either side of the central figure of Moses (Fig. 4). Comparison with archival photographs from 1916 of the mural revealed that the appearance of the gold in 2003 was not correct (Fig. 5). The gilded background must have been glazed originally, because in the photograph it was much less reflective that the gold cornice above it. There was no evidence of a glaze layer on the gold in 2003, and it was surmised that it was removed during a past treatment. The reflective, untoned gold background minimized the prominence of the tablets held by Moses at the center of the frieze and cast the prophets on either side into strong silhouette against a very bright background.

After consulting with the advisory committee, the conservation team decided to reglaze the two gilded panels in order to reestablish the original balance of the frieze. The color and texture of the glaze was matched to that of an original glaze layer on the base of the frieze. The gilded panels now recede from the center, the cornice is distinct from the mural, and the tablets have regained their central status (Fig. 6).

Reinstating Sargent's Original Decorative Paint

Restoring the decorative paint in Sargent Hall proved very successful and was one of the most satisfying parts of the finished project. Conservators from the Straus Center served as consultants to Building Conservation Associates, an architectural preservation firm as well as the decorative painting firm to determine the original paint colors in Sargent Hall. Samples were taken from the walls, later additions of paint were removed with solvent and colorimetric tests were performed on the exposed original surfaces. More solvent exposures were opened up directly on the walls down to the original layers to determine patterning and color. Archival photographs of the Hall taken during and after Sargent's installation phases proved invaluable in determining the original appearance of the paint. The 1916 photographs documented the paint just after it was applied and clearly showed that the 1953 campaign had altered the patterning of the ceiling by covering a sponged and glazed paint with a single flat tone. The restored paint applied in 2003 returned the estimated warmer tones and variable patterning, reintegrating the murals back into the fabric of the architecture (Fig. 7).

To reinstate Sargent's original lighting scheme, the light fixtures added in 1953 were removed, Sargent's sconces were rewired and illuminated, the skylights were reopened to allow natural daylight into the room. The overall effect is mysterious and somewhat dim. The daylight entering the Hall varies with the seasons, the weather and the time of day, creating an ever-shifting impression of the mural cycle (Fig. 8).

Conclusion

The visual relationships established by Sargent within the architectural space have been reinstated as closely as possible to their appearance in 1919 when he installed his final murals. However, when Sargent stopped work in the room, there were already imbalances between murals and the decorative paint surfaces. Images from 1919 when Sargent last touched the Hall, shows how sooty and black the walls had already become in just three years since the decorative paint had been applied. Was Sargent aware of the differences caused by time and pollution as he installed murals in both 1916 and 1919? If so, was he concerned? Did he selectively coat his later murals in response to these imbalances or was it simply an issue of light and reflectance? These questions may never be answered. However, as a result of this treatment campaign, the murals are greatly improved by cleaning, better protected against future grime and treatment by varnishing and new air filtration in the Hall and are surrounded by an excellent approximation of their original environment. In addition, a great deal of information was gained about Sargent's innovative techniques on this, his first and most ambitious, mural cycle.

Endnotes

1. Klausmeyer, Philip, and Gianfranco Pocobene. "Resurrecting John Singer Sargent's 'Triumph of Religion' at the Boston Public Library: Issues for Future Conservation Treatment." *Papers Presented at the Twenty-Eighth Annual Meeting of the American Institute for the Conservation of Historic and Artistic Works*. Philadelphia, Pennsylvania. Comp. Jill Whitten. June 8–13, 2000, pp. 27–43

2. Pluronics®, manufactured by BASF, are a series of surfactants with a range of hydrophile lipophile balance numbers that consist of block co-polymers of ethylene oxide and propylene oxide.

3. Glenn Gates, Angela Chang, Narayan Khandekar, Kate Smith Maurer, Gianfranco Pocobene, Ruxandra Stoicescu, Philip Klausmeyer, "The Identification of Carbohdrates Used by John Singer Sargent for the Triumph of Religion Mural Cycle." The American Institute for Conservation of Historic and Artistic Works Research and Technical Studies Group, 13 June 2004 Session Publication.

4. Letter from H.E. Thompson, February 25, 1924, Boston Public Library Rare Books Collection.

5. Wehlte, Kurt. *The Materials and Techniques of Painting*. Trans. Ursus Dix. New York: Van Nostrand Reinhold, 1975.

6. Letter from W.G. Constable to Robert P. Bellows, Esq., April 22, 1938, Boston Public Library Rare Books Collection.

7. Letter from R. Arcadius Lyon to Edward W. Forbes, November 9, 1938, Boston Public Library Rare Books Collection.

8. Gammell, R. H. Ives. "A Masterpiece Dishonored." *Classical America* 4 (1977): 47–53.

9. Personal communication, Erin Murphy, 2003.

Figure 1. Sargent Hall, northeast view, 1999 photo, before restoration.

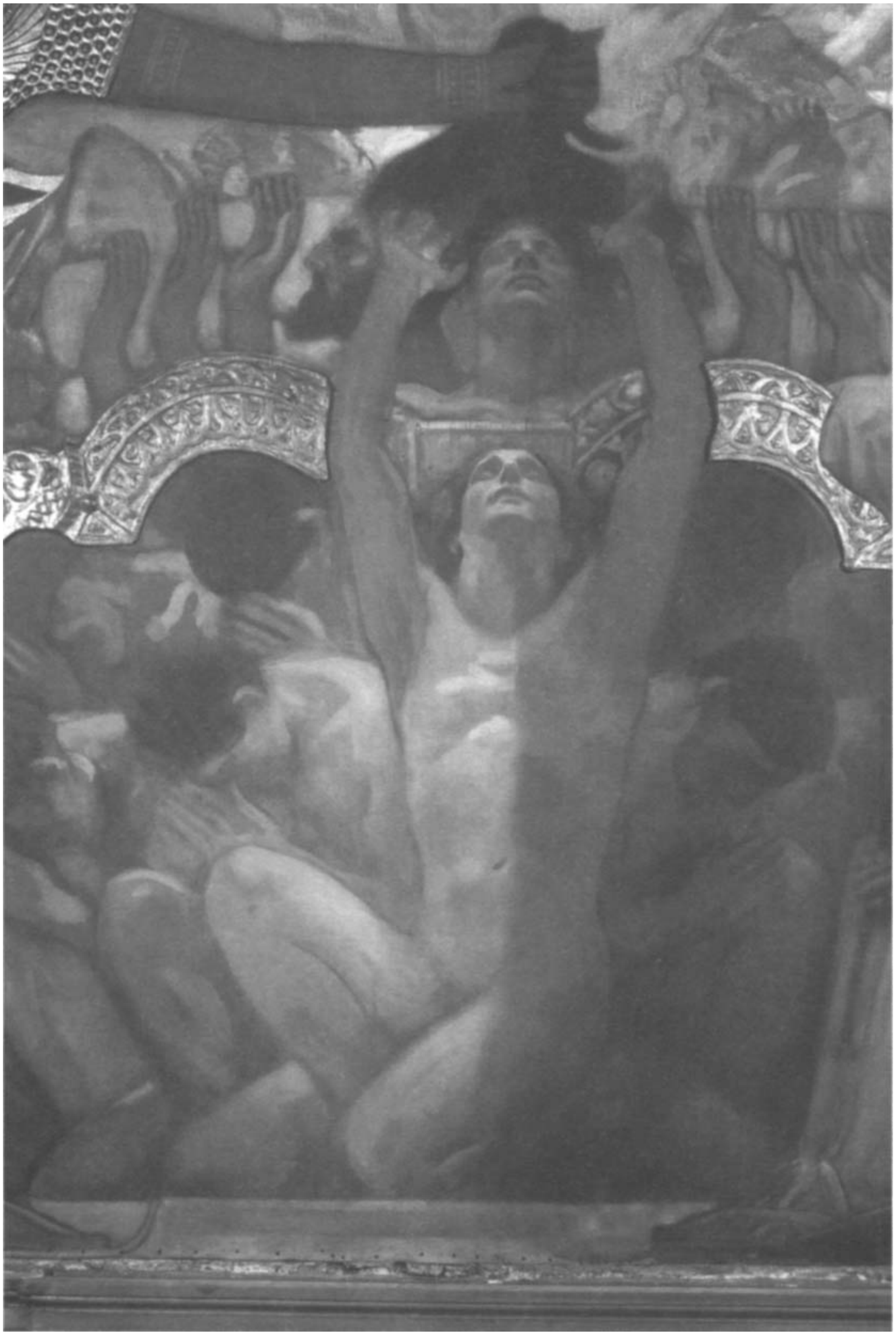


Figure 2. *Israelites Oppressed*, detail of central figure during cleaning.

