Quarto Classroom with Liz Lee Heinecke

# Agnes Pockels b. 1862

## SURFACE TENSION

### KITCHEN SINK CHEMIST

Agnes Pockels was born in Venice, Italy, in 1862. Her father was an officer in the royal Austrian army, but when she was nine years old, he became very ill with malaria. Her family moved to Brunswick in Lower Saxony, which is part of Germany. Although she attended a high school for girls and was fascinated by science, women were not accepted into universities. She wanted nothing more than to continue her studies, but she was forced to remain at home to take care of her two ailing parents while her brother went off to college.

### KITCHEN SINK SCIENCE

Fortunately for the field of chemistry, Agnes's curiosity was unstoppable. She began to notice interesting phenomena while washing dished in her kitchen sink. Fascinated by how oils and particles formed films on water, she observed that those films could be disturbed by soaps and other materials. Agnes transformed her kitchen into a research station and dove into the study of surface tension, which is the name for the way molecules stick together on the surface of a fluid. Her brother Fredrich, who was studying science at the university, recognized his sister's hunger for knowledge and supported her in every way he could. Besides observing her work, he gave her access to a physics journal so that she could learn what other scientists were doing in their more well-equipped laboratories.

### SLIDE TROUGH

By the time she was twenty, Agnes had invented a "slide trough," which allowed her to play with the way a liquid's surface behaved, by sliding a wire or metal strip across the top of it. She used her apparatus to create very thin layers of fluids and then to test the effect of different contaminants, such as fine powders, on surface tension. Besides discovering methods for applying uniform layers of particles to a surface, she discovered that her trough could sweep a surface free of surface contaminants.

### PUBLICATION

Agnes shared her results by writing a letter to another scientist who studied the surface of liquids. He was impressed, and eventually her work was published in the famous journal *Nature*. She was delighted to learn that other scientists were using her research results and trough design in their own laboratories. Pockels continue studying surface tension, and her work led to many discoveries and innovations in surface tension research and material science.

### A KIND HEART

Agnes Pockels's brother died in 1913, and following World War I her beloved physics journal was no longer published. She lived out the rest of her life in relative obscurity, always helping others. Four years before her death, Agnes was awarded the Laura R. Leonard Prize of the German Colloid Society, "for her quantitative investigation of the properties of interfaces and surface films, and for the methods she used, which have since become fundamental in modern colloid science."

# SURFACE TENSION

Agnes Pockels, the founder of surface chemistry, loved science, but she was trapped in a life of domestic chores. She became interested in the surface tension of liquids while washing dishes one day and the rest is history. In this experiment, you'll use dish soap and alcohol to disrupt the surface tension of milk, water, and oil.

**Fig. 8.** Observe the changes in surface tension.

## MATERIALS

- Small dish
- Dish soap liquid
- Plates
- Milk
- Liquid food coloring
- Cotton swabs
- Vegetable oil (or canola oil)
- Cornstarch, fine pepper, or confectionary dusting powder
- Rubbing alcohol (isopropanol) in spray bottle (optional)

## SAFETY TIPS AND HINTS

If using rubbing alcohol, perform the experiment outdoors or in a well-ventilated area. Small children must be supervised. Safety goggles are recommended.

## PROTOCOL

**1** In a small dish, mix together some water and a large squirt of dish soap.

**2** Pour a shallow layer of milk onto a plate. *Fig. 1.*

**3** Add several drops of food coloring to the milk. *Fig. 2.*

**4** Dip a cotton swab into the soapy water. Touch it to the surface of the milk to break the surface tension. Hold the swab in once place and observe what happens to the food coloring. *Fig. 3* and *Fig. 4.*

**Fig. 1.** Pour milk on a plate.

**Fig. 2.** Add several drops of food coloring to the milk.

**Fig. 3.** Touch a soapy swab to the milk to break the surface tension.

**Fig. 4.** Hold the swab in one place and observe what happens.

**Fig. 5.** Add oil to colored water.

**Fig. 6.** Touch a soapy swab to water, oil, and food coloring.

**Fig. 7.** Wearing safety glasses, spray the oil-water mixture with alcohol.

**Fig. 9.** Use a camera to record the movement of the fluids in slow motion.

**5** Mix water and a drop of food coloring together on a new plate. Add a few small pools of oil to the plate. ***Fig. 5.***

**6** Drop some food coloring into the oil and add some fine powder (optional) such as cornstarch, pepper, or dusting powder. Touch a soapy swab to the water and to the oil to see what happens. ***Fig. 6.***

***Optional:*** Spray a mixture of food coloring, water, oil, and powder with rubbing alcohol to see what happens to the surface tension. ***Fig. 7, Fig. 8, Fig. 9.***

## CREATIVE ENRICHMENT

Use a camera to record the experiment in slow motion to observe the movement of the liquids.

Study how different powders suspended on milk or water react to breaking the surface tension using dish soap.

Use different objects, such as a feather or a paper towel, to remove oil or powder from the surface of water. Will dish soap remove the oil from feathers?

Wash the dishes at your house to see how soap breaks up oil and fat in the sink.

Test different methods of physically removing oil from water.

## THE STORY BEHIND THE CHEMISTRY

Water molecules love to stick together. They're called polar molecules because they have positive and negative poles like a magnet. The pole, where the two smaller hydrogen atoms hang out, is positively charged, while the oxygen end carries a small negative charge. Like weak magnets, the positive regions of water molecules are attracted to the negative regions of nearby water molecules.

If you pour liquid water onto a plate, attractive water molecules pull on each other from all directions, which keeps most of them fairly evenly spaced as they move around in the liquid. The exception is the water molecules on the surface. Because they are next to the air, nothing is pulling on them from above, so they can snuggle up to neighboring water molecules.

This packing of water molecules next to the air forms sort of an elastic skin on the surface, and the scientific name for the way the molecules stretch across the water is "surface tension." Milk is mostly made of water. In this lab, dish detergent acts as a chemical knife that breaks the surface tension on milk and water, so that food coloring and floating particles are free to swirl freely through the liquid. It's also interesting to experiment with detergent and alcohol to see how they disrupt the surface tension of a mixture of water, food coloring, and oil.