The Application of Analytical Techniques in Art Conservation

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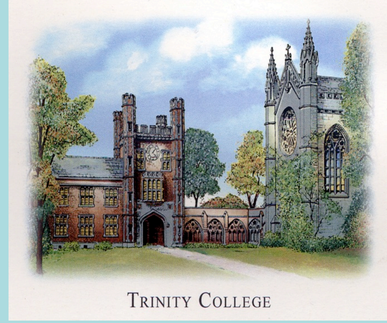

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Introduction

•Art conservators are able to recreate and repair original works as well as determine if a work is fraudulent through analysis of a paintings materials.

•Direct Analysis in Real Time–Time of Flight Mass Spectrometry (DART-TOF MS), and Scanning Electron Microscopy–Energy Dispersive Spectroscopy (SEM-EDS) can be used to determine a material's identity in the field of art conservation.

•This study explores the use of DART-TOF MS in following the changes in masses as a function of time on aged binders.

•Linseed Oil is a common pigment binder used either alone or in combination with a resin to make paint. Linseed Oil originates from dried flax seeds (Linum usitatissimum).

•Samples of Linseed Oil were analyzed in 24-hour intervals after being aged using various methods.

•In order to test whether the data discovered in the aged binder experiments may be applied to paint binders, paint was made using a dry Cobalt Blue pigment ($CoO•Al_2O_3$) and Linseed Oil.

•A commercial Cobalt Blue Oil Color was purchased for comparison purposes.

•The prepared and purchased paints were analyzed by the use of DART-TOF MS to determine the identity of the binder and by the use of SEM-EDS to determine their pigment identity.

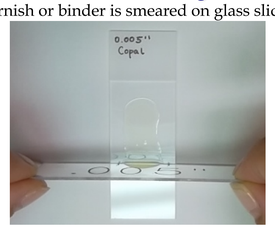
•A library of elemental compositions of forty-eight 19th century pigments obtained from The Wadsworth Atheneum Conservation Library was created using SEM-EDS.

•The library was used to determine the pigment composition of the prepared and purchased paint.

Experimental Methods

Varnish and Binder Changes Over Time

Varnish or binder is smeared on glass slides



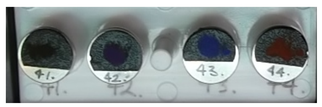
A thickness of 5mills is achieved using a coverslip
Slide is placed on a hot plate (80°C) for artificial aging

Paint Preparation

Dry Cobalt Blue Pigment + Binder (Linseed Oil) = Prepared Cobalt Blue Linseed Oil Paint