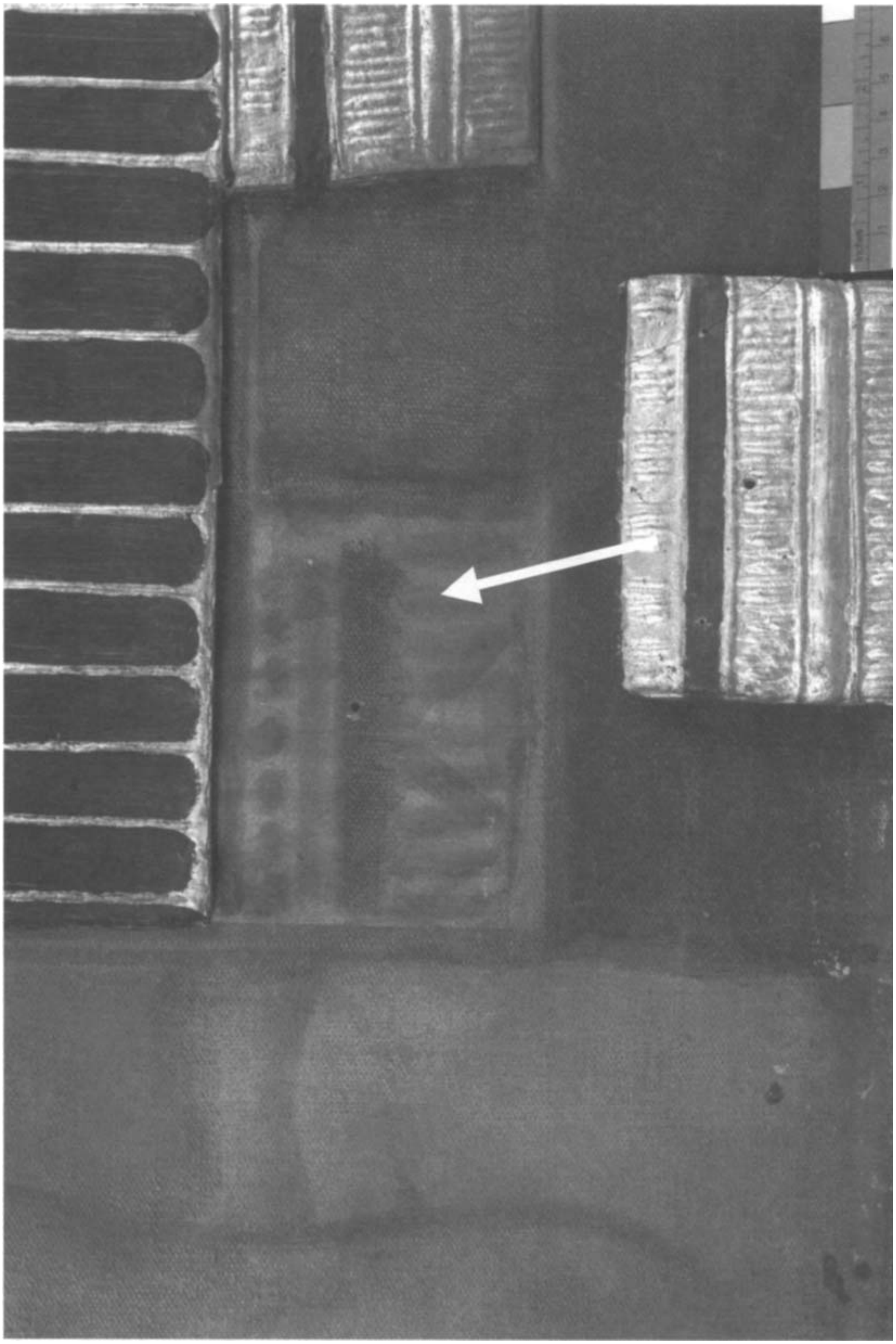


Figure 3. *Israelites Oppressed*, detail of gilded plaster relief removed to reveal original paint below (view horizontally).

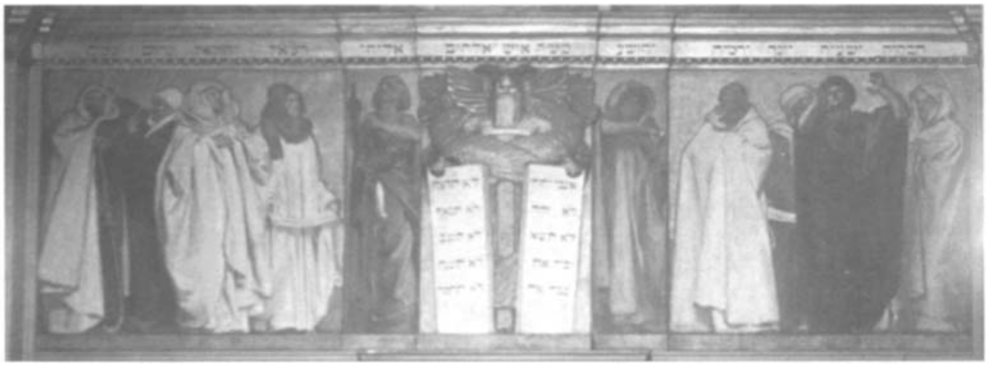


Figure 4. *Frieze of Prophets*, 1919 photograph. The two side panels of the frieze are gilded and toned. Photograph courtesy of the Boston Public Library.

Figure 5. *Frieze of Prophets*, detail of center, before reglazing, 2003 photograph.

Figure 6. *Frieze of Prophets*, detail of center, after reglazing, 2003 photograph.

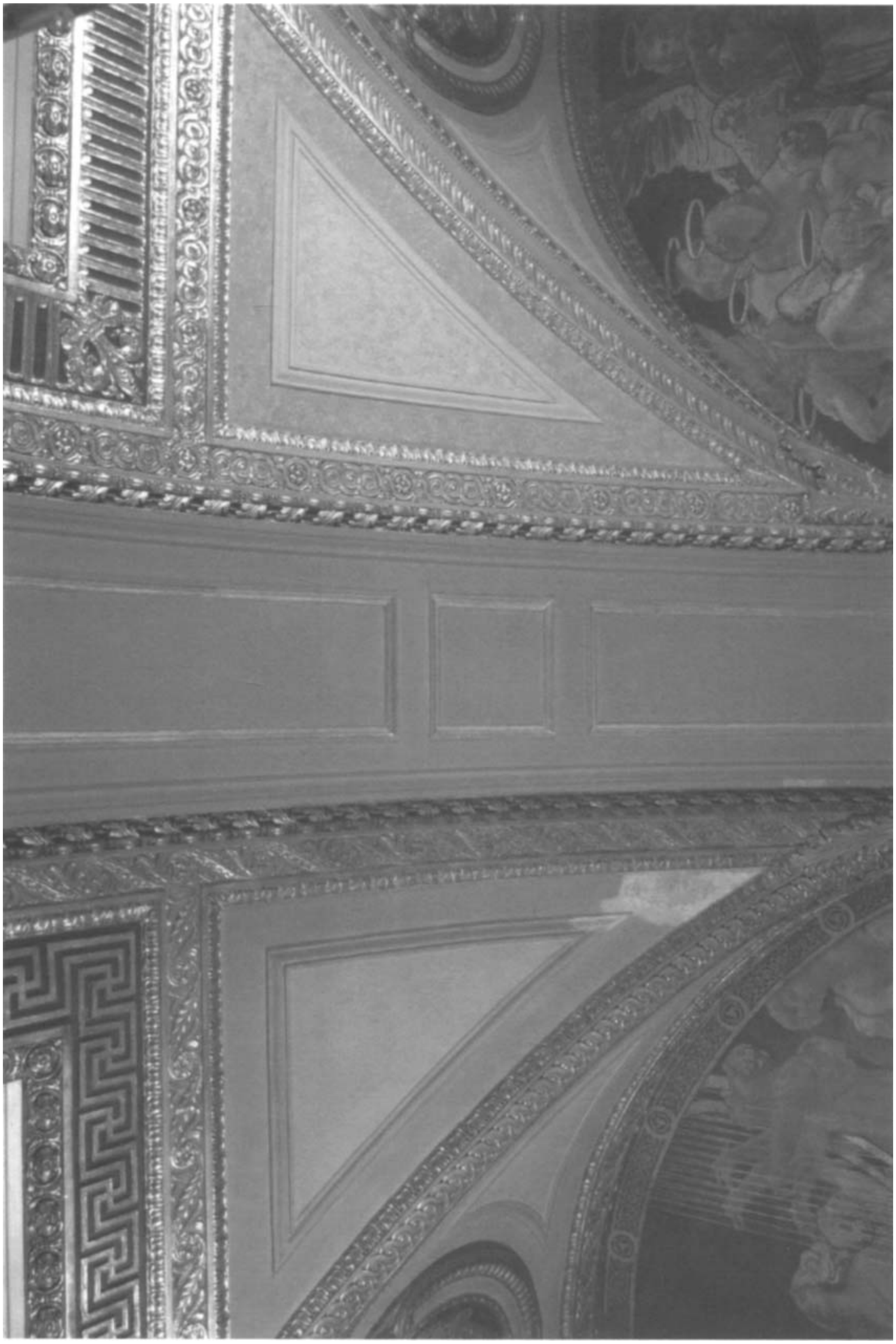


Figure 7. Spandrels and pendentives of the east wall during treatment. The right side has been cleaned and repainted (view horizontally).

Figure 8. Sargent Hall, northeast view, 2004 photo, after restoration.

HANDLING LARGE TEXTILE OBJECTS

Sarah C. Stevens, Associate Textile Conservator

I am responsible for the stabilization and re-housing of the New York State Battle Flag collection. The 1,750 flags in the collection vary in size from one foot square to 12' x 24'. I would like to share how I move and handle the larger, fragile flags in this collection, using one large, regimental flag as an example:

For humidification, I started with an 8' square table-top humidification chamber, which accommodates the majority of the flags in the collection (Figure 1). This set-up did not allow me to work in the chamber for longer than 20 minutes, since the humidity escaped around me when I was inside. It was also difficult to reach the center of the table top. I discussed what I needed with our maintenance man, who suggested an outdoor storage shed, usually used for cars (Figure 2). We were able to order one locally and although it was a custom job because it was smaller than usual, it was very cost effective. The original 8' square table-top, a bridge and I can now fit inside so I can reach the center of the table and object. The humidity inside the tent is adjustable to a certain range and once it reaches that point, it holds.

