



COLORADO STATE UNIVERSITY
EXTENSION

Wade Ingle M.Ed

Magic Milk Surface Tension

Objective: Students will be able to define surface tension and make connections between surfactants and their uses in industry and the production of common household products .

Materials

At your station, you should find the following materials:

- 3 shallow clear containers
- 3 containers of milk (skim, 2%, whole)
- 1 container of water
- Liquid food coloring
- Mystery liquid
- 1 penny
- 1 eye dropper

Pre-Lab Exploration Activity

Penny Drop Procedure 1

1. Place the penny on a flat surface in front of you. *Using the eye dropper, we are going to add water to the top of the penny one drop at a time until the water flows off the penny.*
2. First take a guess as to how many drops will stay on the penny before the water flows off of the penny.
3. Counting the drops, add drops of water onto the penny until the water spills over the edge.
4. How many drops did the penny hold? (*record your results*).

Penny Drop Procedure 2

5. Using a paper towel, dry off your penny and your work space.
6. Limit the drops to 5 less than the number of drops the penny would hold in part 1. (Example: if it took 20 drops to get the water to spill over, you will only add 15 drops this time.)
7. Add one drop of the mystery liquid to the water on the penny.
8. Observe the results. (*Record your observations*).

Share and Process

1. Record your results from procedure 1 and make a hypothesis of why you observed a change in your results when the mystery liquid was added in procedure 2. Record your answer and share your hypothesis with your team members.
2. Why do you think the water spilled off the penny once the mystery liquid was added?

Hypothesis: *An explanation made on the basis of limited evidence as a starting point for further investigation.*

Background

The word “**surfactant**” is a contraction of the three words “Surface Active Agents.” What is a surfactant? Surfactants are materials that lower the surface tension (or interfacial tension) between two liquids or between a liquid and a solid. In the general sense, any material that affects the interfacial surface tension, can be considered a surfactant, but in the practical sense, surfactants may act as **wetting agents**, **emulsifiers**, **foaming agents**, and **dispersants**.

<https://knowledge.ulprospector.com/3106/pc-surface-active-agents>



7th grade Colorado Science Standard: 1. Mixtures of substances can be separated based on their properties such as solubility, boiling points, magnetic properties, and densities.



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Generalize and connect

In what other fun ways can we use surface tension to do a fun experiment?

Surface tension is what kept the water on the penny creating a dome-shaped puddle on top. When the water spilled off of the penny, it was due to gravity acting on the water. The last drop created enough pressure to overcome the strength of the surface tension between the water molecules. Once this happens, the molecules break apart slightly and spill over the edge of the penny.

Conclusion

How did the results in each container differ?

How were the results in each container the same?

Why do you think you got the results you observed?

In what ways do you think the results you observed could be used in the world’s workplaces?

Connect your thoughts to a scientific career.

Procedure

1. Pour one type of milk to each shallow clear container until the bottom of the container is covered.
2. Using your imagination, divide the milk into quarters (like a pie cut into four pieces).
3. Place three drops of food coloring about an inch from the center of the puddle of milk. Use a different color for each “pie piece”.
4. Place one drop of mystery liquid in the center of the puddle of milk in between the colors you have just added.
5. Observe the results.

Career Connection

Chemical engineers create products such as:

- Paint colors
- Scotch Guard
- Laundry detergents
- Shampoos, bath products and hand soaps
- Food ingredients
- Concrete plasticizers



Career Connections

Surface active agents play an important role as cleaning, wetting, dispersing, emulsifying, foaming and **anti-foaming agents** in many practical applications and products, including: paints, **emulsions adhesives**, inks, **biocides** (sanitizers), shampoos, toothpastes, firefighting (foams), detergents, insecticides, de-inking of recycled papers and ski waxes.

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Magic Milk Surface Tension (Instructor Guide)

Objective: Students will be able to define surface tension and make connections between surfactants and their uses in industry and the production of common household products .

Explore Activity (Part 1)

Begin with the learn-by-doing exploration activity (Penny Drop).

- Review the instructions, or ask them to perform each step per your instructions.

After the results of part 1 are observed ask/explain the following:

- Ask the students: “Why do you think the water puddled up into a dome shape on top of the penny?”
- Explain that water, like all fluids, have surface tension that holds the particles (molecules) together.
- Explain:” It is like a puzzle with all the pieces attached laying over a ball, or rock.”
- Explain:“ Once you added the last drop, the force of gravity overcame the surface tension and caused the water particles (molecules) to break apart enough to make the water flow over the edge of the penny.

Mystery Liquid = Rubbing Alcohol, or Dawn Dish Soap

Explore Activity (Part 2)

- Review the instructions, or ask them to perform each step per your instructions.
- Discuss the difference between the results from Part 1 and Part 2. “Why did your results differ?”
- Ask: “Why do you think the mystery fluid caused a difference?”

Share and Process

- Explain the mystery fluid is a Surfactant. (See background information)
- Surfactants are used in the production of many different types of household items. Can you think of a few products where surfactants may have been used?
- Explain that we are now going to do an experiment using the mystery fluid. During the procedure of the Magic Milk experiment, predict what will happen to the milk and food colors that we will be using.

