CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

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Project Number

36204

Project Title

Drop by Drop: Manipulating the Surface Tension of Water to Find the Best Way of Cleaning

Abstract

Objectives/Goals

This project explored how temperature, surfactant, and salt would influence the surface tension of water, in order to find the best method of cleaning. I hypothesized that the best way to lower water surface tension is to manipulate, or otherwise, disrupt the intermolecular pull among the polar water molecules at or near the water-air interface. I attempted to do so by using 1) temperature to increase the kinetic energy of water molecules, 2) surfactant, (e.g. soap) to target the water molecules on the water surface, and 3) ions of Na+ and Cl- to influence the hydrogen bonds between water molecules on the surface and in the bulk.

Methods/Materials

Based on the principle of a stalagmometer, I developed a version of the drop weight method using a syringe and plastic tubing to determine the surface tension of the following liquids: aqueous solutions of sodium lauryl sulfoacetate (SLSA) at 0.01375%, 0.0275%, 0.055%, 0.1%, 0.2% and 0.5% concentration levels at 20oC, and aqueous solutions of NaCl at 0M, 1M, 2M, and 3M concentration levels at 20oC. The surface tension of distilled water at 5oC, 15oC, 20oC, 35oC and 50oC was also measured.

Results

A higher temperature lowered the surface tension of water linearly by moderate amount. Surfactant (SLSA) reduced water's surface tension dramatically until the critical micelle concentration (CMC) was reached at around 0.1%, beyond which the surface tension of SLSA solution remained steady at about 30 dynes/cm. The surface tension of salt water rose slightly (by about 1.7dyn/cm per molar) as salt concentration increased.

Conclusions/Discussion

My hypothesis was supported by all but one discovery: salt actually raised (not lowered) water's surface tension. In the real world, knowing how much soap to use to wash objects is important, since adding too much beyond CMC wouldn't necessarily clean better. When surfactants aren't available, hot water would be most efficient. The concepts of surfactant, CMC, and micelle are fascinating. I'm planning to investigate the properties of different surfactants and find ways to lower CMC to further improve the cleaning process, for example, how do temperature and salt affect CMC? Knowledge gained is useful in real life applications such as oil recovery, environmental remediation, and drug delivery.

Summary Statement

I developed a modified stalagmometric method to study the influence of temperature, surfactant, and salt on water surface tension. I found that surfactant was much more effective in lowering surface tension than rising temperature.

Help Received

Ms. Davignon offered valuable advice and support, and taught me the fundamental chemistry concepts that enabled me to carry out this project. My father tried out my procedure to verify repeatability, and helped me with Excel graphing. My parents purchased all of my materials.