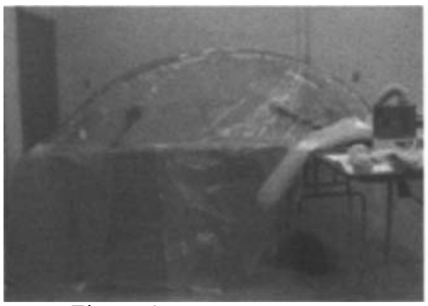


Figure 1

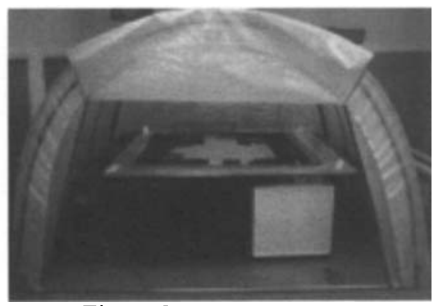


Figure 2

So what happens after the humidification is complete, but the curator wants to exhibit or simply see the other side of a two-sided flag? I expanded the common practice of turning a two-dimensional textile between two boards to turning between two stretcher frames. Each frame is stretched with muslin and a sandwich is built with the stretcher, a layer of Mylar®, the object, another layer of Mylar® and another stretcher placed up-side down (Figure 3). To secure the flag, pins are placed around the edges and inside any losses (Figure 4). (Note: The flags in this collection lend themselves to this very well, since there are usually extensive losses. This may not work for other types of objects.) The stretchers are then securely clamped together and turned as one unit with two or four people, depending on the size of the stretchers. The pins can be removed from underneath and the top stretcher removed to see the other side of the object.

Figure 3

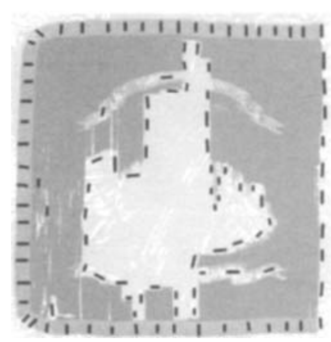


Figure 4

Sarah C. Stevens, Associate Textile Conservator
NYS Bureau of Historic Sites, Peebles Island
P.O. Box 219, Waterford, NY 12188

The large fragile flags that are chosen for display are usually pressure-mounted. After the conservation is complete, the flag is transferred to a padded mount. The flag is moved onto the mount on its Mylar® working support (Figure 5), but then, how to best remove the Mylar®? Pulling out the Mylar® in one sheet can be difficult due to the static charge that builds up. Instead, the Mylar is rolled away from underneath. The leading edge of the Mylar® is secured to a tent pole, left over from the table-top humidification set-up (Figure 6). While one person at the end of the flag holds the Mylar® so it doesn't slip, two people roll the Mylar® around the tent pole (Figure 7). The small diameter and flexibility of the tent pole keeps the flag from lifting too high and becoming misaligned.

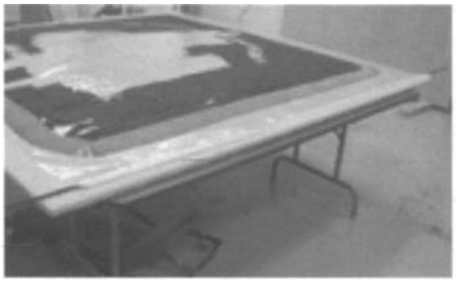


Figure 5


Figure 6

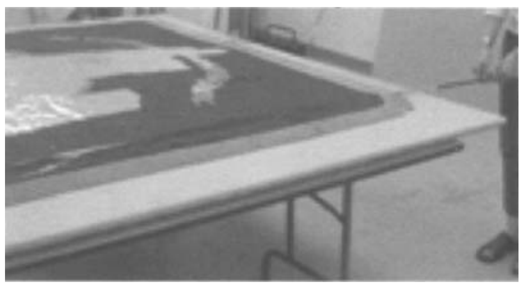
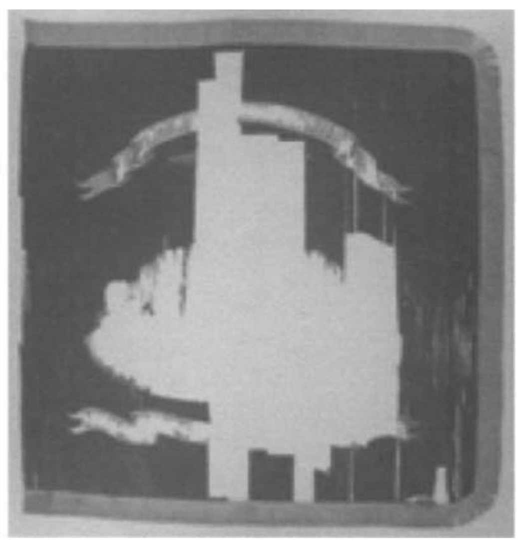


Figure 7


Before conservation image of the flag (Figure 8)


After conservation image of the flag (Figure 9)

Supplier for humidity chamber:
Fred's Tents and Canopies
7 Tent Lane
Stillwater, NY 12170
+1 (800) 998-3687
sales@wemaketents.com
http://www.fstcinc.com

EMULATING GLAZED CHINTZ FABRIC WITH B-72

Ann Frisina, Textile Conservator

Glazed chintz is a cotton print fabric that has been polished or applied with a finish creating an extremely smooth and reflective surface. It is often difficult to find a replacement show-cover of glazed chintz in production that is similar to the fabric originally applied to an historic artifact. While conserving an 1870's buttoned back chair, a cotton print fabric of suitable color and design was found. However, this material was of dress weight and had no surface sheen. So in an attempt to recreate the sheen of a glazed surface, I painted a dilute solution of Paraloid B-72® onto the fabric. The steps are as follows:

- Lay a piece of Silicon Release Mylar on the table and tape in place.
- Position the fabric you wish to be coated face up on the Mylar and tape in place.
- Set up a ventilation system that will evacuate fumes. This is especially important when you are doing yardage.
- Paint the dilute .05%-.02% solution of B-72 onto the surface of the fabric.

Take care not to over-paint an area already coated as each layer of B-72 results in a darkening of the fabric's color.

Results are mixed, but positive. I created a fabric with some sheen and a stiffer hand emulating the properties of glazed chintz. However, with the application of Paraloid B-72®, the fabric now had an extremely strong memory to creases. Once folded, a crease was permanently set in place. This created a difficult and more exacting task for me as I was positioning this fabric on a buttoned-back chair. Each button has four folds; if the fabric is wrongly folded, a crease will remain. This technique of applying Paraloid B-72® allowed me to take modern day fabric and alter its surface creating yardage that is more historically correct as a replacement show-cover for an 1870's button back chair.

Ann Frisina, Textile Conservator, Minnesota Historical Society

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BETTER SWAB GRIPS

Nancy R. Pollak, Conservator of Paintings and Painted Textiles

The grip on a typical bamboo skewer swab stick can be cushioned to reduce hand fatigue. A length of silicone tubing, available in hobby stores as fuel line tubing for model aircraft, can be fed over the skewer to make a soft grip which also helps reduce contact with solvents that may wick up the bamboo during use. The tubing comes in a variety of bright colors, enabling swab sticks to be color-coordinated for different tasks or users. One source is Dubro Racing Nitro line fuel tubing, available at HobbyTown USA® hobby stores.

For a bigger swab stick grip, insert a shorter length of bamboo skewer into a handle with a pin vise fitting. By adjusting the length of the skewer, the swab stick can be more or less flexible as desired.

A LINING FABRIC FROM A FABRIC STORE

Nancy R. Pollak, Conservator of Paintings and Painted Textiles

Posh lining fabric is a commercially available (apparel) lining fabric composed of multi-filament, plain weave polyester. It is useful in the conservation lab as a strip lining fabric or for lightweight overall linings. The thin fabric, which has a slightly matte surface, comes in a wide variety of colors, is fairly strong, and when pulled in the weave direction, has little stretch. It is available at Jo-Ann™ fabric stores and on line.

STABILTEX 'FALSE EYELASH' REPAIRS

Nancy R. Pollak, Conservator of Paintings and Painted Textiles

Stabiltex, a sheer, multi-filament, plain weave polyester fabric available in a number of colors, is used in many textile conservation applications. It can also be prepared as a heat-set support fabric for mending tears in painted flags and banners, and in other light-weight painted fabrics. A palette of mends can be made by pulling threads from a small piece of Stabiltex to make rows of lines two or three threads wide. The threads in the other weave direction are not pulled, so that they will extend on either side of the rows, resembling lines of false eyelashes. The Stabiltex is then coated with adhesive and allowed to dry against a silicone release board. The resulting rows of mends can be cut to the size needed and applied. The long rows of threads run parallel to the tear, while the 'eyelashes' run perpendicular, holding the two edges of the tear together. The variety of available colors is very useful when making invisible repairs on double-sided painted textiles.

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THE USE OF CYCLODODECANE AND RE-MOISTENABLE TISSUE PAPER
...as a temporary moisture barrier and temporary facing...

Beth Szuhay, Conservator of Textiles
Joanne Hackett, Conservator of Textiles

Cyclododecane and re-moistenable tissue proved very useful in the conservation of the regimental colors of the 4th Infantry California Volunteers, a Civil War flag belonging to the State of California. The flag was previously restored in 1928 by Katherine S. Richey, and when it arrived at the lab it was lined with heavy blue linen and entirely covered with a gridwork of stitching. The painted eagle, scroll, and stars in the center of the flag were sewn through with a random pattern of stitching, giving the appearance of embroidery, perhaps as a method of compensation for loss. The flag was subsequently displayed for many decades in the well-lit rotunda of the State Capitol building in Sacramento. The resulting light damage left the silk in a brittle condition and with a disfiguring sunbeam pattern in the silk repair stitches. In this state the flag could neither be used for study or display. Though the previous repair may seem harsh to today's standards it was responsible for keeping the myriad paint chips and pieces of brittle silk together as a whole.