Additions to content: Physical vs. chemical change is an excellent addition to content which can be discussed in a whole group setting.

Background

The word “**Surfactant**” is a contraction of the three words “surface , active and agents.” What is a surfactant? Surfactants are materials that lower the surface tension (or interfacial tension) between two liquids or between a liquid and a solid. In the general sense, any material that affects the interfacial surface tension, can be considered a surfactant, but in the practical sense, surfactants may act as **wetting agents**, **emulsifiers**, **foaming agents**, and **dispersants**. <https://knowledge.ulprospector.com/3106/pc-surface-active-agents>



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Magic Milk

Surface Tension

(Instructor Guide)

Objective: Students will be able to define surface tension and make connections between “surfactants” and their uses in industry and the production of common household products .

Generalize and Connect

Note to instructor: Although recording results is important in the scientific process, instructors may elect to have discussions about the results of each experiment. Consider age and time limitations and adjust accordingly.

Discuss: In what other fun ways can we use surface tension to do a fun experiment? *(Answers will vary)*

Surface tension is what kept the water on the penny creating a dome-shaped puddle on top. When the water spilled off of the penny, it was due to gravity acting on the water. The last drop created enough pressure to overcome the strength of the surface tension between the water molecules. Once this happens, the molecules break apart slightly and spill over the edge of the penny.

Magic Milk Procedure

Review the steps in the procedure prior to conducting the lab. Have students label their clear container (clear plastic saucers work well).

It is also recommended that instructors perform each experiment process prior to administering it to youth.

- Review the instructions, or ask them to perform each step per your instructions.

Discuss the following questions:

- In what ways did the results in each container vary?
- How were the results in each container the same?
- Why do you think you got the results you observed?
- In what ways do you think the results you observed could be used in the world’s workplaces?
- Connect your thoughts to a scientific career.

Discuss the “Career Connections” Information above.

Examples of household products that are surfactants: Paint colors, Scotch Guard, laundry detergents, shampoos and soaps, food ingredients, and concrete plasticizers.

Mystery Liquid = Rubbing Alcohol, or Dawn Dish Soap

Career Connections

Surface active agents play an important role as cleaning, wetting, dispersing, emulsifying, foaming and **anti-foaming agents** in many practical applications and products, including: paints, **emulsions, adhesives, inks, biocides** (sanitizers), shampoos, toothpastes, firefighting (foams), detergents, insecticides, de-inking of recycled papers and ski waxes.

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Magic Milk

Surface Tension

(Instructor Guide)

Explanation of Results

Simplified response: The alcohol does not mix with the milk. Instead it floats on top and spreads over the surface. As it spreads, it grabs the food coloring. Alcohol is a "degreaser" so the molecules in it are attacking the fat in the milk, causing motion which creates the swirling of the colors. Where the colors meet, they combine and form new colors

More details: Liquids like water and milk have a property known as **surface tension**, due to the cohesive forces of the liquid's molecules. If you look closely at the edge of the surface of water in a clear glass, the water appears to rise up the side of the glass because the surface tension of the water is actually pulling the water away from the glass inward toward the center of the surface. Since milk is mostly water, it has surface tension like water. Homogenized milk has gone through a process where the fat is broken up into tiny pieces of fat called **globules** and spread throughout the milk. When the food coloring was added to the milk, the fat globules were steady and undisturbed. Food coloring is less dense than milk, so it floats on the surface. When alcohol touches the surface of the milk, things begin to move. Alcohol weakens the milk's bonds by attaching to its fat molecules. As the alcohol diffuses into the solution it surrounds the fat globules in the milk. When you drop the alcohol into the center of the milk, it quickly spreads out toward the edges, because alcohol reduces the surface tension of water/milk.

Alcohol molecule shows surfactant-like behaviors due to one hydroxyl (OH) group in its chemical makeup. Active ingredients in liquids such as dish soap is a class of chemicals called **surfactants**, which change the properties of the surface of a liquid, greatly reducing the surface tension. When the advancing surfactant 'wave' hits the colors, the surface tension relaxes and the drops of color can mix MUCH faster. The stronger surface tension of the surrounding liquid then pulls the surface away from the weak, soapy region. The food coloring moves with the surface, streaming away from the alcohol. This movement sets up currents on the top and bottom of the milk and forces the food coloring under the surface of the milk. The alcohol reduces the surface tension of the milk by dissolving the fat molecules. The interaction between the alcohol and the fat in the milk causes turbulence in the bowl as the alcohol breaks down the fat in the milk. This rapidly mixing fat and alcohol movement causes the food coloring to swirl. The swirling food coloring shows what is happening in the milk allowing us to observe the invisible activity of how the surface of the milk moves and changes in response to the alcohol breaking up the fat in the milk. As the alcohol becomes evenly mixed with the milk, the action slows down and eventually stops. With the alcohol removed from the surface, surface tension returns to its original strength. Adding another drop of alcohol will start the process again and the experiment can be repeated. Eventually all of the fat globules in the milk will be surrounded by alcohol and some alcohol will remain on the surface causing surface tension movement to stop.

Career Connections

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