Teacher Guide

Paper & pH Activity

Introduction:
Many paper materials including historical documents, prints, and drawings are worth preserving. Paper is defined as a matted sheet of cellulosic fibers, and wood pulp is the most common source of cellulose for modern paper. Previously, paper was made from linen and cotton fibers, which are longer than the fibers of wood pulp. Over time, cellulose fibers break down. Acidity is a key agent of fiber deterioration because it catalyzes hydrolysis, a process that severs the chains of paper molecules. Higher quality papers have less inherent acidic components like lignin, and therefore they do not degrade as quickly. However, these papers can still become acidic through environmental exposure. Conservators often bathe acid-damaged paper in water to remove acidic discolorations, reestablish broken hydrogen bonds, and help prevent further damage. In this lab, students will explore the acidity of different papers and test the aqueous treatment process.

Objectives:
- To examine the acidity of different types of paper and understand the use of acid-base properties in aqueous treatment baths

Georgia Performance Standards:
SC7. Students will characterize the properties that describe solutions and the nature of acids and bases.
b. Compare, contrast, and evaluate the nature of acids and bases:
- Arrhenius, Bronsted-Lowry Acid/Bases
- Strong vs. weak acids/bases in terms of percent dissociation
- Hydronium ion concentration
- pH
- Acid-Base neutralization

Supplies:
various paper types (newspaper, construction paper, notebook paper, printer paper, archival paper, cotton rag paper etc.)
acid identifier pen
old, yellowed paperback book
filter paper (large)
scissors
tweezers
pH test strips or pH meter
test tubes (large)

laboratory film
beaker, 100 mL
graduated cylinder
microspatula
weigh boat
calcium carbonate ($CaCO_3$)

Safety:
Safety goggles and gloves should be worn when handling acidic and basic solutions.

Teacher Pre-Lab:

- For Part I, include a range of papers. Examples of lower quality paper include newspaper, construction paper, notebook paper, and yellowed paperback book pages. Examples of higher quality paper include cotton and linen rag paper, artist's paper, archival paper, and acid-free scrapbook paper. You can test materials that you have readily available at home or around the classroom. If papers are marketed as acid-free (with or without buffer), have students test this claim.
- Acid identifier pens are available for $4.49 each from Art Supply Warehouse (http://www.artsupplywarehouse.com/prodDetail.php?id=18624). Pens can be shared among student groups.
- For Part II, purchase an old paperback book from a used bookstore. Look for books that have severely yellowed and discolored pages. Paperback books made around 1950-1970 tend to show these characteristics. Make sure the books you choose are disposable.
- Teachers can either make a stock solution of $CaCO_3$ or have students prepare it during the lab.

Procedure:
Part I

1. Obtain a variety of paper sample scraps, ranging from low-quality to high-quality.
2. Using an acid identifier pen, make a mark on each scrap of paper and record your observations. Compare qualities, such as paper's color, thickness, texture, translucency, flexibility, etc.

Part II

1. Obtain a page from an old, yellowed paperback book. Cut strips that are thin enough to fit in a test tube, and cut these strips into ½ inch segments. You will need 20 scraps.
2. Obtain 2 sheets of large filter paper. Cut strips that are thin enough to fit in a test tube, and cut these strips into ½ inch segments. You will need 10 scraps.
3. Obtain 3 test tubes. Place 10 scraps of book paper in one test tube. Label this tube #1. Place 10 scraps of filter paper in the second test tube. Label as #2. Leave the third test tube for your blank. Label #3.

4. Add approximately 5 mL hot water to all 3 test tubes. Your paper scraps should be submerged, but excess water makes the results difficult to interpret. Cover each tube with laboratory film and allow them to sit for 10-30 minutes, occasionally agitating or swirling the tubes.
5. Obtain a 100 mL beaker. Using a graduated cylinder, measure 10 mL of distilled water and add to the beaker.
6. To make a saturated solution of $CaCO_3$, weigh 0.1g of the solid and add to your beaker. Stir with microspatula. Some solid will remain undissolved at the bottom of the beaker. Using tweezers, dip a pH test strip into the solution to determine the pH. Record observations.
7. Add your remaining 10 scraps of book paper to the beaker. Agitate gently to soak the strips. Cover with laboratory film and allow the solution to sit for 10-30 minutes.
8. After 10-30 minutes have passed, return to your 3 test tubes. Using tweezers, dip a fresh pH test strip into each tube. Record your observations. Compare the acidity of the water baths in tubes 1, 2, and 3.
9. Use tweezers to remove the 10 strips of book paper from the $CaCO_3$ solution in the beaker. Place the strips on a paper towel and pat dry.
10. Transfer the book paper strips to a fresh test tube. Label the tube #4. Add 5 mL hot water. Cover with laboratory film. Allow the tube to sit for 10-30 minutes.
11. After 10-30 minutes, test the pH of the water in the test tube. Record your observations.
12. Compare the acidity of the water baths in tubes 1 and 4, the book paper with and without soaking in the $CaCO_3$ solution.

Clean up:
Dispose of solutions appropriately.

Selected Resources:

- The Invention of Paper. Robert C. Williams Museum of Papermaking. Georgia Tech. Retrieved July 28, 2021 from: https://paper.gatech.edu/invention-paper-0

- All About Paper. Retrieved July 28, 2021 from: http://www.hqpapermaker.com/paper-history/

- Barrett, T (2014). European Papermaking Techniques 1300-1800. *Paper Through Time: Nondestructive Analysis of 14th – through 19th – Century Papers.* University of Iowa. Retrieved July 28, 2021 from: http://paper.lib.uiowa.edu/european.php

- Burge, Daniel, Reilly J, and Nishimura, D (2002). Effects of Enclosure Papers and Paperboards Containing Lignins on Photographic Image Stability. *Journal of the American Institute for Conservation*, *41*(3), 279-290. http://cool.conservation-us.org/jaic/articles/jaic41-03-006_1.html