The aim of our treatment was to remove the old repairs, to stabilize the silk and painted areas, to compensate for losses, and to mount the flag for display. In order to handle the flag safely during the removal of old repairs and the application of a new adhesive impregnated silk crepeline lining, the painted areas of the flag were temporarily faced with tissue. To minimize the amount of moisture involved in the process and to prevent tidelines from forming in the silk surrounding the painted areas a novel combination of re-moistenable tissue and cyclododecane was used.

This preparation of re-moistenable tissue follows the technique outlined by Quandt et al: Quandt, A., E. O'Loughlin, P. Hepworth, and P. Anderson. 2002. Remoistenable tissue for mending paper damaged by copper pigments. Handout prepared for the 2002 IIC meeting held in Baltimore, MD. 2002.

Prepare two adhesive solutions; a 3% solution of Dow Methocel A4M methylcellulose in de-ionized water, and cooked wheat starch paste diluted to the consistency of whole milk. Mix the two adhesives in equal parts and pour into a shallow container. Cut pieces of polyester film into 45 cm x 30 cm pieces. Cut Rayon tissue paper into 40 cm x 25 cm pieces. Paste the adhesive mixture onto the polyester film using a wide Japanese paste brush. Allow the adhesive film to settle for a minute to reduce air bubbles. Lay the rayon tissue onto adhesive by holding opposite corners of the tissue and allowing the center of the sheet to touch the adhesive first. Weight the edges of the polyester film to prevent the sheet from curling while the adhesive dries.

To reactivate, score a small piece of tissue and remove from the polyester sheet using tweezers. Draw the piece of tissue through a puddle of de-ionized water. Both sides of the tissue should be moistened to prevent curling. Place the re-moistenable tissue adhesive side down on the area to be consolidated. Tamp down with a soft artists brush to ensure contact and cover the area with a layer of Reemay® spunbonded polyester, a layer of blotting paper, and a small weight. Allow to dry. To remove, roll moistened swabs over the surface and lift tissue with tweezers.

To use cyclododecane as a temporary barrier, place a small amount of cyclododecane in the well of an electric kitsky and allow to melt. Draw the tip lightly along the surface forming a line of cylododecane approximately 2mm wide. Apply the cyclododecane in short sections as needed, as it can sublime sufficiently in 24 hours to no longer be an effective barrier.

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Indianapolis, IN 46208

Suppliers

Cyclododecane
Kremer Pigments Inc
288 Elizabeth St.
New York, NY
1-212-219-2394

Electric Kitsky (Ukrainian egg decorating tool.)
The Caning Shop
926 Gilman St.
Berkeley, CA 94710
1-800-544-3373

Methyl Cellulose A4M and Wheat Starch Paste
Bookmakers
6701B Lafayette Avenue
Riverdale Park, MD 20737
1-301-927-7787

NON STICK COATING FOR TACKING IRON TIPS

Robert Proctor, Paintings Conservator*

Tacking iron tips can be coated with "Non-Stick Cookware Repair" to reduce the need for using silicone coated Mylar® or paper. The material is sprayed on the tips and then baked on in the oven. Unlike silicone and other lubricating sprays, it will not rub off immediately and therefore should not be transferred to the art work. Word of caution: BEVA® will stick to this material and will remove it from the tips over time.

Non-Stick Cookware Repair ($5.99 + shipping)
www.wdrake.com
Search word: cookware repair
Item # 56433
Or: Walter Drake Co., Colorado Springs, CO Tel # 877-925-8373

* Robert Proctor, Whitten and Proctor Fine Art Conservation, 402 Byrne Street, Houston, TX

USING AQUAZOL: A BRIEF SUMMARY

Julie Arslanoglu, Assistant Scientist, The Getty Conservation Institute

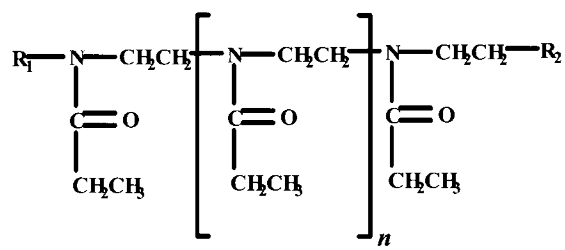
Aquazol is being used in art conservation in a variety of ways. I became interested in the material during a painting conservation treatment as a Mellon Fellow at the Balboa Art Conservation Institute, San Diego CA. As I discussed the use of Aquazol with my colleagues and searched the literature for information on how and when to use Aquazol, I became interested in understanding the material more and understanding how conservators were using the material in conservation today.

A two-part project was undertaken at BACC and the Los Angeles County Museum of Art. The first part was an empirical study of effect of humidity and solvent choice on the physical properties of three molecular weights of Aquazol (50, 200, 500). The second part was interviews with conservators from several disciplines in order to understand how they were using Aquazol in practice and to learn what aspects of the material they were most concerned with. This article is a very brief summary of the results of the project. A complete account of the research can be found in two papers published in the WAAC Newsletter that are referenced at the end of this article.

Chemistry

Aquazol is a unique molecule. (See Figure 1) It has an amide backbone similar to that of a protein. It has electron rich and polar regions around the nitrogen atoms and the carbonyl groups, which allow it to interact with materials that are electron poor or polar. It also has non-polar regions, the aliphatic ethyl groups, which can interact with other non-polar molecules.

Figure 1. Structure of Aquazol (Poly(2-ethyl-2-oxazoline), [PEOX])



Aquazol was originally investigated by Richard Wolbers as a consolidant for paintings on glass: it is one of the few adhesives that adhere to glass and has a similar RI to glass (Aquazol $n_D = 1.520 \pm 0.001$; glass $n_D = 1.529$). Aquazol is also compatible with wax, which means it is also compatible with waxy adhesives like BEVA 371. Aquazol can be used to adhere dirty surfaces, for example consolidation on site in an historic building. Because Aquazol is compatible with so many different types of materials it also allows retreatment with other adhesives if the treatment with Aquazol was unsatisfactory. In essence, if Aquazol is used, no avenues of further treatment are closed.

In addition, tertiary amides are one of the most stable, configurations for nitrogen. This means that Aquazol would be expected to be relatively stable under normal conditions. In artificial aging studies (equivalent of 30 years) Richard Wolbers did not observe any cross-linking or yellowing for any of the molecular weights tested. (1994) These results indicate that Aquazol should remain soluble over time in the same solvents that

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could be used to apply the resin. Wolbers did observe that there was evidence that in the presence of divalent ions, such as those found in pigments, Aquazol forms a high molecular weight complex, which is less soluble after aging.

Properties

Aquazol has a unique set of properties that make it a very accommodating material to work with; yet, it is not always appropriate in every conservation treatment.

Aquazol is non-toxic. One of its industrial uses is as an adhesive for attaching labels to food and food packaging. Unlike other aqueous adhesives, Aquazol does not shrink as it dries, become brittle or support mold growth.

Aquazol is available in three molecular weights, 50,000, 200,000 and 500,000 g/mol known as Aquazol 50, 200 and 500. The different molecular weights have different viscosities and bond strengths. They can be blended in order to achieve the bond strength desired.

In aqueous solutions Aquazol is pH neutral. This means that it will not significantly affect the pH of the aqueous solution to which it is added: if the deionized water is pH 5, the Aquazol solution will also be pH 5.

Aquazol is soluble in a variety of solvents. It is readily soluble (25% or more by weight) in water, methanol, ethanol, isopropanol, acetone and methyl ethyl ketone, for example. It is also very slightly soluble (2% or less by weight) in some aliphatic solvents such as toluene, n-Butyl acetate and n-Pentane. Some conservators take advantage of this property by making alcohol:aliphatic solvent emulsions for a sensitive paint surface. In addition Aquazol is soluble in blends of water and other miscible polar solvents. Conservators can take advantage of the solubility of Aquazol to select the appropriate solvents for the sensitivity of the surface being treated.

Aquazol has a significant response to elevated relative humidity (RH). A summary of the moisture gain observed in this study can be found in Table 1. Aquazol absorbs more water than animal glues or PVA emulsion over a period of time. In addition, there appears to be a solvent effect: the Aquazol film made from a solution in isopropanol:water (1:1, v:v), appears to absorb slightly less water than the aqueous films at 75% and 84% RH.

Table 1. Summary of Moisture Gain for Aquazol

Adhesive	Moisture Gain at 75% RH (%)	Moisture Gain at 84% RH (%)	Moisture Gain at 97% RH (%)
10% Gelatin in water	4	10	35
5% Sturgeon's glue in water	5	12	45
10% Aquazol 50, 200, 500 in water	10-12	18-23	60-70
10% Aquazol 200 in isopropanol: water (1:1, v:v)	~8	~15	60-70
Dilute PVA emulsion	~0.5	~1.5	~13

In situations where Aquazol is mixed with dry pigments or used to consolidate under bound paint, Aquazol may form high molecular weight complexes, mentioned previously in this paper in the section on stability. These complexes are reported to be less soluble in solvents, so they may also be less reactive to high RH.

This means that pure resin films would be more reactive to elevated RH than those where complexes with divalent ions had been formed.

In spite of its hydroscopicity, empirical data from this study showed that at RH below 84% there still appeared to be significant tensile strength, as indicated by Richard Wolbers' data. At 84% RH, all of the molecular weights of Aquazol were observed to be in a gel-like state. At 97% RH, Aquazol 50 (20% in water) was observed to flow.

