Dye/Fabric Interactions

Materials:

Item	Amount per student	Amount for 24 students
Orange II (synthesized by students)	0.1 g	0.24 g
Martius Yellow	0.1 g	0.24 g
Indigo (synthesized by students)	0.1 g	0.24 g
Any Procion (fiber-reactive) Dye (AXE)	1 oz	1 oz
Multi-fiber fabric strips (~1 inch wide)	4	96
Sodium carbonate (Na_2CO_3, sat'd aq sol'n)	10 mL	240 mL
Sodium sulfate (1 M aq sol'n), 10 drops	1 mL	24 mL
H_2SO_4 (dilute, 1 M (~10%) aq)	11 drops	264 drops
Alconox solution (sat'd aq sol'n)	1 mL + washing sol'ns	240 mL + washing sol'ns
NaOH (3 M, or 10%, aqueous solution)	2.5 mL	60 mL
$Na_2S_2O_4$ (sodium hydrosulfite)	1 - 2 g	24 - 48 g

Equipment:

Item	Amount per student	Amount for 24 students
Snack sized zip lock bags	1	24
Disposable gloves, pairs	1	24

Staff Notes:

Safety Issues:

- Sodium hydrosulfite is a reducing agent and should be treated with care.
- Follow the usual acid-base protocols….

WARNING: All of the dyes will easily dye your skin as well as fabrics....
WEAR GLOVES and OLD CLOTHES!!!

Procedures:

The application procedures of dyes, as well as the types of bonding interactions of the dyes with fabrics, are the ways that dyes are categorized. We will use two direct dyes (Orange II and Martius Yellow), a vat dye (indigo), and a fiber reactive dye (a Procion dye). The fiber strips that we will dye are made of a series of 13 fiber types (starting at the black thread end):

Acetate rayon (cellulose di- or triacetate),
SEF (Monsanto's Modacyclic),
Arnel (cellulose triacetate),
Cotton,
Creslan (polyacrylonitrile),
Dacron 54 (polyester with a brightener),
Dacron 64 (polyester without a brightener),
Nylon 6.6 (polyamide),
Orlon 75 (polyacrylonitrile),
Silk (a natural polyamide),
Polypropylene,
Viscose Rayon (regenerated cellulose), and
Wool (a natural polyamide).

A Fiber-Reactive Dye

Fabric Strip #1:

1. Soak a fabric strip in a beaker containing ~10 mL of saturated aqueous sodium carbonate (Na_2CO_3) for at least 15 minutes at room temperature.
2. Remove the fabric strip and squeeze out the excess liquid -- do NOT rinse!
3. Immediately place in a zip-lock bag with the prepared dye solution and zip up!
4. This dye is very slow to react and must sit in contact with the fabric for at least 4 hours; you can rinse it out and let it dry during the next lab period. (Wear gloves!)
5. Attach the fabric strip to your LNJ page where this procedure is described.

Direct Dyes

Fabric Strip #2:

1. Prepare a dye bath of ~0.1 g of Orange II, 1 mL of 1 M aqueous sodium sulfate, 30 mL of water, and 10 drops of 1 M (or 10%) aqueous H_2SO_4 in a 100 mL beaker.
2. Heat the bath on your hot plate to near boiling and add the strip of test fabric. Heat the fabric in the bath for 5 minutes.
3. Remove the fabric with tongs, and let cool slightly. Wash it thoroughly with cold soapy water, rinse out the soap, and allow the fabric to dry.
4. Attach the fabric strip to your LNJ page where this procedure is described.

Fabric Strip #3:

1. Prepare a dye bath using ~0.1 g of Martius Yellow, 30 mL of water and ONLY ONE drop of dilute sulfuric acid. (1 M H_2SO_4 or 10% H_2SO_4 would be fine.)
2. Bring the bath to a boil and heat the piece of test fabric in this dye bath for 1 minute.
3. Remove it with tongs, rinse, wash with soapy water, and rinse again. Let it dry.
4. Attach the fabric strip to your LNJ page where this procedure is described.

A Vat Dye

Fabric Strip #4:

1. Prepare a dye bath by mixing 50 mL of water, ~0.1 g of indigo (a dark blue powder), ~1 mL of saturated aqueous Alconox (soap) solution, 2.5 mL of 3 M aqueous NaOH, and 1 g of $Na_2S_2O_4$ (sodium hydrosulfite).
2. Heat the mixture to a boil (or steaming). Be careful not to inhale the steam from this cauldron. The top of the solution will appear blue (or greenish) still, but looking through the side of the flask, you should see a transparent or slightly yellow solution. If not, add more $Na_2S_2O_4$ until you do.
3. Add the fourth strip of test fabric and heat for at least 10 minutes.
4. Remove the fabric strip with tongs and note the appearance of the fabric immediately upon removal from the bath. Wash the fabric with soapy water, and rinse thoroughly. Note the appearance of the fabric at this point and again in 20 minutes. If you'd like a deeper shade of blue, you can repeat this dyeing process with the same fabric strip.
5. Attach the fabric strip to your LNJ page where this procedure is described.

CLEAN-UP: All of these solutions should be diluted with at least 1 L of water and flushed down the drain with plenty of water.

Reflections:

1. Describe what is happening chemically during the drying process of Fabric Strip #4, dyed with indigo.
2. To examine the fabric strips to see which fibers react best with the various dyes, make a table of fiber types and rank color intensity for each dye with each fiber.
3. Can you see any trends in the type of fibers (and their structures) that work best with the different dyes (and their structures)? Think about the kinds of intermolecular and intramolecular interactions that hold the dyes to the fibers and try to explain the trend(s) that you see.