

Duplicating the Artist's Palette: A Classroom Exercise Illustrating the Role of Pigments, Natural Binders and Gold Foil Inlays in Illuminated Manuscripts: An Exercise for Forensic Chemistry and Art Conservation Students

Douglas A. Ridolfi, M.S.

Coordinator of Forensic Chemistry, Buffalo State College, Chemistry Department, Chemistry Department, 1300 Elmwood Avenue, Buffalo, NY 14222.

This paper provides an outline of an exercise related to the reproduction of the pigment and natural binders used in historical illuminated manuscripts. Students are introduced to the microscopic examination of modern pigments and how they differ from historical, hand ground pigments derived from mineral and natural pigments. They also prepare natural binders derived from egg white and egg yolk and observe the relative utility of these natural adhesives for pigment vs. gold inlay application to art paper.

Key words: Pigments, natural binders, illuminated manuscripts

Introduction

The exercise outlined in this paper was developed for a class in forensic paper analysis and authentication of historic documents offered as a special topics class in the forensic chemistry program at Buffalo State College. It has also been adapted to an exercise on pigments in a class on optical microscopy.

Students are introduced to the microscopic examination of modern pigments and how they differ from historical, hand-ground pigments derived from mineral and natural pigments (Finlay, 2002). Students also prepare natural binders derived from egg white and egg yolk and observe the efficacy of these natural adhesives for pigment and gold inlay application to art paper.

Students mixed their own pigment compositions using modern dried pigments with natural adhesives and had the opportunity to observe these preparations under the light microscope. Students were given instruction in the use of paint brushes, methods for transferring image designs from a template onto art paper and use

of burnishers and related tools for the handling of gold leaf applying it to paper surfaces, using natural adhesives (Thompson, 1933; Whitley, 2000). Lecture material related to the binding and production methods in the preparation of historical illuminated manuscripts was provided along with an outline for duplicating pages from these historical documents (Clemens & Graham, 2007; Brownrigg, 1995; Alexander, 1992; Brown, 1994). Sample letters of medieval design were taken from a Google search of "illuminated letters."

Because the binders and many of the pigments are of natural origin and utilize many of the same types of materials as used in the Middle Ages, instrumental methods that rely on differences in composition may not prove to be useful in differentiating between ancient and modern. The condition of the material, the effects of aging and attempts to make modern material appear ancient might hold clues for distinguishing genuine vs. fake. Uniformity of grinding, uniformity of pigment particle size, presence of contaminants and narrower size distribution when visualized in cross section are important points of observation.

Methods and Materials

Modern manufactured dry, ground pigments were obtained from Sinopia Pigments, P.O. Box 884354, San Francisco, CA 94188-4354 (www.sinopia.com) and comprised a set of 15 pigments from their *Complete Set*. Burnishers, gold leaf, art paper and additional binders were obtained from John Neal Book Seller, 1833 Spring Garden Street, Greensboro, NC 27403 (www.JohnNeal-Books.com).

Students created two types of binders from each egg. Egg tempera was prepared from the egg yolk and glair was prepared from the white of the egg.



Figure 1. Egg yolk after being dried on paper towel or between both hands is punctured with scalpel to release yolk.

An important goal of the lesson was to reinforce the concept that careful study and gathering of materials and studies of medieval practices such as gilding could go a long way in creating materials that could potentially fool even experts. A lecture detailed the working conditions and division of labor of medieval scribes (Brownrigg, 1995). Consideration needed to be made not only of the medieval scribes' working conditions but also their environment and ability to acquire supplies of uniform quality and composition.



Figure 2. Students mixing egg yolk with pigment.

Students also needed to understand that scribes worked on a full time bases and that even simple techniques could introduce subtle nuances that might permit distinguishing the work product of one scribe from another.

Students were provided with simple instructions on separating egg yolk and egg white for egg tempera and glair, respectively and recommended proportions for mixing with dry pigments. Lessons were also provided on transferring the outline of the image to the paper stock that would eventually be coated with pigment or gold overlay. Students could modify the letter design as they wished and could select colors and areas for application of gold leaf.

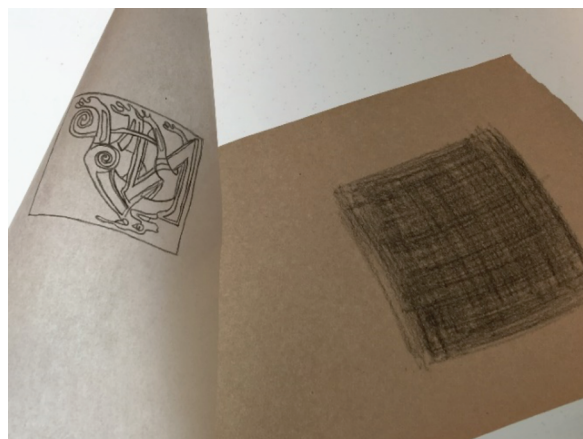


Figure 3. Example of graphite transfer method.