Uses in Conservation

Aquazol is used most in three ways in conservation: consolidation, adhesion and inpainting. Consolidation refers to gluing down small flakes of paint or other material where penetration as well as bond strength and adhesion is important. Examples of consolidation are matte or friable paint, cracked gilding, fractured materials in general and gluing small losses. Plasticization and flattening of cupped/tented paint can also be included here. Adhesion describes gluing two parts of an art object together. Usually the pieces are larger and thicker than small flakes of paint. Issues for this type of treatment are bond strength, wetting, penetration, gap filling and clearing. For this paper, conservators who dealt with objects or furniture were more concerned with adhesion than consolidation.

Many conservators have become familiar with Aquazol as an inpainting medium through the work of Richard Wolbers and Mark Lewis while others learned about it in Jim Bernstein's Inpainting Workshop. In general Aquazol paint is described as having properties in between gums and oils (which have body and are flexible). It has sheen and some conservators have described it as having an "oil paint consistency".

Aspects that conservators liked about working with Aquazol was its stability, its lack of shrinkage, its adhesion to a variety of materials, its inability to support mold growth, the versatility achievable with the different molecular weights and solvents and the ability to retreat an area if the Aquazol treatment was unsatisfactory.

Aspects that conservators did not like about Aquazol include its hydrscopicity. Aquazol does pick up more water than sturgeon's glue or gelatin under elevated RH conditions. In some instances, this property may make Aquazol an unsuitable choice. However, the decrease in hydroscopicity of the high molecular weight complexes formed by Aquazol and divalent ions may offer promise in the cases of inpainting or consolidation.

Other comments included that Aquazol turned gummy when clearing. Most conservators discussed clearing immediately after use. Some conservators felt that Aquazol had a gummy feel during application, not at all like other aqueous based protein glues. Some conservators felt that Aquazol was not strong enough. These comments came mostly from conservators trying to use Aquazol as an adhesive, especially for weight bearing repairs

In general, for consolidation, most conservators used Aquazol 200 in a 5-10% concentration in water, ethanol or isopropanol. The most common application methods were by brush. The clearing solvent used was water. In general, for adhesion, the most common molecular weight used was 500. Conservators would make a 20% stock in alcohol containing 10-50% water and apply the adhesive by brush or by syringe. Clearing was achieved with water or ethanol.

For inpainting, conservators used either Aquazol 50 or 200. They would make a saturated solution, ~67% for Aquazol 50 and ~33% for Aquazol 200, in alcohol with 0-20% water added. Conservators would mix the resin solution with dry pigments or add the solution to water color or gouache paints. Several conservators suggested sealing the Aquazol inpainting with a varnish in order to decrease its reactivity to elevated RH and to protect it against abrasion.

Conclusion

Aquazol is currently being used in the treatment of many different types of art objects. Conservators from different conservation disciplines have different, and specific, expectations of how Aquazol would serve them best. It has several characteristics that can be manipulated in order to adapt its properties. However, as with other adhesives, Aquazol is not the answer for all conservation problems. Its hydroscopic nature is a concern for many conservators, however the lack of reports of treatment failure due to high RH and the many reports of satisfaction with Aquazol treatments over time, indicates that Aquazol is an adhesive to be considered.

References

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Arslanoglu, J. "Aquazol as Used in Conservation Practice", WAAC Newsletter, Vol.26, No. 1, January 2004, pp.10-15.

Wolbers, R. C., McGinn, M. and Duerbock, D. "Poly(2-Ethyl-2-Oxazoline): A new Conservation Consolidant," in *Painted Wood: history and Conservation* ed. V. Dorge and F.C. Hault, Los Angeles: Getty Conservation Institute, 1994, pp. 514-517.

PNEUMATICALLY GENERATED MIST FOR ADHESIVE REACTIVATION

Kathleen Kiefer, Associate Textile Conservator

This tip describes using pneumatically generated water mist to reactivate wheat starch paste adhesive. It's really a two part tip. One part describes the equipment and the other part describes the technique. The equipment is an inexpensive, compact, portable compressor and nebulizer intended for use in treating asthma. Many conservators have adapted these medical devices for use in consolidating friable, leanly bound, matte paints but they are also useful in delivering a fine mist of water to a surface in a controlled, gentle manner.

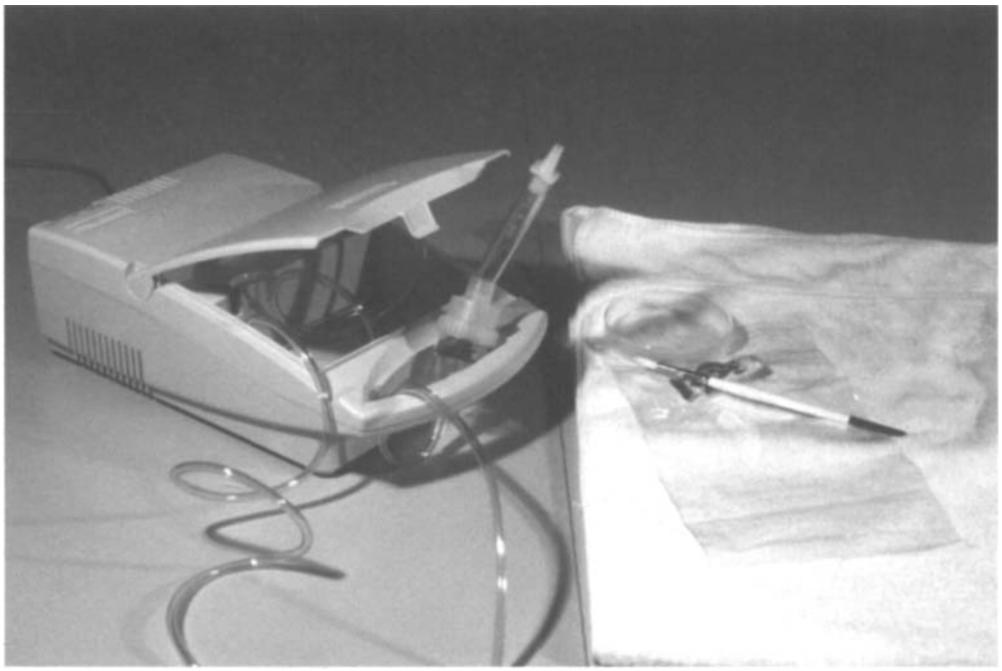

Fig. 1 DeVilbiss Pulmo-Aide® LT Compressor/Nebulizer

A DeVilbiss Pulmo-Aide® LT Compressor/Nebulizer, Model 3650D, is pictured in figure 1. When purchased about three years ago it sold for just under $100.00. It came with a Micro-Mist™ Disposable Nebulizer (the clear plastic container for medication, conservation consolidant or water) and a generous length of tubing to connect the nebulizer to the compressor unit. An additional length of laboratory tubing with a small plastic connector serving as a nozzle was added to adapt the equipment for conservation use. Delivery nozzles can be selected from among a wide range of pipettes, pipette tips, droppers and tubing connectors available through laboratory and equipment suppliers, chosen to best meet the needs of the project at hand. Additional disposable nebulizer containers are available at fairly low cost.

The nebulizer setup described above (fig 1) was used to reactivate wheat starch paste in the treatment of a 19th century skippet or wax seal box (fig 2 & 3). One of Winterthur's objects conservators, Margaret Little, treated the metal components of the skippet in preparation for exhibition related travel, but she was concerned about the stability of the loose fragmentary fabric covering the tassels' wooden forms (see arrows in fig 2). To prevent loss of these vulnerable textile elements they were adhered to the wooden tassel forms. Wheat starch paste was chosen as the adhesive based on its aging characteristics, reversibility, working properties and compatibility with the cellulosic textile and the wooden tassel from.

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Winterthur Museum, Garden & Library
Winterthur, DE 19735

Fig. 2 Lifting fabric before treatment

Fig. 3 Adhered fabric after treatment

To provide access to the treatment area, the metal bullion tassel skirts were folded back and protected with small pieces of polyethylene sheeting. The loose fragments of fabric were humidified locally to relax creases allowing alignment according to original placement. The fragments were adhered as follows: A thin layer of dilute wheat starch paste was brush applied to each wooden tassel form in areas corresponding with where the fabric fragments were to be attached. The paste was allowed to air dry. The fabric fragments were then adhered by reactivating the paste with misted deionized water. The nebulizer with attached plastic nozzle allowed the mist to be directed between the fabric and the wood. The fabric fragments were then tamped gently in place with a small Japanese stencil brush and the paste was once again allowed to air dry. This method allowed a very thin film of paste and limited moisture to be used, thereby preventing penetration and staining of the fabric. The method was quick and did not require any special weighting techniques to achieve good adhesion between the fabric and the wood.

Sources

DeVilbiss Pulmo-Aide® LT Compressor/Nebulizer and Micro Mist™ Disposable Nebulizer – dmeonline, P. O. Box 2069, Tri-Cities, WA 99302, (509) 374-9530, www.dmeonline.com/nebulizers.html

Japanese stencil brush "Surikomi" – Aiko's Art Materials Import, Inc., 3347 North Clark Street, Chicago, IL 60657, (773) 404-5919

Laboratory tubing, connectors, fittings, pipettes and pipette tips – Fisher Scientific, (800) 766-7000, www.fishersci.com,Cole-Parmer, (800) 323-4340, www.coleparmer.com, or McMaster-Carr Supply Company, (732) 329-3200, www.mcmaster.com

Zen Shofu wheat starch paste – Talas, 568 Broadway, New York, NY 10012, (212) 219-0770, www.talasonline.com

TIPS ON USING AZEOTROPES FOR CLEANING SOLVENTS AND ADHESIVE DELIVERY SYSTEMS

Christopher Augerson, Conservator

An azeotropic solution is a precise mixture of solvents having sufficient intermolecular forces binding them together that the mixture has a single boiling point. Thus the overwhelming advantage of using azeotropes is that solvents evaporate together, rather than leaving behind a component of lower volatility. Moreover, because the single boiling point of azeotropic mixtures is lower than that of any component solvent, evaporation also happens so rapidly that surfaces are not disrupted by their use.