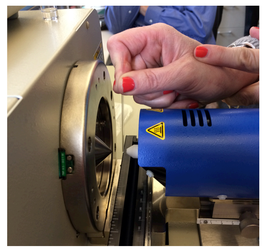
Measurements: SEM-EDS

Scanning Electron Microscope Using Energy Dispersive Spectroscopy

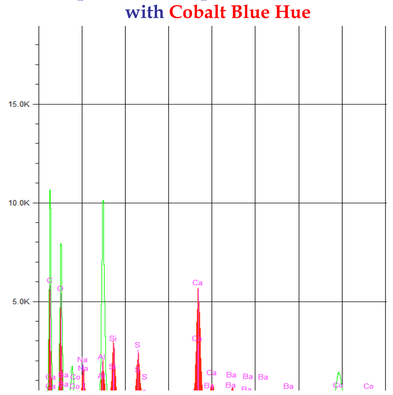


Measurements: DART-TOF MS

Direct Analysis in Real Time using Time of Flight Mass Spectrometry



Comparison EDS Spectrum of Cobalt Blue with Cobalt Blue Hue

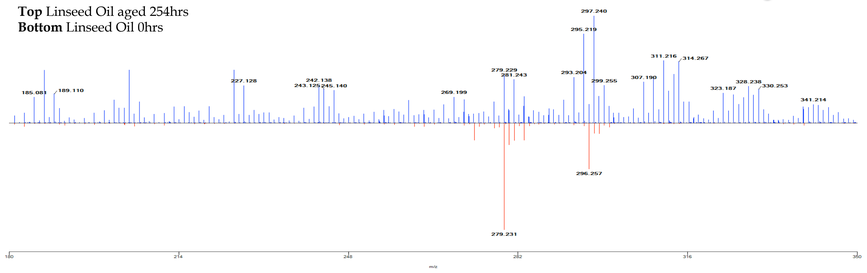


Research Goals

- Construct Libraries of Resin Varnishes and Pigment Compositions to Help Art Conservators Identify Pigments, Binders and Varnishes in Easel Paintings
- To Identify the Resin and Binder in a Paint Sample Using DART-TOF MS
- To Determine the Pigment Composition of Prepared and Commercial Paints Using SEM-EDS
- To Mirror Part of the Process Art Conservators Use in Determining the Materials of an Easel Painting

Summary of Results

Top Linseed Oil aged 254hrs
Bottom Linseed Oil 0hrs



Top Linseed Oil aged 254hrs
Bottom Prepared Linseed Oil Cobalt Blue Paint aged 287hrs

Top Linseed Oil aged 254hrs
Bottom Commercial Linseed Oil Cobalt Blue Paint aged 281hrs

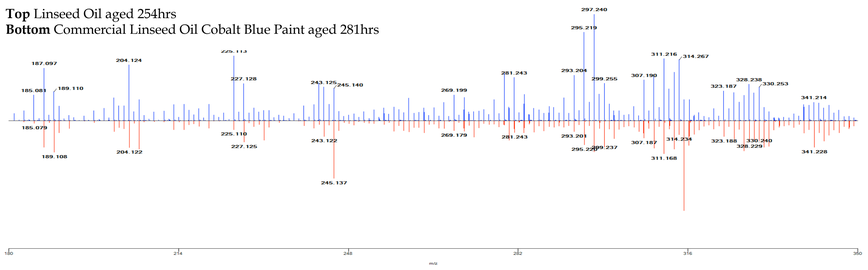
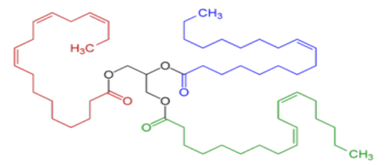


Table 1: 19th Century Blue Pigment Compositions determine by SEM-EDS compared with Pigment Compositions in Paint

Pigment or Paint	Chemical Composition	Major Elements	Minor Elements*
Manganese Blue	$BaMnO_4•BaSO_4$	Ba, S	Mn
Cerulean Blue	$CoO•n(SnO_2)$	Sn, Mg, Co	Al, Zn
Phthalo Blue	Copper porphyrin	Cu, Ca	Si, Cl, Ti
Milori Blue	$Fe_4[Fe(CN)_6]_3$ (Prussian Blue)	Fe, N	Na, S, P
Cobalt Blue	$CoAl_2O_4$	Co, Al	S
Ultramarine Green	$Na_{6-8}Al_6Si_6O_{24}S_{2-4}$	Si, S, Al, Na	K, Cl, Mg
Commercial Cobalt Blue **Hue** Linseed Oil Paint after 93hrs Δ exposure at 80°C		Ca, Ba, Si, S	Na, Al
Prepared Cobalt Blue Linseed Oil Paint after 98hrs Δ exposure at 80°C		Al, Co	Si

* Minor Elements include all elements reported as less than 10 wt. %
Elements reported in order of decreasing wt. %



Linseed Oil – 878 amu
Oleic Acid – 282.46 amu
Linoleic Acid – 280.45 amu
α-linolenic Acid – 278.43 amu

Conclusions

- Established a procedure that allows identification of resin varnishes and binders in paint. (DART-TOF MS)
- Established a procedure that allows pigment composition identification in raw pigments and paints.
- Obtained information about resin varnishes, binders, and pigment compositions and created libraries of reference material for Art Conservators.

References

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Acknowledgments

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