

## The Effects of pH on Plant Derived Dyes

### Introduction

Dyes are organic chemicals that chemically bond to a material and give it color by reflecting specific wavelengths of light. They can be obtained from many sources, both synthetic and natural. Natural dye sources include plants, animals such as insects, and minerals. The native peoples living on the Flathead Reservation, for example, have traditionally used plants such as Oregon Grape, and Mountain Alder as dye sources.

1) As part of their tradition, the Salish, Kootenai and Pend O'Reille people of the Flathead Reservation use natural dyes. What types of substances are they coloring?

A)

C)

B)

D)

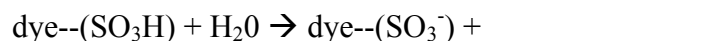
2) What type of molecule are all of the above substances made of?

Typically, the dye process takes place in a water bath. The plant parts containing the dye molecule are put in the water bath, where often the dye molecule ionizes. Next, the substance to be dyed, known as the substrate, is added to the bath. The charged dye fragment then forms a strong ionic bond with the substrate, coloring it. The dye fragment, depending on its chemical nature, may be a positive ion, a negative ion, or it may not ionize at all.

3) What is another name for a positive ion?

4) What is a negative ion called?

5) Fill in the blank in the equation below, which shows a typical way that a dye ionizes in water:



6) Because the dye in the above equation donated a proton ( $\text{H}^+$ ), it would be considered an \_\_\_\_\_ dye.

7) In this case, the negatively charged or anionic dye fragment would form a bond with a \_\_\_\_\_ site on the substrate.

Most plant-derived dyes ionize into anionic dye fragments and so are called *acid dyes*. They tend to work better in slightly acidic baths because the free protons present bond to the substrate creating many cationic sites to which the anionic dye fragment can bond. If the pH is too low, however, this will inhibit the dye's ability to bond to the substrate.

- 8) Chemically speaking, how does a very low pH prevent the dye from bonding with the substrate?

In the following lab you will investigate how changes in the pH of the water bath alter the color achieved when dyeing a substrate. You will use natural plant dyes that are traditional dyes of the native people living on the Flathead Reservation.

- 9) What is pH a measure of?

- 10) What type of substance can you add to a liquid to lower its pH?

- 11) How can you raise the pH of a liquid?

- 12) What tool will you be using to measure pH?

### **NOTE**

You will be using substances that can be harmful to your skin, eyes, respiratory system and clothing so be sure to **WEAR GOGGLES** and **EXERCISE EXTREME CAUTION**. **Do not smell the solutions at any time!**

### **Materials**

Goggles for each group member	300 ml of distilled water
Shavings of the root of Oregon Grape -about 1/4 cup	2 glass stirring rods
Small pieces of Mountain Alder bark- about 1/4 cup	Hot Plate
pH paper or other instrument for measuring pH	1 paper towel
1-500 ml beaker filled with tap water	2 – 300 ml beakers
6 small pieces of a substrate to dye (buckskin or feathers)	6 – 150 ml beakers
Dropper bottle of 1 M ammonia solution	1 pair of beaker tongs
Dropper bottle of white vinegar	

## Procedure

1. Pour 150 ml of distilled water into each of the 300 ml beakers. Place the Oregon Grape shavings into one beaker and the Alder bark pieces into the other. Place the beakers on the hot plate and simmer the solutions for 30 minutes.
2. Label the 150 ml beakers to distinguish them from each other.
3. Carefully use the tongs to pick up the Oregon Grape beaker and decant the liquid equally into the three "A" beakers.
4. Repeat the procedure with the Alder solution, decanting the liquid into the "B" beakers.
5. Use the acid and base available to explore how changing the pH of each type of dye affects its dyeing abilities on a natural substrate. Leave the substrate in the dye for at least ten minutes, then remove it and rinse it in tap water.
6. Create a data table to record your results.
7. Write a summary of your results with a hypothesis to explain what happened in your experiments.

### Post Lab Questions

1. A) Which two beakers probably had the most dye fragments bonded to the substrate?  
B) Give a chemical explanation for your answer to the question above.
2. Some typical substrates that native people might dye include hides, porcupine quills, hair and feathers. All of these substances are proteins, long chain polypeptides.
  - A) What are types of substances are chained together to make a polypeptide molecule?
  - B) What is a common functional group in a protein molecule?
  - C) If the amino group on the protein substrate becomes a positive ion, an anionic dye fragment can bond to it. This can occur if the amino group bonds with a free proton in the water bath. Where would the free protons (H<sup>+</sup>) likely come from?
  - D) What kind of bond is formed between an anionic dye fragment and a cationic site on the substrate?
  - E) What type of substance is formed when an anion and cation bond in the dying process?
  - F) How does lowering the pH in the dye bath create more binding sites for an anionic dye fragment?
3. In this lab you used vinegar to lower the pH of the dye bath.
  - A) Is vinegar a strong or a weak acid?
  - B) How can you tell?
  - C) How would using a strong acid in the water bath affect the quality of the dying process?
  - D) When washing clothes, it is recommended to separate dark and light colors to prevent dark dyes from ruining your light colored fabrics. Chemically speaking, what is your hypothesis for what is happening when soapy water (a base) causes dyes to run?
4. In this lab, we used indigenous plants as dye sources.
  - A) What does the word indigenous mean?
  - B) What other indigenous plants have been used traditionally by the native peoples living on the Flathead Reservation to make dyes