In the paint industry, azeotropic solutions were proposed to retain precise control of solvent-blend composition while at the same time replacing solvents prohibited by air pollution laws (Ellis and Goff). For the dissolution of alkyd resins, for example, an azeotropic solution of n-butanol and n-octane is used, with the concentration of n-butanol slightly less than the azeotropic concentration insures that it will not build up in the residues during evaporation. Their use has since been proposed for certain conservation treatments.

In cleaning paint of water-soluble debris, for example, Masschelein-Kleiner (27) has proposed the use of azeotropic mixtures with water, so as to accelerate evaporation and prevent the blanching that water may cause on paint. In addition, when oil paint has a high pigment-to-volume concentration, soluble salts at pigment-binder interfaces may be drained off by water, also producing blanching (Funke). To increase the rate of evaporation and thereby limit the action of water, Masscelein-Kleiner recommended using an azeotrope such as 3 % acetic acid in water (azeotropic boiling point 76.6 °C).

When using organic solvents in art conservation, it has likewise been advised that relatively fast-evaporating solvents might be employed to limit the leaching of organic components (White and Roy). In a series of treatments, I have used azeotropic mixtures of organic solvents of low toxicity for the cleaning of painted surfaces, replacing aromatic solvents and mineral spirits that contain them – a solution that has been relatively safe for both the work of art and the conservator (Augerson 2000; Augerson 2004).

This paper presents a series of case studies, in which paint or textile surfaces were cleaned with such azeotropes. In all cases, I used azeotropes to hasten the evaporation of a relatively strong solvent diluted in a relatively weak solvent, thereby limiting the paint's exposure to strong solvents, with the intent of restricting solvent action to surfaces or minimizing any leaching from the paint film.

Cleaning painted surfaces

I first began employing azeotropic mixtures while cleaning "The Skaters," a sleigh dating to the Regency of Louis XV, in the collection of the Coach Museum of the Château of Versailles. I had determined that mineral spirits were somewhat effective for removing spots of a dammar-beeswax mixture that had been used for consolidating the gilding, simultaneously removing the water-soluble grime onto which the consolidant had dripped. Aromatic solvents like toluene were effective for the slow removal of a shellac layer applied to hide losses in a previous treatment, and equally effective for carefully reducing the thickness of the early varnish on the paintings on the sides of the vehicle, a varnish that, according to GC-MS data, consists of a specially-prepared drying oil Augerson and Demailly). After these initial solvent tests were complete, I investigated using less-toxic, azeotropic solvents to replace the mineral spirits and aromatic solvents that had proved effective (Augerson 2000). This was done by determining from the Teas diagram which solvent mixtures might do the same job, while also referring to published tables of azeotropes – converting proportions by weight to volumetric dilution ratios, and plotting them on the graph (Kurtyka, 6/13–6/163; Horsley). Several azeotropic solvent mixtures predicted to be in the desired regions of the Teas diagram were tested.

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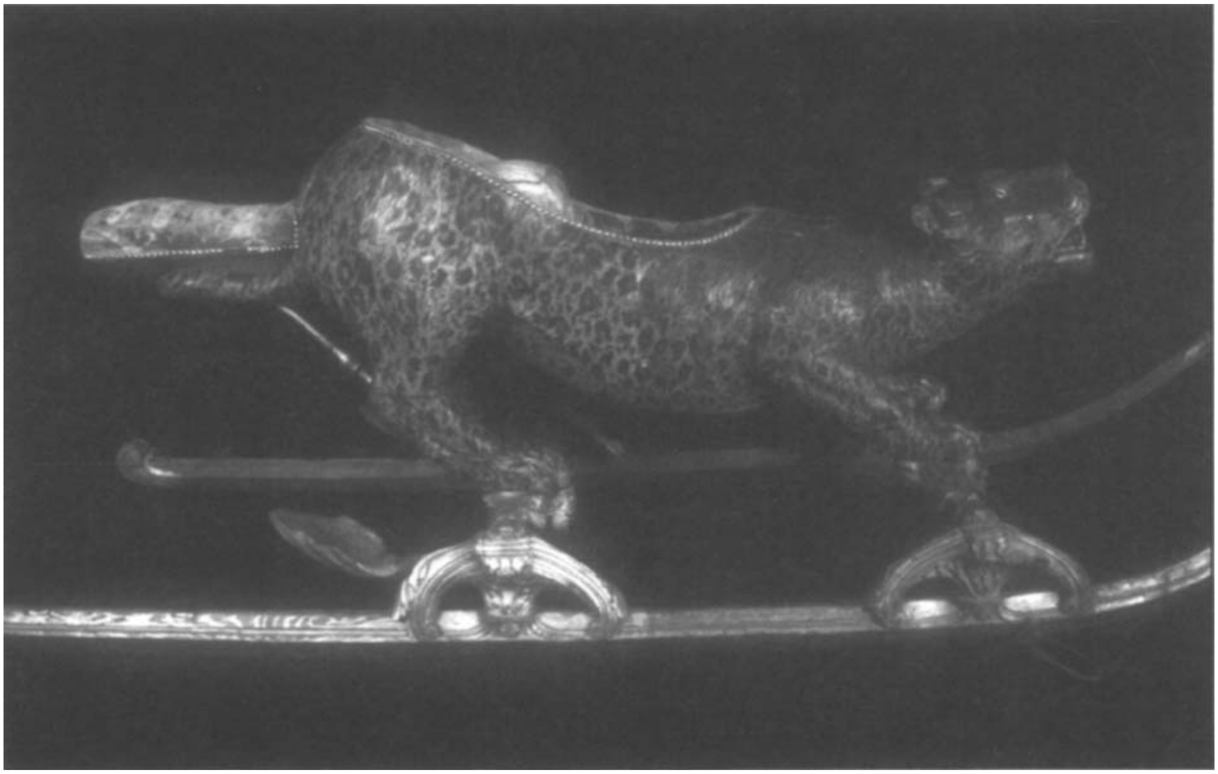

Figure 1 : The sleigh "The Leopard," during the cleaning of its polychromy (the front portion has been cleaned).

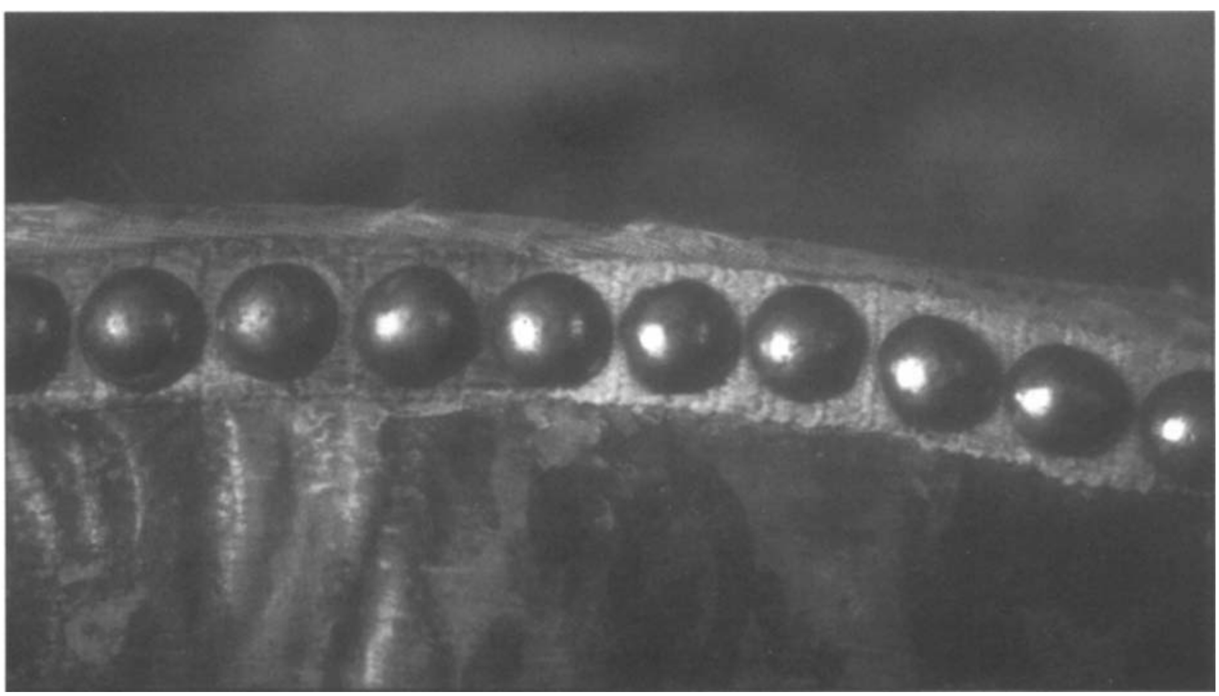

Figure 2 : The cleaning of the silk tacking ribbon on the sleigh "The Leopard."

