**The Physical and Chemical Properties of Paper**

**INTRODUCTION**

The properties of paper play an important role in many different domains including artwork and historical preservation. Artists need to be able to control how their paper interacts with their medium of choice, as well as how well the paper will last. At the same time, historians have an interest in conservation and restoration of documents and works that may not have held up well over time. All these procedures are dependent on the stability and properties of a paper. The physical properties of paper allow for dry media such as pencil or pastels to physically attach by rubbing into the fibers and let liquid media such as inks or paints absorb into the paper. A paper’s chemical properties determine how well it will retain coloration planned by the artist and discoloration due to other reactions.

In this lab, we will use three experiments to outline the physical and chemical properties of paper. We will examine the surface of several papers with a dissecting microscope. As suggested by the name, dissecting scopes are used most in biology, but the way in which these instruments are constructed to light an object from both above and below will allow us to better examine the fibers on the paper’s surface. Also, we will consider how quickly water and oil will absorb into the paper. Both of these liquids are important ingredients in paints and other wet media. The details of how a particular paper will interact with and retain the materials used on the paper play an important role in the use of the paper.

Finally, we will study the process of bleaching paper through the comparison of two bleaches, NaClO, sodium hypochlorite (household) bleach and NaBH4, sodium borohydride, a useful reducing agent in organic chemistry. Bleaching processes remove the color from the fibers in paper (and other substances), by breaking or changing their bonds and thus rendering the fibers colorless. Reducing agents, such as the borohydride ion, reduce the oxidation level of the cellulose in the paper, and in this way reduce the number of chromophores present in the paper. Chromophores may also be destroyed through oxidation by oxidizing agents, such as the hypochlorite ion. The way these reagents interact with the paper will have strong effects on the final appearance of the bleaching.

**MATERIALS**

55 mL of 8.25% concentrated household bleach

1 large watch glass

1 pair of tweezers

6 samples of brown paper bag

3 samples of newspaper

20 mL of 0.3 M NaBH4 solution

30 mL of ethanol

3 petri dishes

Dissecting microscope

Several different art paper samples

Pencil, pen

linseed oil or walnut oil

2 disposable dropper pipets

2 samples of 2 art papers

2 samples of 2 gessoed papers

**PROCEDURES**

Bleaching Paper – Part 1: Please note that due to the fumes of the bleach, this entire process must be done in the hood.

1. Obtain 3 100 ml beakers and one 250 ml beaker.
2. Prepare two solutions of household bleach, one blank, and a rinse beaker.
   1. Using a graduated cylinder for measurement, pour 50 mL of DI water into one beaker. Label the beaker “blank.”
   2. Measure out 5 mL of household bleach and pour into a second beaker. Add 45 mL of DI water. Label the beaker “10%.”
   3. Measure out 50 mL of household bleach and pour into a third beaker. Label the beaker “100%.”
   4. Pour approximately 100 mL of DI water into the 250 ml beaker for rinsing.
3. Obtain 3 samples of brown paper bag. Label one “blank”, one “10%” and one “100%.”
4. Place each piece of brown paper bag into its corresponding bleach solution. Let stand for 5-10 minutes. Record your observations of the paper during this time.
5. Using tweezers, remove each paper from the solution.
   1. Rinse off the bleach by dipping into the rinse beaker.
   2. Put the paper on the watch glass and let it dry under the hood for at least 20 minutes.
   3. Record all observations.
   4. Dispose of all solutions in the proper waste container.

Bleaching Paper – Part 2: Please note that for safety concerns in working with organic chemicals, this entire process must be done under the hood.

1. Obtain 1 100 mL beaker and 3 petri dishes.
2. Lay out 3 petri dishes in a row, with the tops located nearby. Add 10 mL of ethanol to each petri dish. Fill the 100 mL beaker with ~50 mL DI water
   1. Clearly mark 2 petri dishes for the experiment, and mark 1 as a blank.
   2. Place 1 sample of brown paper bag and 1 sample of newspaper in each petri dish.
   3. Ensure that the corresponding tops to each dish have matching labels.
3. Add 10 mL of NaBH4 solution to the two experimental petri dishes.
4. Add 10 mL of DI water to the blank petri dish
5. Let the papers bleach for 20 minutes
   1. Record any observations during this time.
6. Remove the papers from the petri dishes, rinse by dipping in the beaker of DI water, and place them on the tops to the petri dishes.
   1. Let the papers dry for at least 20 minutes under the hood
   2. Record any observations during this time.
   3. Dispose of all solutions in the proper waste container.

Paper Surface

1. Obtain 3-5 samples of art paper.
2. Observe each under a dissecting scope and record observations
3. Tear each paper and observe the edges.
4. Mark each paper with a pencil or a pen
5. Observe each mark on each piece of paper with the dissecting scope and record observations.
6. Erase part of your mark and observe the surface after erasing.
7. Recycle the paper

Paper Absorbencies

1. Obtain two samples of untreated paper and two that have been covered with gesso.
2. Using a pipet, drop a drop of water and a drop of oil onto each paper.
3. Observe how the liquids absorb into the paper
4. Recycle all papers, dispose of the liquids in the proper waste container, throw out the droppers

Sources:

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