Tie-Dyeing

Introduction

Learn chemistry while making a colorful tie-dyed shirt!

Concepts

- Dyes
- Covalent bonding vs. adsorption
- pH
- Affinity (hydrophobic/hydrophilic)
- History of chemistry

Materials (for a class of 30 students)

Reactive dyes, various colors, 200–300 g total
Sodium carbonate anhydrous, 500 g
Urea solution, 650 g
Beakers, 1000-mL, 4
Newspaper
Oven racks or sturdy plastic coat hangers
Pipets, Beral-type, jumbo, 15-mL bulb capacity, 120
Plastic bucket, large enough to soak the T-shirts
Plastic drop cloth
Rubber bands, size 33 (3½″ L × ⅛″ W), 120
Rubber gloves
T-shirts, 100% cotton, PFD (prepared for dyeing)
Ziploc® bags or small trash bags

Safety Precautions

Students should wear old clothes and shoes. Reactive dyes are "wash fast." Once the reactive dye makes contact with clothes it will not wash out. Hands may become stained from the reactive dye. The dyes are not easily washed off and will take about two days to wear off hands and skin. Students should wear appropriate protective clothing and chemical splash goggles, disposable plastic gloves and chemical-resistant aprons. Do not let the students get sloppy. Students should not squirt each other with filled pipets of reactive dye solution. Sodium carbonate activator solution is very basic. Be sure to wear rubber or plastic gloves when placing the T-shirts in solution and when the shirt is wrung out at the end of the activation period. Please review current Safety Data Sheets for additional safety, handling and disposal information.

Preparation

1. If T-shirts are purchased that are not prepared for dyeing, they must be prewashed in hot water with two tablespoons of a mild detergent like Joy®, Dawn®, Ivory®, etc. Most new T-shirts are not prepared for dyeing. Do *not* use a detergent with phosphates or chlorines. Dry shirts on the hot cycle to remove spinning lubricants or other surface additives.
2. For a class of 30 students, approximately 16 liters (~ 4.2 gal) of sodium carbonate activator solution is needed. To prepare this solution, mix 500 g of sodium carbonate anhydrous into 16 liters of deionized water and stir. A 5-gallon plastic bucket is ideal for soaking the shirts.
3. For a class of 30 students, approximately 8 L of urea solution is needed. To prepare this solution, mix 650 g of urea into 8 L of water and stir. This solution can be stored if it is not mixed with the reactive dye. Urea increases the solubility of the reactive dyes.
4. Place a small amount of cold water in a beaker and add 4 to 6 teaspoons (12–18 g) of the selected reactive dye. Mix until lumps are removed and all dye is moistened. Add urea solution (as described in step 3) to make a total of one liter of dye solution.
5. The amount of reactive dye is not specific as it depends on how strong a color is desired. Colors like yellow will need more dye. Remember, some of the dye will wash out when the T-shirt is washed in hot water, so make the color darker than desired as an end product.
6. The primary colors of red, yellow and blue can be mixed in varying quantities to develop other colors.
7. Each student will require about one cup (~ 250-mL) of dye solution. For a class of 30 students, prepare at least 2 liters of reactive dye solution for each color to be used.

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Procedure

1. Fill the plastic bucket with at least 2 L of sodium carbonate activator solution. Soak the T-shirts in the sodium carbonate activator solution for a minimum of 20 minutes. The ionization of cellulose increases with increasing alkalinity of the solution, and above pH 8 there is an adequate number of ionized hydroxyl groups in the fiber for most dyeing purposes. Soaking the T-shirts for 2 hours will maximize the number of possible bonding sites. After the T-shirt has soaked, wear gloves and wring the T-shirt out over the plastic bucket. Add extra sodium carbonate solution to the bucket as needed.
2. Shirts are now ready to fold and tie. A spiral pattern is created by laying the shirt flat on a surface protected by a clean dropcloth. The shirt is held with the thumb and fingers at the point where the center of the spiral will be located (see Figure 1). Use a twisting motion to coil the shirt and use your other hand to bring the loose ends of the shirt into the circle (see Figure 1). Take four rubber bands and slide them around the shirt so they intersect at the center where the twist began (see Figure 2). Make sure the rubber bands are very tight to prevent dyeing in these areas. The shirt now appears to look like a "pie" cut into eight pieces. The bound shirt can be turned over and dyed on both sides. This type of folding pattern was selected because it is the easiest to do and the entire tie-dyeing process can be completed in a 50-minute lab period. Students also like this pattern the best.