Figure 4. Example of transferred design

The designs were finished with gold leaf and the binders were allowed to dry overnight. The next class meeting, the student-prepared illuminated manuscript letters were examined microscopically and compared to genuine medieval manuscript pages as part of a class exercise in optical microscopy. Optical properties of pigments are best compared to reference material if embedded in the same type of mounting media.



Figure 5. Sample student design.

This exercise requires a minimum of 90 minutes and two hours is preferable. The drying of the binders should be done overnight. For the optical microscopy class, one session of a one hour and fifty minute class was devoted to preparing the illuminated letters and the next class session was devoted to a lecture on pigments and a lab session involving microscopic examination of the student-prepared documents to genuine illuminated manuscript pages.



Figure 6. Sample student design.

Observations

Students had an opportunity to examine their recreations under a stereo microscope and compare their observations to those of a genuine illuminated manuscript page. The binder and the binder-adhesive interaction could be further evaluated under a compound microscope and observations were recorded in a work sheet which detailed binder optical properties.



Figure 7. Student prepared Letter "A."



Figure 8. Genuine illuminated manuscript page.

Sample _____
Color _____
Particle Size Range (μm) _____
Isotropic or Anisotropic _____
Pleochroism ($n_{\parallel}$ and $n_{\perp}$) _____
Relief (high, low, intermediate) _____
Degree of birefringence _____
Opaque or transparent _____
Magnification _____

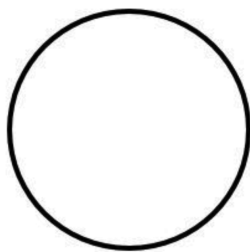


Figure 9. Part of student work Sheet.

Discussion

Students seemed to take an interest in the coloring and preparation of the binder. Students seemed to underestimate the spreading and covering power of the powdered pigment and their mixtures tended to be dark and pasty which effected the spread of the pigment and the area of detail that could be duplicated.

The egg tempura seemed to give better results with the pigments as opposed to the glair. The glair worked better with the gold leaf.

A major problem was the amount of time needed for the exercise. Binders, particularly for the gold leaf, did not have adequate time to be conditioned to optimize binding. A half day workshop

might be more suitable for performing the full complement of activities required for this exercise but students still had a general idea of the various methods when the exercise sheet was combined with the lecture.

Results

Student comments were generally positive. Each student was provided with a survey form to record their comments:

In what ways was curiosity evident among learners and teachers? Students commented on interactivity with tools and materials and how well the content was integrated with the lecture. A work table supplied with drawing material, artist's tools, and colorful pigments attracted student interest.

In what ways was active engagement of learners and teacher evident in this lesson? Students remarked that they enjoyed doing things that were unexpected including art in forensics. Students also had objects and tools discussed in lecture that they could handle, use and make observations.

In what ways was humor and playfulness evident in this lesson? Students could comment on each other's paintings, pose with their own art work as other students took pictures and generally interact with each other and everyone's art.

In what ways did (or could) learners and teacher make a personal connection to the learning? The lesson was personalized because students could pick a letter corresponding to their first or last names. Seeing a demonstration and having a chance to practice the technique themselves was motivating.

In what ways were learners motivated to dig deeper? Participating in hands-on activities encouraged students to ask more and deeper questions. Students appreciated comments regarding their art work from the instructor and other students.

In what ways did the pieces of this lesson connect to the big picture or flow to the content and creativity goals? Students could see how technology has changed throughout the years and students could recreate art work using these ancient methods.

Was there anything unique in the organization or approach to learning evident in this lesson?

The lesson felt more hands-on and this made the experience more endearing to the students.

In what ways was the teacher involved in the learning? Examples of historical paper types such as parchment, velum, papyrus were passed around in class. Demonstration and use of brushes and burnishing tools and different types of gold inlay kept students interested.

What did the teacher do? Say? Interesting lecture that utilized graphics and real examples in a seamless fashion.

What did students do? Say? Topic was of great interest and students listened and participated in the exercise with intensity.

In what ways were the students involved in the learning? Students did the techniques discussed.

Did anything surprising or unexpected occur? Students were surprised of the applicability of natural products as binding materials. Students expressed surprise in the variety of techniques possible to lay down pigment and gold foil leaf.

Any other comments or reflections? The exercise has prompted student interest in taking a more detailed class dealing with historical documents next semester.

Instructions provided to Students—Illuminated Manuscripts

Exercise 12a—The Illuminated Manuscript and Recreating the Medieval Artist's Palette

In this exercise we will be looking at some of the raw materials that medieval artists used in the creation of illuminated manuscripts. The pigments, writing substrate, writing implements, binders, and gold inlay were derived from natural materials. We will be using modern day prepared artist supplies of many of the same materials and applying them in a fashion that was likely done by medieval craftsman.

