Evaluating the Corrosion Behaviors of Pipe Component Materials Used in Commercial Refrigeration Systems

Benjamin Herren
Resurrecting a Graeco-Egyptian Purple
Reverse Engineering an Ancient Pigment of Scientific and Cultural Significance

Benjamin Herren, Garnet Kwader, Alaggio Laurino, Brittany Archuleta, Jennie Coon, Cassie Green, Cameron Quade, John-Paul Stroud, Robin McCown, Hanna Meinikheim, Brittany L. Cannon, Mari Carmen Casas, Janice Neri, Glenn Gates, and Darryl P. Butt

Mystery of The Bearded Man
We explored the processing of several dye precursors accessible to Graeco-Egyptians of antiquity (kermes, lichen, indigo, and the madder and alkanet roots - which can all be color-shifted to purple by a variety of metal and alkali salts) in order to characterize the production of the purple used in "The Bearded Man." Pigments produced experimentally were compared with a sample from "The Bearded Man" in order to better correlate the processing materials and methods available in ancient Graeco-Roman Egypt.

Organic Dye Origins and Methodology
Madder (Rubia tinctorum) is a perennial plant with roots that yield a warm-colored dye (anthraquinone) which can be shifted from yellow to deep red by an alkali substance. Using an iron mordant, it is possible to create a purple color; evidence also suggests that the addition of Egyptian Blue pigment (calcium copper silicate) creates a purple hue.

Lake Pigment Processing
Dyes are extracted by a simple boiling and steeping method. Colors are then shifted by the addition of metal salts and/or alkali solutions. Balanced additions of alkali and alum solutions create insoluble precipitates that absorb the desired color. The precipitate is filtered, washed, dried, and powdered to create a pigment that can then be added to an oil or wax binder.

Results

<table>
<thead>
<tr>
<th>Base Dye Materials</th>
<th>Color Shifts</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kermes</td>
<td></td>
<td>176 nm</td>
</tr>
<tr>
<td>Madder</td>
<td></td>
<td>512 nm</td>
</tr>
<tr>
<td>Alkanet</td>
<td></td>
<td>512 nm</td>
</tr>
</tbody>
</table>

Discussion
The artifact pigment particle had contained certain elements and fluoresced under ultraviolet light. Four raw material dyes were color-shifted to purple, but not all of them fluoresced in a readily detectable manner upon UV light exposure. A lack of bromine eliminated Murex as a possible dye precursor, while a lack of nitrogen did the same for lichen and indigo base dyes. Organic root dyes - mainly Madder and Alkanet - have mimicked the artifact particle most closely when analyzed for absorption and fluorescence behaviors. Current data show root dye precursors to be promising candidates for this study in reverse engineering. Further studies into the effects of dye color-shifting, lake pigment production, and wax binder incorporation are necessary to challenge and/or refine these connections.

Future Work
- Continue color-shifting the dye solutions using alkaline and metal salts
- Create lake pigments from the dye solutions using a mordant, such as Alum
- Obtain further spectral characterization (i.e. Raman and Fluorescence) of dye solutions and final pigments
- Add final pigments to a wax binder

References