The solution that best worked in the place of an aromatic solvent contained 23% (by weight) 2-propanol in hexane. When its Teas solubility parameters were calculated according to molar concentration, as recommended by Torraca (50-51) for the most accurate calculations, it is seen to have solubility parameters much like those of xylenes. Other azeotropes that were predicted to have Teas solubility parameters similar to aromatic solvents – such as pentanone in heptane, ethyl acetate in hexane, or 2-butanone in either hexane or cyclohexane – were too strong, dissolved the paint, and therefore were not used. The published azeotrope most like mineral spirits in its activity contained 6 % (by weight) 2-propanol in pentane. Its predicted Teas solubility parameters were closest, in fact, to those of odorless thinner. Nonetheless, it proved even better than mineral spirits for removing not only the waxy consolidant but also the polar grime. (Perhaps this can be explained by a phenomenon previously examined in the chemical literature: when a polar molecule is very dilute in a non-polar solvent, its polarity may become enhanced, thereby increasing the polarity of the mixture [Nakanishi and Asakura].) Finally, besides being effective in removing grime, the azeotrope of 6 % 2-propanol in pentane did not seem to blanch the oil paints, shellac or oil varnishes on the sleigh.

Certain paints are sensitive to the azeotrope of pentane and 2-propanol. Although it appeared safe in cleaning well-polymerized oil paint, it readily dissolved areas of relatively fresh overpaint, apparently of unpolymerized oil, found on certain crèche figures (Augerson, 2000). A resin-based glaze medium, believed to be mastic varnish, was seen to blanche upon its application (Augerson 2004). Certain paints containing mixtures of oil and resins such as copal remain removable in toluene, even after very long aging; these are also very sensitive to the azeotrope of pentane and 2-propanol (Augerson et al. 2002).

The azeotrope most like aromatic solvents, 23% (by weight) 2-propanol in hexane, was also with success in cleaning the sleigh "The Skaters." This was employed to dissolve a relatively recent application of shellac, and also thinned a darkened, early varnish of specially-boiled oil that lay immediately above the painted scenes on the sides of the sleigh. This was done without any apparent blanching to the surface.

The latter azeotrope was also useful in varnish-removal from another sleigh in the Coach Museum of Versailles, "The Leopard." Again, a high degree of control, and a limiting of the action to the surface, was critical. FTIR analysis indicates that the leopard's spotted fur was painted using a medium of a spirit varnish, most likely containing mastic resin, and thereafter varnished (perhaps twice) with the same or a very similar material (Augerson 2004). Controlled removal of the outer varnish, without disruption of the pigmented layers, was essential. This was done by applying the azeotrope with cotton swabs, which removed both the outer varnish and grime layers. The pigmented varnish was undisturbed, without blanching of its surface perceptible to the naked eye (photo 1).

Cleaning a textile

The azeotrope of pentane and 2-propanol also proved effective in removing grime from the surface of a textile: a silk ribbon that trimmed the upholstery of "The Leopard." This cleaning was done without removing the upholstery fabric, as the ormolu upholstery tacks were considered fragile and risked breaking if removed. Cleaning was therefore accomplished by rolling cotton swabs with the azeotrope over the surface of the silk ribbon. Evaporating faster than either of its components, 2-propanol and pentane, it had relatively little tendency to leave tide lines – an outcome enhanced by the use of barely moistened swabs, as prescribed by the results from cleaning tests done on mockups of silk fabric.

Barely moistening the swabs with the azeotrope was imperative to limit its downward migration. Although the azeotrope did not migrate much across the surface of the silk, it was found to easily migrate downward, driving soiling materials deeper into the fabric and into whatever substrate might be below. In the case of "The Leopard," an 18^{th} -century, goffered velvet upholstery was below the tacking ribbon. For both these reasons, then, swabs were prepared by dipping the tip into the solvent mixture, rolling the swab on a piece of new cotton fabric, and then waving it in the air so that extremely little solvent remained.

It is possible that this type of local, dry cleaning procedure with a fast-evaporating mixture might be made easier in cases where blotting paper could be placed under the textile and larger quantities of solvent could be used on the swabs. In these instances, penetration into and through the textile might be encouraged, rather than restricted, so that staining materials would be dislodged by the azeotrope and driven into the blotting paper. This procedure would also avoid the risk that the rolling action of the swab might fray or break apart the fibers of aged or

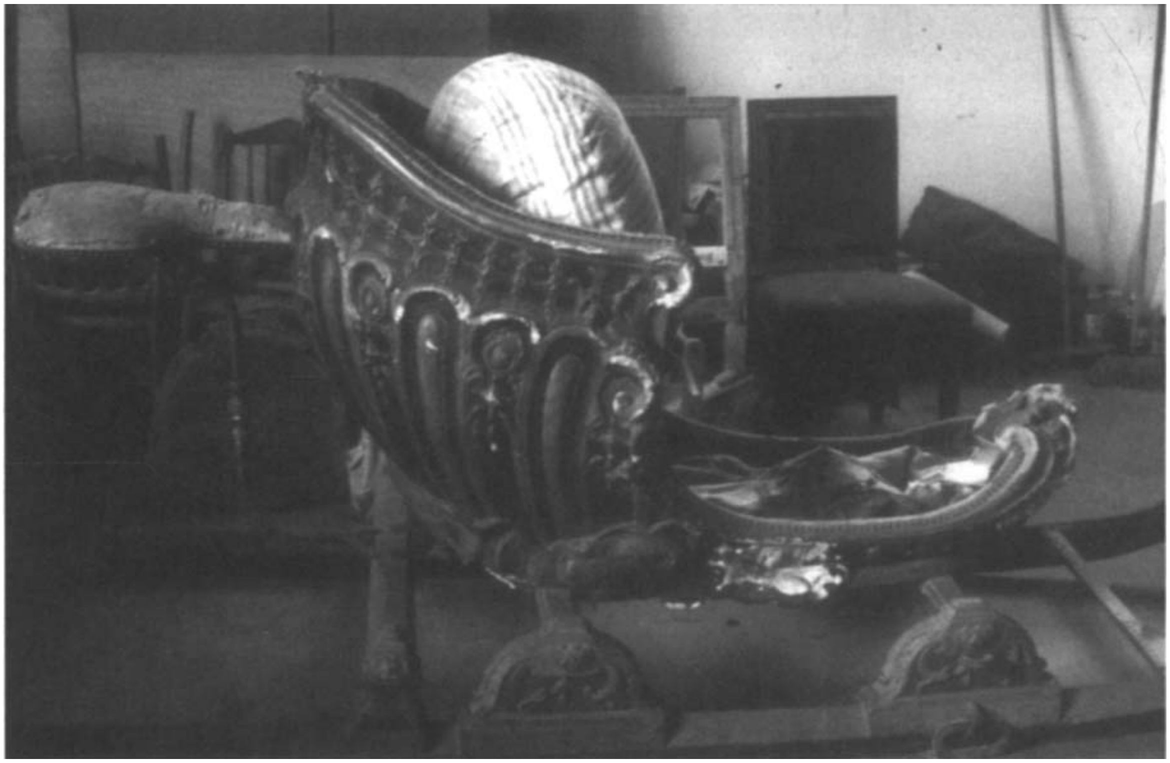

Figure 3 : The sleigh "The Cattails" in storage, before treatment.

Figure 4 : A detail of the *aventurine* at the rear of the sleigh "The Cattails."

deteriorated textiles, though the silk in this case was strong enough to withstand the procedure.

Another issue that arose was the extent to which this azeotropic solvent mixture might act on an experimentally-determined grime mixture of a different polarity. For such tests, I concocted a "dirt" mixture containing % machine lubricating oil, % graphite powder and % reddish umber pigment (wt %, adapted from Wolbers). This I applied to silk and cotton fabrics and observed the effect of rolling successive cotton swabs moistened with the azeotrope of pentane and 2-propanol. The artificial dirt did not clean well: the remaining stains were reddish, indicating a predominance of the reddish umber. In short, although the azeotrope 2-propanol in pentane did pick up the water-soluble grime on the silk ribbon of the sleigh, it was unable to wash out the very polar umber particles in the manufactured dirt.

The variable of particle size in dirt also had to be investigated, since the umber in the artificial dirt appeared to abrade the silk fabric under the rolling action of the cotton swabs, observed at 40x magnification with a Leitz microscope. A new manufactured dirt was prepared with only graphite powder in machine oil, without umber pigment, and it not only cleaned up better but was less abrasive to the fibers than dirt including umber pigment. On the other hand, a mixture of machine oil, powdered graphite and 5-micron grit silicon carbide was very abrasive, with more of the silk fibers being broken during cleaning; in addition, much of the staining matter remained, though more appeared to have been removed than in tests that employed the umber pigment. Finally, to determine whether dirt of a smaller particle size might be easier to remove, I mulled the some of the umber/graphite/machine oil mixture on a glass plate for an hour, and again tried cleaning with the azeotrope of 2-propanol in pentane. The result was ambiguous and hard to interpret, but it appeared that much staining matter – including both graphite and umber – was retained.

In conclusion, while the unknown staining matter on the silk ribbon on the sleigh "The Leopard" was easy to remove and did not appear to contain hard and abrasive material (photo 2), the use of the 2-propanol/pentance was not as successful in grime removal with the majority of my mock-ups with manufactured dirt.

Solvent delivery of a consolidant

Another sleigh, "The Cattails," is currently being treated and has posed a number of interesting problems because of its varied paint layers, which in many areas was applied over papier-mâché. Initial tests indicate that the paper mâché has a glue-based preparation, while that on wooden arts such as the runners is oil-based, and these were originally surfaced with what appears to have been an encaustic paint, probably based upon beeswax. This sleigh was redecorated in the later 18th century with drying oil paints, local oil gilding and spirit varnish. Certain parts were decorated with *aventurine*, flakes of a platinum-copper alloy, suspended in varnish over a bluish green ground, then covered with another coat of varnish (photos 3 and 4).

