Developing New Methods for Recoloring Faded Taxidermy Specimens at The American Museum of Natural History

Becca Pollak[1], Julia Sybalsky[2], Elizabeth Nunan[2], Judith Levinson[2], Lisa Elkin[2], Corina Rogge[1]

[1]Buffalo State College Art Conservation Department, 1300 Elmwood Avenue, Rockwell Hall 230 Buffalo, NY 14222

[2]American Museum of Natural History, 200 Central Park West New York, NY 10024

Abstract

In 2010-2012, the AMNH undertook a renovation of the natural habitat dioramas in its premier Hall of North American Mammals. Installed in the 1940s, many of these 45 dioramas were exposed to unusually high light levels for 70 years, leaving much of the taxidermy embrittled and discolored to the point of scientific inaccuracy.

Prompted by an energy-efficient lighting project, a renovation team comprising conservators, curators, exhibitions staff and a master taxidermist sought a means of restoring the naturalistic appearance of the faded mounts.

The Hall of North American Mammals at the American Museum of Natural History. Photo Credit: Denis Finnin (AMNH).

The original color of a badly faded mink specimen is preserved in dark brown areas on the tail and underside where the fur was masked by adjacent foreground materials.

Treatment Goals

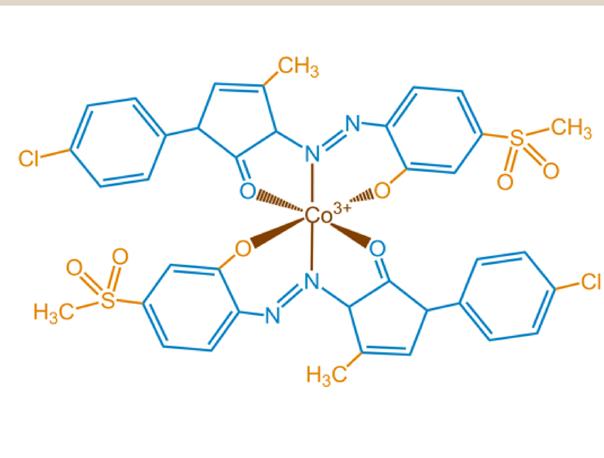
The project required a colorant whose application would not alter the hair morphology, hindering future re-treatment. The colorant must be applied in situ, with no rinsing of excess. In addition, it should have:

- A high lightfastness rating
- A sufficiently broad palette
- Low toxicity
- Simple preparation and storage

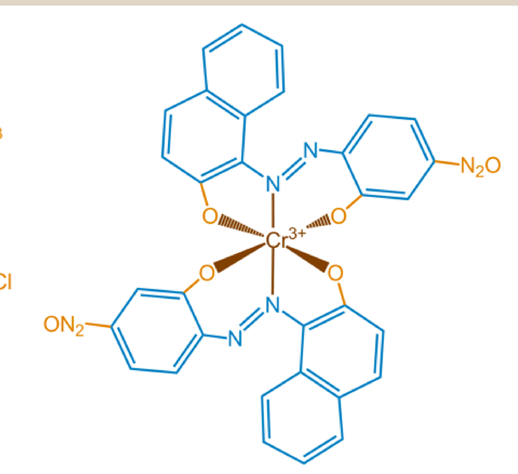
Introduction to Orasol® 1:2 Pre-Metallized Dyes

Structure

1:2 pre-metallized dyes consist of a transition metal ion such as chromium, copper, or cobalt complexed to two symmetrical dye molecules. The latter are typically monoazo structures with a chromophore(s) (imparts color), and auxochrome(s) (modulates the color and intensity and may enable hydrogen bonding, ionic bonding, or dipole-dipole interactions with the substrate). These dyes are insoluble in water and soluble in various organic solvents. They are currently marketed by BASF for coatings and printing inks.



Molecular structure of Orasol Orange G.
Legend: auxochrome, chromophore, metal ion.



Molecular structure of Orasol Brown 2RL.

Lightfastness

In general, these dyes are relatively lightfast (1) due to the stability of the chelated complex and their large particle size. However, chromophore and auxochrome structures vary, making some dye colors more susceptible to photodegradation. The manufacturer (Ciba) reports a marked range in both lightfastness and solubility from color to color. All previous studies, however, were done in binding media, and the stability of the dye alone was unreported.

