Introduction

- Art conservators are able to recreate and repair original works as well as determine if a work is fraudulent through analysis of a painting's 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\(\cdot\)Al\(_2\)O\(_3\)) and Linseed Oil.
- A commercial Cobalt Blue Oil Color was purchased for comparison purposes.

Methods

- Paint Preparation
  - Dry Cobalt Blue Pigment + Binder (Linseed Oil)  
  - Prepared Cobalt Blue Linseed Oil Paint
- Measurements: DART-TOF MS
  - Direct Analysis in Real Time using Time of Flight Mass Spectrometry

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

Experimental Methods

- Varnish and Binder Changes Over Time
- Measurements: DART-TOF MS
- Direct Analysis in Real Time using Time of Flight Mass Spectrometry

Materials:

- Commercial Cobalt Blue Oil Color
- Prepared Cobalt Blue Linseed Oil Paint

Summary of Results

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

<table>
<thead>
<tr>
<th>Pigment or Paint</th>
<th>Chemical Composition</th>
<th>Major Elements</th>
<th>Minor Elements*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangoes Blue</td>
<td>BaMgO_4(\cdot)SnO(_3)</td>
<td>Ba, Sn</td>
<td>Mg, Al</td>
</tr>
<tr>
<td>Gesso Blue</td>
<td>CoO(\cdot)SnO(_3)</td>
<td>Sn, Mg, Co</td>
<td>Al, Zn</td>
</tr>
<tr>
<td>Phthalate Blue</td>
<td>Cu, Ca</td>
<td>Cu, Zn, Pb</td>
<td>Si, Ti</td>
</tr>
<tr>
<td>Milioli Blue</td>
<td>Fe(<em>2)(Fe(</em>{3})O(_4))(_2)</td>
<td>Fe, N</td>
<td>Na, P, S</td>
</tr>
<tr>
<td>Cobalt Blue</td>
<td>Co(_3)Al(_2)O(_6)</td>
<td>Co, Al</td>
<td>S</td>
</tr>
<tr>
<td>Ultramarine</td>
<td>Na(_2)Al(_2)O(_5)</td>
<td>Si, Al, Na</td>
<td>K, Cl, Mg</td>
</tr>
<tr>
<td>Commercial Cobalt Blue Linseed Oil Paint after 93hrs A exposure at 80°C</td>
<td>Ca, Ba, S, S</td>
<td>Na, Al</td>
<td></td>
</tr>
<tr>
<td>Prepared Cobalt Blue Linseed Oil Paint after 93hrs A exposure at 80°C</td>
<td>Al, Ca</td>
<td>Si</td>
<td></td>
</tr>
</tbody>
</table>

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

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.

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