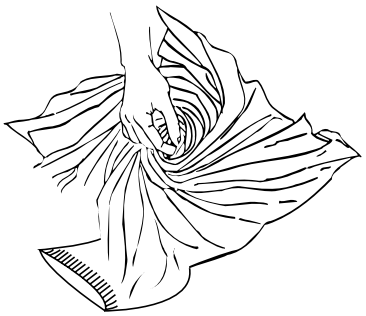

Figure 1.

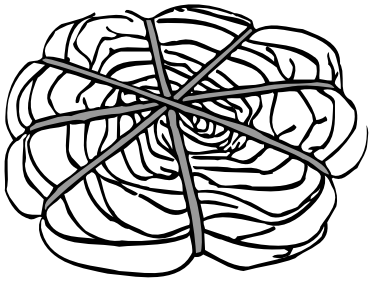

Figure 2.

3. Wear gloves when dyeing and handling the shirts. Dyeing can be done on oven racks placed over sinks or directly on newspaper to absorb excess dye. After a shirt is placed on a *clean* rack, dyes can be applied using jumbo Beral-type pipets. Apply the dye to one side of the shirt by slowly applying the reactive dye solution onto each section of the shirt. A beautiful design can be made by dyeing each section of the shirt a different color. Once one side of the shirt has been dyed, turn the shirt over and repeat the dyeing process on the other side. Shirts should drain for 15 minutes if possible.
4. Wrap the shirt in some dry newspaper and place it in a plastic Ziploc® bag or small trash bag—close the bag to keep the shirt moist. Most colors will have completely reacted after 4 hours, but less reactive colors, such as green and yellow, will take as long as 24 hours. Be patient. Let the dyes react completely.
5. At home, remove the shirt from the bag and rinse it in warm water (75–90 °F) in order to remove the unreacted dye and the sodium carbonate activator. Change the water and continue to rinse. Repeat until the water remains clear and the shirt does not feel slippery.
6. Set the washing machine on the HOT water setting and wash as many as 10 shirts at one time in two tablespoons of the prewash, such as Joy® or Dawn® dish soap. Dry shirts on the hottest dryer setting. The reactive dye is washfast so it is now safe to wash with other clothes using normal detergents. The reactive center of the dyes is a dichloro-triazinyl group so do not use bleaches on the shirt.
7. Now be creative! Try other patterns for folding. Dye labcoats, socks, tennis shoes, etc. As long as the material is 100% cotton, it will work fine. This makes a great lab to do before the Christmas holidays. Students can make personalized gifts that are affordable. Use this activity as a fundraiser for the science club at your school.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. All of the chemical solutions and reactive dyes may be disposed of according to Flinn Suggested Disposal Method #26b.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, chemical reactions, motions and forces

Tips

- Reactive dyes should be stored at room temperature and have a shelf life of two years.
- Prepared dye solutions should be used within a week.
- Perform the binding process in an area separate from the dyeing area to prevent shirts from picking up dye by mistake.
- Students tend to use a lot of dye and there is a lot of dripping and spillage so be prepared. Using a painting plastic drop cloth will make clean-up easier.
- Fewer beakers of dye and more pipets work best. Too many beakers take too long to clean up and reorganize between classes. Shirts can pick up some extra color dyes by mistake, but students will be applying so much dye that it probably will not matter. Clean work areas will minimize problems.
- Flinn carries 10 reactive dyes for tie-dyeing.

Acknowledgment

Special thanks to Elnore A. Grow, Lakewood, Colorado, and Penney Sconzo, Westminster School, Atlanta, Georgia for providing us with the instructions for this activity.

Materials for *Tie-Dyeing* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP8700	Tie-Dyeing—Chemistry Fun Activity Kit
AP8701	Pipets, Jumbo, Beral-type, 15 mL capacity, pkg/120
AP8702	Urea, 650 g
S0052	Sodium carbonate, 500 g
AP8704	Reactive Dye, Yellow, 45 g
AP8705	Reactive Dye, Red, 45 g
AP8706	Reactive Dye, Blue, 45 g
AP8707	Reactive Dye, Green, 45 g
AP8882	Reactive Dye, Royal Purple, 45 g
AP8883	Reactive Dye, Orange, 45 g
AP8884	Reactive Dye, Hot Pink, 45 g
AP8885	Reactive Dye, Turquoise, 45 g
AP8886	Reactive Dye, Sky Blue, 45 g
AP8887	Reactive Dye, Black, 45 g
AP9073	Tie-Dye Lab Coat Kit
AP6304	Rainbow Tie-Dyed Lab Coat, S
AP6293	Rainbow Tie-Dyed Lab Coat, M
AP6294	Rainbow Tie-Dyed Lab Coat, L
AP6295	Rainbow Tie-Dyed Lab Coat, XL

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.