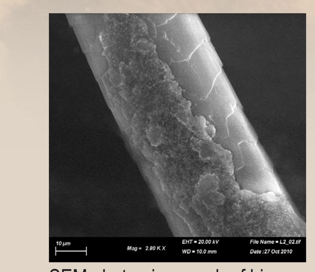
Interaction with Wool Fiber Substrate

1:2 pre-metallized dyes can be applied without acidic salts, eliminating the need for rinsing. In this application, the dye is deposited on the cuticle, with minimal interaction with the hair substrate.

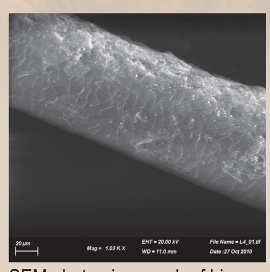
Analysis and Results

Initial PLM and SEM

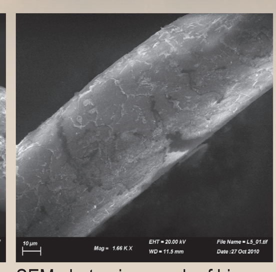
Examination of initial mock-ups using polarized light microscopy (PLM) and scanning electron microscopy (SEM) suggested the suitability of Orasol® dyes relative to other colorants. The color palette available met the project needs, and the dyes had minimal impact on hair morphology.



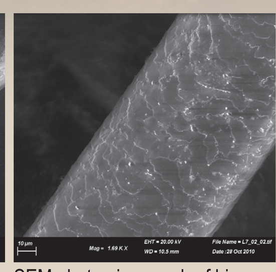
SEM photomicrograph of bison hair with Wildlife Colors acrylic emulsion (Smith Paints).



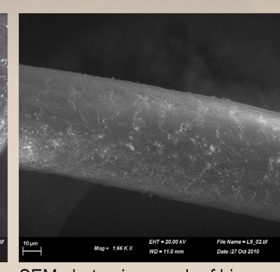
SEM photomicrograph of bison hair with Polytranspar acrylic lacquer (Wildlife Artists Supply Company).



SEM photomicrograph of bison hair with water-dispersable "XSL" micronized pigments (Kremer Pigments).



SEM photomicrograph of bison hair with Orasol dye (B ASF).



SEM photomicrograph of bison hair control.

Accelerated Aging Studies

To better characterize the lightfastness of Orasol dyes in the absence of a binder, a course of analyses was conducted.

Test swatches were produced by airbrushing a 1% solution of each stock dye color in ethanol onto unbleached worsted wool flannel. Another set of wool swatches was produced from 8 dye mixtures developed to recreate the natural appearance of the American bison. One further set of swatches was produced using a medium application of the dye mixtures on pieces of bison fur.

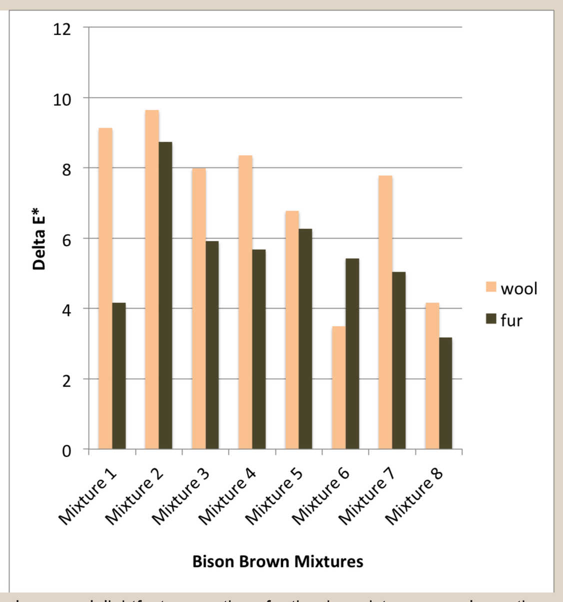
Wool test swatches were prepared from each dye color in three levels of application.

Relative lightfastness of the Orasol® dyes

The swatches were aged in a Q-Sun light aging chamber according to ASTM D4303 (2). Evaluation of relative lightfastness was based on CIE L*a*b*DE 76 values calculated from measurements taken before and after exposure. The DE* values ranged from 2 to 21. Based on these results, a subset of Orasol dyes with optimal lightfastness was identified.

