Swirling and Churning Milk

Although you might think food color and soap would spread throughout milk as they do in water, they don't. Milk's nonpolar fat globules have an effect on the dispersion, as the following activity will show. You might be surprised by your results!

Materials

- 2 small, clear, plastic cups or glasses
- water
- 1/4 cup whole or 2% milk
- several different food colors in dropper bottles
- cotton swab
- dishwashing liquid
- 1/4 cup measure

Safety

Do not drink the milk used in this activity.

Exploration

Step 1 Pour about 1/4 cup water into one of the cups or glasses. Add one drop each of several different food colors to the surface of the water. What happens during the first minute? Why?

Step 2 Pour about 1/4 cup of milk into the second cup or glass. Add one drop each of several different food colors to the surface of the milk. What happens to the food color? Explain why the food color behaves differently in milk than it does in water.

Step 3 Wet one tip of the cotton swab with water and touch it to one of the food color drops in the milk. What happens to the food color?

Step 4 Wet the other tip of the cotton swab with dishwashing liquid. Touch it to one of the food color drops in the milk. What happens to the food color?

Challenge

Look up the term "micelle." Describe a micelle, and include an illustration. Then describe the nature of milk as containing fat micelles. Explain the observation in Step 4 based on the chemical nature of soap and milk.

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Concepts

micelles, polarity, solubility, properties of detergent

Expected Student Responses to Exploration

Step 1 (a) Color from the drops slowly spread outward in the water as the drops slowly sink.
(b) The drops spread out because they are water-soluble. They sink because they are more dense than water.

Step 2 (a) The drops essentially remain intact on the surface of whole milk. With 2% milk the drop remains on the surface for some time but eventually sinks.
(b) The drops of food color float because they are less dense than milk. They do not spread because the nonpolar fat globules interfere with the dispersion of the dye molecules.

Step 3 Little happens; some of the intact food color drops may soak into the swab.

Step 4 (a) The food color swirls and churns in the milk.
(b) A micelle is a collection of long molecules whose long nonpolar ends come together in a spherical shape. Their polar ends point out into the water, thus excluding the nonpolar portions from the polar water. Students should also have a drawing illustrating this. (See Figure 1.)

Expected Student Answer to Challenge

Because it is less dense than milk, the food color floats. Nonpolar fat globules in milk prevent the food color from spreading. When soap is added, it causes the food color to swirl around. The nonpolar ends of the soap molecules are attracted to the nonpolar fat globules of the milk, forming fat globule–soap micelles. This attraction pushes the water in the milk away, carrying the food color with it, resulting in the swirling color.

Reference

"Food Colors in Milk"; Fat Chance—The Chemistry of Lipids; Sarquis, M., Ed.; Science in Our World Series; Terrific Science: Middletown, OH, 1995; pp. 71–75.

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