"The Cattails" had large areas of flaking paint and gilding requiring consolidation. Yet because of all the many types of decorative coatings, done in variously-soluble media, consolidation was problematic, since practically any delivery solvent for the consolidant might dissolve one or another of the layers of polychromy. In an attempt to prevent this from happening, a fast-evaporating azeotrope was employed as the delivery solvent. For paint consolidation over the wooden runners, BEVA 371 ®, was chosen as the consolidant, dissolved in the azeotrope of hexane and 2-propanol. Drops of the adhesive solution were tested on the various paint layers, including the wax-based paint exposed within losses, and these air-dried rapidly without dissolution of the paint; only with much rolling with cotton swabs were the surfaces of the wax-based paint and the varnish layers soluble. During consolidation, the adhesive solution was applied with a tiny (½ cc) tuberculin syringe into the paint cracks or under cupping paint. If the paint was lifting from the support, a piece of silicon-coated Mylar ® was applied to the area a half-minute after injection, and held down with the fingers. The paint seemed to be very slightly plasticized by the presence of the solvent-adhesive mixture, which helped in reducing the laying down of paint. The mylar was released after two minutes, at which time the azeotrope had evaporated. The adhesion of the paint to the structure was remarkable.

Wherever the Mylar ® had been held down, it appeared to have impressed a shiny flat surface. Otherwise evaporation occurred so rapidly that the excess consolidant dried relatively matte, evaporation having occurred before the adhesive could form an even film. It might be possible that certain very fast-evaporating azeotropes consolidate the paper mâché and the preparatory layers. This was likewise administered in a fast-evaporating

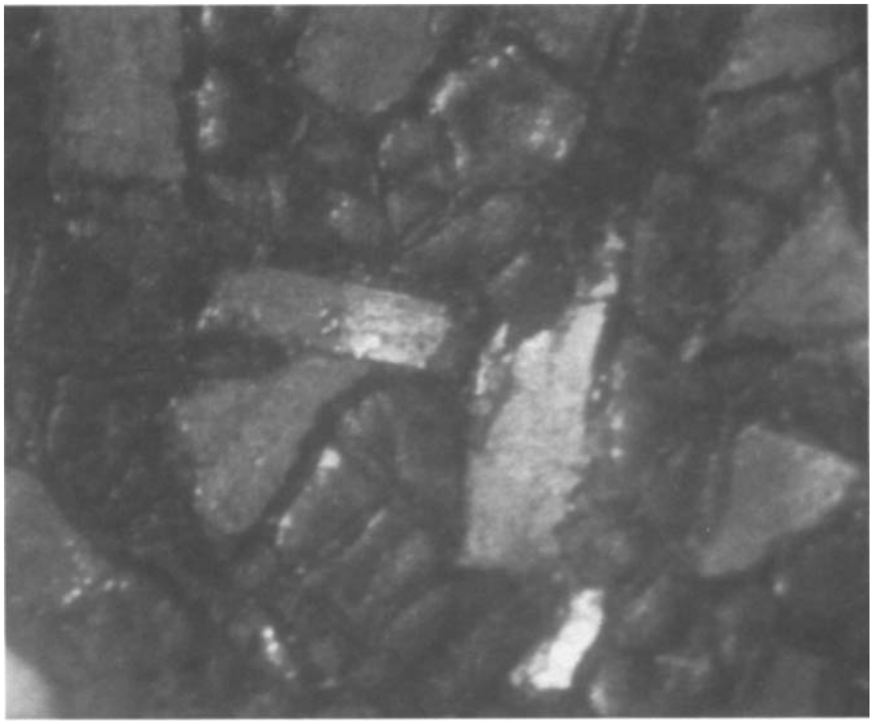

Figure 5 : Area of *aventurine* examined with the binocular microscope at 40x, before cleaning.

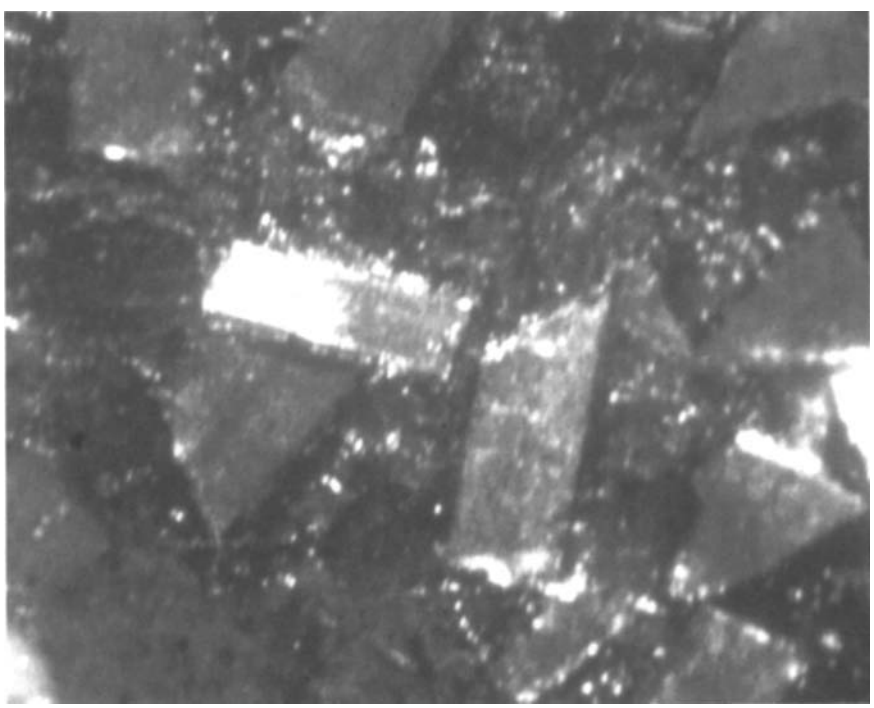

Figure 6 : The same area of *aventurine*, cleaned with the azeotrope of 2-propanol (isoproponal) in hexane, applied with cotton swabs. The surface grime has been removed – without dislodging the delicate metal flake embedded in the lower layer of varnish – and subsequently the thickness of the surface varnish has been slightly thinned. The craquelure was reduced during the thinning (and partial re-forming) of the varnish.

azeotrope, at 10 % concentration in a solution of 40 % 2-butanone in cyclohexane (wt%).

These consolidated surfaces on "The Cattails" have yet to be cleaned, but preliminary tests indicate it is likely that cleaning can be accomplished with the same azeotrope and cotton swabs, acting exclusively on the surface, without reactivation of the consolidant. Cleaning tests under the binocular microscope also illustrate that the varnish over the gilding can be surface cleaned and then reduced in thickness, to revive the shine of the gold, without blanching or any other disturbance. Moreover, the craquelure of the gilt surface appears undisturbed by cleaning with the azeotrope. Similarly, the delicate flakes of aventurine are not dislodged when the varnish overlying them is thinned with the azeotrope; nonetheless, under 40x magnification, a slight reduction of the craquelure was observed, perhaps due to a small extent of "reforming" of the varnish over the *aventurine* during the slight reduction of its thickness (photos 5 and 6).

Conclusion

To summarize, azeotropic solvent mixtures may be useful in certain treatments of painted surfaces and textiles, and their use can be an effective way to control the evaporation rates of component solvents. Referral to published tables of azeotropes, in conjunction with estimations of their activity based on the Teas diagram, can help in designing solvent systems for cleaning and the delivery of resins. Calculations of Teas solubility parameters of the mixtures based on molar concentration or volumetric proportions are rough estimates, with estimations based on molar concentration being somewhat more accurate.

For cleaning of polychrome and silk, an azeotropic solution of 2-propanol in pentane was successful in removing some water-soluble grime, despite the predicted low polarity of the solvent mixture. It was, however, generally unable to wash out very polar particles of raw umber in test cleanings of manufactured dirt from textiles. Certain resinous layers were removed from a variety of painted surfaces, and with great control, using the azeotrope of 2-propanlol in hexane. More work is necessary to better understand the solvent activity of these azeotropes. It would be particularly interesting to further study nature of the kinds of polar debris that can be dispersed by the azeotrope of 2-propanol in pentane.

Generally speaking, the use of extremely fast-evaporating mixtures may favor solvent action on the outermost surface of materials, while limiting it on lower layers. This has far-reaching benefits for certain delicate or local cleaning and consolidation treatments of paint and textiles.

In closing, I'd like to thank the French Heritage Society and the Florence Gould Foundation for their continued support of conservation projects by my colleagues and me at the Coach Museum at Versailles. I would also like to thank Merri Ferrell for her significant encouragement and Bonnie Baskin and Zoe Perkins for their suggestions to this text.

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Supplies

Solvents (HPLC grade, for their purity)
Aldrich Chemical
L'isle d'Abeau Chesne – B.P. 701
38297 Saint Quentin Fallavier
France

Materials in the cleaning tests
"Nigrin" Fine Mechanic's oil
Stinnes-Intertec GmbH
Klaus-von-Klitzing-Str. 2
76829 Landeau/Pfalz
Germany

Graphite powder (product no. 10 589 336)
Pressol
Knebelstrasse1_3
90427 Nuremberg Germany

Reddish raw umber pigment
Kremer Pigmente
Hauptstrasse 41-47
D-88317 Aichstetten/Allgau
Germany

5-micron grit silicon carbide
Société d'équipement scientifique et industriel lyonnais (ESCIL)
81, Avenue du progrès – b.p. 7
69682 Chassieu Cedex
France

For paint consolidation
BEVA 371 ® (Conservator's Products Co.), Silicon-coated Mylar ® (Du Pont), Paraloid B72 ® (Acraliod B72, Rohm & Haas)
C.T.S. France s.a.r.l.
26 passage Thiéré
75011 Paris