Dyestuff	Substrate	Average Delta E*	ASTM Lightfastness Rating	Stability Class	Selected for Use
Red BL	wool	11.633	III	fair	
Red G	wool	7.531	II	very good	X
Red 3GL	wool	6.508	II	very good	X
Orange G	wool	3.254	I	excellent	X
Orange RG	wool	8.013	III	fair	
Yellow 2GLN	wool	9.032	III	fair	
Yellow 2RLN	wool	2.979	I	excellent	X
Yellow 3R	wool	3.085	I	excellent	X
Yellow 4GN	wool	14.735	III	fair	
Brown 2GL	wool	2.920	I	excellent	X
Brown 2RL	wool	2.958	I	excellent	X
Brown 6RL	wool	2.600	I	excellent	X
Black CN	wool	2.101	I	excellent	X
Black RLI	wool	2.375	I	excellent	X
Blue GL	wool	8.719	III	fair	
Blue GN	wool	8.444	III	fair	
Pink 5BGL	wool	17.456	III	fair	

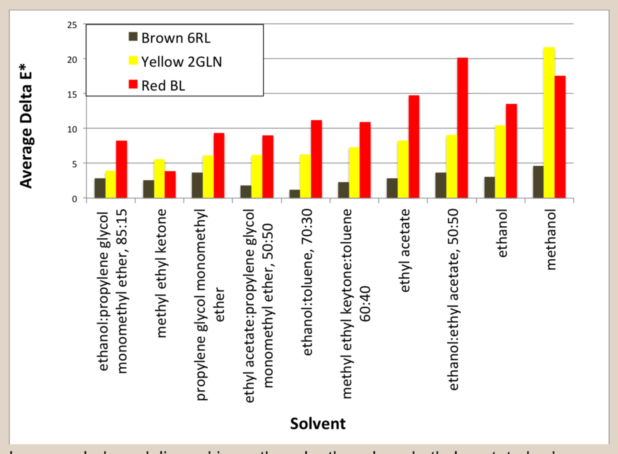
ASTM lightfastness ratings for Orasol dyes provided criteria for selecting restoration materials.



In general, lightfastness ratings for the dye mixtures were lower than those for their primary components, and the mixtures returned lower DE* values when applied to fur than wool.

Solvent effect on lightfastness

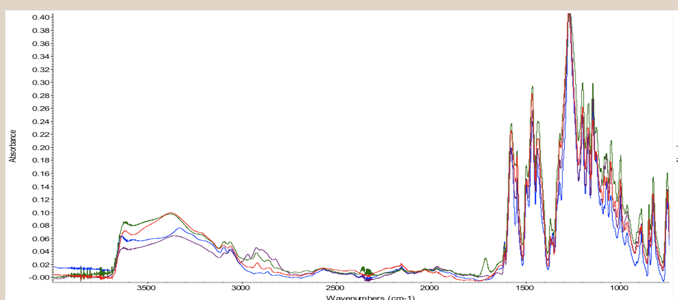
Among Orasol colors, differences in polarity, size, etc. of the dye structures on the metal ion impart wide variation in solubility across a range of solvents. In order to test the effect of solvent choice on lightfastness, swatches were prepared in three colors in ten solvents and aged in the Q-Sun chamber as before. Results revealed surprising differences in lightfastness.



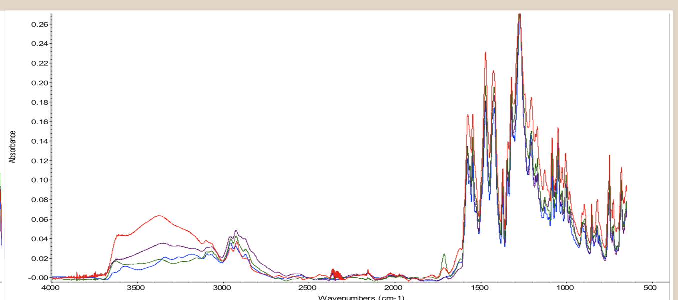
In general, dyes delivered in methanol, ethanol, and ethyl acetate had higher DE* values than those delivered in PGME, MEK, and toluene.

Dye-Solvent Interaction

To investigate the impact of solvents on the dyes, evaporites of three dyes from three solvents were investigated by FT-IR. Despite showing differing lightfastnesses depending upon application solvent, FT-IR detected no differences other than residual solvent. This suggested that no structural changes to the dyes had occurred upon solubilization.



