CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Zoe E. Dubrow

Project Number
S0607

Project Title
Multi-Phase Droplets on Superhydrophobic Surfaces

Abstract

Objectives/Goals
The purpose of this project was to determine if liquids other then water could form droplets with contact angles above 150 degrees on a superhydrophobic surface. Once other liquids were discovered that had superhydrophobic properties to attempt to make multiphase droplets and characterize their properties, as well as to develop useful applications for multiphase liquid droplets on superhydrophobic surfaces.

Methods/Materials
The effect of surface tension on superhydrophobicity was determined and based on the criteria determined, certain liquids and solutions were screened on hydrophobically treated silica nano-particle based superhydrophobic surfaces. Methods were developed to combine these fluids into multiphase spherical droplets that could be physically and chemically manipulated by rolling them on a superhydrophobic surface. Durable superhydrophobic liquid marbles where a superhydrophobic membrane is suspended on the exterior of the droplet were also created both with a single liquid and as a multiphase marble.

Results
The high surface tension and polarity of water results in the formation of spherical (150° or higher contact angle) droplets on superhydrophobic surfaces. It was found that surface tension was the dominant property in determining if a liquid would form spherical drops. Glycerin and sorbitol solutions are two examples of such liquids. Liquids such as DMSO that had high polarities but only modest surface tensions wetted the superhydrophobic surface. Droplets on superhydrophobic surfaces and liquid marbles with multiple liquid phases have not been previously documented in the literature.

Conclusions/Discussion
A liquid droplet resting on the tips of the nano-particles of a superhydrophobic surface is essentially a container without walls. When multiple phases can be combined in a single drop new applications can be attempted. The utility of these multiphase droplets was shown in several experiments that made use of the rapid gas diffusion out of the drops as well as the concept of fluid mixing by rolling. A novel rapid bioassay is proposed for E. Coli detection utilizing the unique properties of multiphase liquid droplets.

Summary Statement
Surface tension was found to be the main factor that allows liquids to bead up on superhydrophobic surfaces, a finding which enabled the creation of novel multi-phase liquid drops and several potential applications.

Help Received
Dr. Hugh Daniels and Mr. Robert Dubrow gave valuable advice.