CALIFORNIA STATE SCIENCE FAIR
2009 PROJECT SUMMARY

Name(s)

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Project Number

S0506

Project Title

F.L.A.S.H.; The Formation and Characterization of Floating Self-Assembling Super-hydrophobic Nano-particle Membranes

Abstract

Objectives/Goals

While working on traditional super-hydrophobic surfaces, a method to create self-assembling membranes on the surface of water from hydrophobic fumed silica nano-particles was discovered. The purpose of this project was to characterize the properties of the membranes and determine possible applications.

Methods/Materials

Properties of the membranes such as permeability, porosity, contact angle, inhibition of evaporation as well as vapor phase reactions across the membrane were investigated.

Results

It was discovered that when hydrophobic fumed silica nano-particles are vigorously agitated in water, they self-assemble at the air/water interface. The monolithic membrane that forms was determined to be approximately one micron in thickness and had pores of 10-100nm in diameter. When a drop of water is placed on the silica membrane, it exhibits a contact angle above 150 degrees and rolls. There is no liquid water diffusion between drops on the surface of the membrane and the water below it. The vapor permeability of the membranes were determined and found to be dependent on thickness. Vapor phase chemical reactions were performed between the underlying aqueous layer and drops on the surface.

Conclusions/Discussion

A method for the creation of ultra-thin floating super-hydrophobic membranes through the agitation of hydrophobic fumed silica particles in water was discovered. Super-hydrophobic membranes formed using this method are self-assembling and self-repairing requiring no organic binders or special chemistry. The membrane reduced the evaporation rate of water only about 10% when floating on its surface. Liquid water does not migrate through the membrane despite its thin low density structure. It was demonstrated that vapor phase chemical reactions can take place between a drop on the surface of the membrane and the underlying liquid poolThe membranes have enough structural integrity to support a 5mm polystyrene ball and can be removed from the water surface with a glass slide intact.

Applications of these membranes for chemical sensing are also discussed.

Summary Statement

Vapor permeable, super-hydrophobic, monolithic membranes were created in-situ on the surface of water by the self-assembly of hydrophobic silica nano-particles and properties of the membranes were investigated for use in applications.

Help Received

Jay Goldman operated the scanning electron microscope and gave his opinion on the membranes; Bob Dubrow gave valuable advice; Nanosys Inc., Palo Alto Ca., for allowed use of their laboratories and equipment.