Because the material is of natural origin and the same types of material as used in the Middle Ages, instrumental methods that rely on differences in composition may not prove to be useful in differentiating between ancient and modern. Take this into consideration when considering methods for distinguishing between original medieval materials and modern day copies. The

condition of the material, the effects of aging and attempts to make modern material appear more ancient might be some ways of determining genuine vs. fake.

The first goal of this lesson is to reinforce the concept that careful study and careful gathering of materials and practice in ancient crafts such as gilding can go a long way in creating materials that can potentially fool even experts. Reflect on the working conditions of medieval scribes. Consider their environment and their ability to acquisition supplies. Also ponder that medieval scribes performed their functions on a full-time basis. Consider the individual nuances that might be introduced into even simple techniques and consider if these may be of sufficient variance to distinguish among scribes and in turn distinguish between genuine products and modern reproductions.

Preparing an Egg Tempera for Painting

Supplies:

- Pad made from two or three folded paper towels
- Two beakers
- Tongue depressor for stirring
- Scalpel for cutting yolk sac
- a fresh egg
- selection of ground pigments
- mixing brushes
- palette or spot plate

Procedure:

1. Tap the middle of the egg gently on the edge of a beaker to crack it.
 2. Hold the egg over one cup and put your thumb nails at the crack.
 3. Gently open the crack until most of the egg white falls into the beaker.
 4. Pass the egg yolk from one half shell to the other letting as much of the egg white as possible.
- Separate and let the egg white fall into the beaker.

To use the egg yolk

1. Slide the egg yolk gently from palm to palm, each time wiping the residue of egg white from your hand onto a layer of paper

towels. Repeat this until the egg yolk is dry.

2. With the yolk now in one palm, position it over a beaker and gently pinch the yolk sack near the top with your thumb and fore finger.
3. With a scalpel, pierce the bottom of the yolk sack and let the contents fall into the beaker. The yolk sack is discarded.

To make glair

1. Beat the white with a tongue depressor, fork or whisk to remove the stringiness; it is not necessary to beat the yolk into a froth but a little froth will likely develop on the top surface.
2. Leave it to settle for a couple of minutes. Pour off and use the liquid under the foam as this provides another adhesive support.

To add pigments to the egg tempera

1. Add a little of the ground pigment to a well in the spot plate.
2. Add egg yolk (or glair although this will be more difficult to work with) to the pigment and stir gently. Add water in roughly equivalent amounts to the egg yolk. The behavior and general solubility of the pigment will dictate the final dilution that will produce a workable mixture.
3. If you want to mix colors, then do so at this point. Add dark pigments to lighter pigments.
4. Add drops of water or more egg, if necessary, until the paint is the consistency of a thin, runny cream.

A good test for egg tempera is to paint a small strip along a piece of glass. If the paint sits well, and when dry comes off as a strip when peeled with a knife, then the mix is just right. If the paint is powdery and when dry can be brushed off with the hand, more egg is required. If the paint is too sticky to flow well, then more water is required.

This might be a good point to reflect on the nature of how pigments are prepared in a modern setting compared to medieval times. Imagine the living and working conditions of medieval craftsmen. They would often obtain raw, unprocessed pigment materials from tradesman traveling along specific trade routes so the sources of the pigment were often varying in quality and might have numerous contaminants. Grinding was typically done by the individual craftsman or in larger cities by a dealer in pigments who still

relied on hand grinding. Compare and contrast this with modern equipment, better raw material recovery methods and process control to reduce contamination. Consider these differences in terms of:

- Extent of contamination
- Uniformity of grind
 - Particle size
 - Particle distribution
- Color quality control

Reflect on the types of instrumentation that might be of value in making distinctions between materials of the same composition but different degrees of processing.

Transferring Designs to Paper Supplies:

- Tracing paper with finished design
- 2B or 4B pencil
- Cotton wool
- Quality paper
- Red ochre pigment
- Light box
- Masking tape

Carbon transfer

1. Trace image on tracing paper. Turn over the drawing and go over the lines with a 2B or 4B pencil.
2. Remove excess graphite by smoothing over the lines with cotton ball.
3. Place the drawing right side up in the correct position over a piece of quality drawing paper. Tape it with masking tape and use a sharp 2B pencil to transfer the drawing by tracing the lines.
4. Remove the tracing paper to reveal the drawing. If some parts of the carbon transfer are too thin, go over these lines lightly with a sharp 2B pencil (Figure 3).

Graphite transfer paper

1. You can make reusable transfer paper by taking a piece of tracing paper and going over it several times with a 2B or 4B pencil, first in one direction across the paper and then continuing with the paper repositioned 90 degrees laying down a uniform, thick scribble.