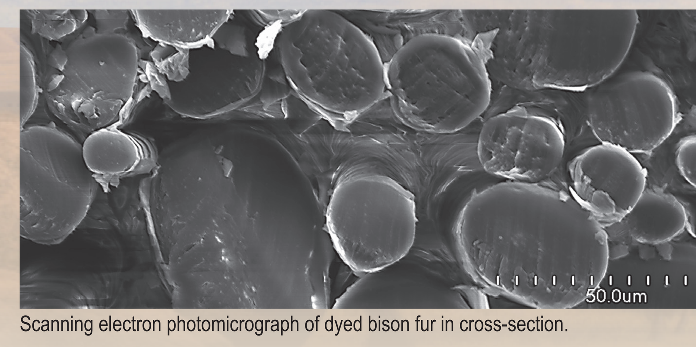
FT-IR spectra of Orasol Brown 6RL evaporites from various solvents.
Legend: control (stock dyestuff), PGME, ethanol, ethyl acetate.



FT-IR spectra of Orasol Orange G evaporites from various solvents.

Dye Penetration

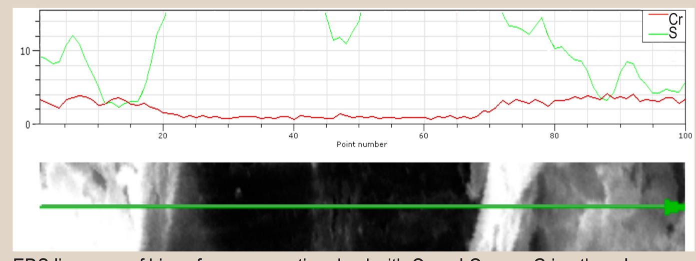
When airbrushed onto fur, Orasol dyes are easily removed by wiping the hair with solvent, suggesting their limited penetration into the fiber, and offering a good indicator of reversibility.



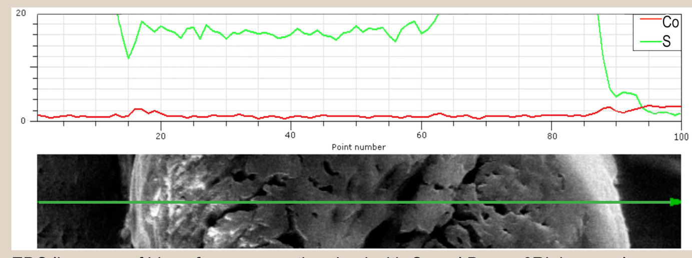
Scanning electron photomicrograph of dyed bison fur in cross-section.

To examine the effect of the solvent on the depth of dye penetration, and to determine whether penetration correlates with lightfastness, dyed fiber cross-sections were analyzed using SEM-EDS. Chromium- and cobalt-based colors in three solvents were applied to samples of bleached bison hair. In all samples, metals were detected on the surface of the hair, but no measurable penetration into the keratin substrate was observed.

EDS line scan of bison fur cross-section dyed with Orasol Brown 6RL in ethyl acetate.



EDS line scan of bison fur cross-section dyed with Orasol Orange G in ethanol.



EDS line scan of bison fur cross-section dyed with Orasol Brown 6RL in propylene glycol monomethyl ether (PGME).

Conclusions

- Orasol dyes show promise for restoring the naturalistic appearance of deteriorated taxidermy specimens.
- The dyes offer good lightfastness, minimal effect on the texture and behavior of fur, low toxicity, and can be applied in situ.
- Careful selection of dyes and solvent can improve the lightfastness of the treatment.
- Minimal dye penetration facilitates reversibility of the treatment, but may complicate future cleaning through unwanted colorant removal.
- This treatment is therefore not appropriate for exposed specimens that may be touched by viewers or require frequent cleaning.

Coyote mount before treatment with Orasol dyes.

Coyote mount after treatment with Orasol dyes.

Future Testing

- Consider alternative causes for the effect of the solvent choice on lightfastness, including solvent impurities that diminish dye stability, or the size of dye particles deposited.
- Investigate whether Orasol dyes accelerate or retard deterioration of the keratin substrate.
- Explore the use of laser scanning microscopy to visualize dye penetration into the substrate.

References

1. Manufacturer's data, "Ciba ORASOL dyes for printing inks" 2001-Oct-01 (current manufacturer: BASF)
2. ASTM D4303 : Standard Test Methods for Lightfastness of Colorants Used in Artists' Coloring Materials

Acknowledgments

The authors would like to thank the American Museum of Naural History, the Conservation Department at Buffalo State College, Bethany Palumbo, Stephen Quinn, and Richard Webber of AMNH, George Dante of Wildlife Preservations, LLC., and Paul Whitmore of Carnegie Mellon University. Corina Rogge acknowledges funding from the Andrew W. Mellon Foundation.