2. Tape the good paper down on a drawing board or clean surface having first ruled a base line. Line up the base of the design with the base line and tape down. Slip the carbon sheet with the lead face down and trace over the image—transferring the design to the paper below.

Red ochre or Armenian bole transfer paper

1. Place some pigment in spot plate.
2. Dip cotton wool into red ochre powder or Armenian bole and rub into paper starting from the center and moving outward. Keep adding more pigment and working outward until the sheet is sufficiently covered.
3. Shake off the excess pigment.
4. Tape the good paper down on a clean surface and rule a base line for the design. Line up the base of the design with the base line and tape down. Slip the ochre paper between the tracing paper with the image and the good paper, with ochre side down and trace over the image with a pencil or fine stylus transferring the design to the paper below.

Light box

1. Tape the finished image onto a light box or window.
2. Place good paper on top and tape down. Trace design using a 2B or F pencil.

These techniques illustrate some very simple lay out methods. Medieval artists often commissioned a number of specialists in the design of a manuscript for a client of sufficient means. In such a situation, layout was very important. The illustrations were usually placed first and a scribe would transcribe the written text around the illustration block. A craftsman specialized in gilding would lay down the gold work. An illustrator would then come in to complete the drawing and add the color pigments. Remnants of layout lines allow us to work backward in reconstruction of how an entire illuminated manuscript may have been put together.

When authenticating a complex document such as an illuminated manuscript, consider what types of clues might suggest if the manuscript was prepared by one person or a number of people at different times. If prepared by different people, the likelihood of corrections of placement and design would seem more likely and such

clues might offer a suggestion of authenticity. Consider other features relating to image placement, layout and the general flow and harmony of design features and what bearing this may have on authenticity.

Gilding

Supplies: –Burnishers

- i) spade-shaped flat agate burnisher, long handle
- ii) agate dog tooth short handle
- iii) lipstick shaped short handle
- iv) agate pencil short handle

–Loose leaf gold

–Scissors

–Gum ammoniac solution

–flat blade tweezers

–shell gold

–glassine or weighing paper

–Transfer gold

–eye dropper and bottle with distilled water

–Gilder's knife

Gold leaf comes in books of 25 leaves and should be at least 23 $\frac{3}{4}$ carat. Transfer gold is attached to a backing sheet which makes it easier to handle. Gold leaf is not attached but is supplied between sheets of soft tissue paper. Shell gold is gold mixed with a gum Arabic adhesive and can be painted on directly without the use of other binders.

Flat Gilding with Leaf Gold

1. Apply adhesive (gum ammoniac solution) to area where flat gold gild is to be applied.
2. Leave to dry for 30 minutes.
3. Activate layer with heat and moisture from a deep breath, three times.
4. Within a few seconds of breathing on the gum, lay the leaf gold face down and peel off the backing sheet to reveal the gold adhering to the gum.
5. Burnish the gold gently through a sheet of glassine. Repeat step 4 to add a second sheet.

6. Leave to dry for at least 30 minutes before adding a second layer of gold (Whitley, 2000).

Flat Gilding with Shell Gold

1. Use a dropper to add two or three drops of water to the edge of the shell gold tablet to moisten it.
2. Mix the gold to the consistency of ink. Tilt the spot plate to one side so that you can control the consistency.
3. When applying the first layer of gold, make it quite watery and let it dry
4. Mix the second layer thicker and lay it in crosshatch strokes to build up the layer in as uniform manner as possible. Leave it to dry for ideally 30 minutes.
5. Burnish the gold through glassine to help smooth out any irregularities.

Consider those areas of the illuminated manuscript that might be suitable for DNA analysis.

Below are possible border and letter designs that you may want to use to practice on. Consider drawing simple designs on your own that you might like to color and gild. Try borders and motifs in addition to letters added to the illuminated document. These designs have been useful in tracing possible medieval artists and craftsmen. They have also been useful in identification of forgeries. Some forgers have used figures and events that were inconsistent with the age the document was purported to be. Considering the time period of 500 CE to 1500 CE when illuminated manuscripts were in vogue and think of events that might have been important to the church during that time period. The Bayeux Tapestry is particularly detailed regarding events from around this time period.

Note: Letters are obtained from the Internet from a Google Search of "illuminated letters." The actual letters are adjusted from one exercise to the next to correspond to letters in student names of those students currently taking the class.

Conclusions

Duplicating the artist's palette is a simple exercise that introduces students to the process of how medieval scribes created illuminated manuscripts. The exercise also helps to enhance student's observational skills and sample preparation related to pigment examination. It is the author's hope to reinforce the logical evaluation of evidence where the context of ancient crafts and manufacturing methods, even though using the same types of materials, can be distinguished between ancient and modern artists.

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