Center for Advanced Studies in Novel Surfactants (CASNS)

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Center website: http://www.columbia.edu/cu/iucrc/

Greener, More Sustainable Solutions for the Mining Industry

Mineral separations have been becoming increasingly challenging due to the emergence of problematic ores in several existing operations. It is well known within the mining industry that in selective flotation separation of valuable minerals from complex ores, certain silicates and slime-forming minerals have significant detrimental effects. Until recently such effects were attributed to chemical factors such as heterocoagulation between the silicates and valuable minerals, which is generally referred to as slime coating. Previous approaches to this slimes problem have been unsatisfactory because they consume too much energy and water and are not sustainable.

Researchers at CASNS, in cooperation with Cytec Industries and centers' sponsor Vale-Inco, have developed new techniques to study rheological properties of such ore pulps. This research program, which was designed to develop a scientific understanding of contributions from both physical and chemical factors of slimes to selective mineral separation and suspension rheology, has discovered the large role played by morphology of certain silicate minerals, when present in even small amounts in a complex mixture of minerals.

When the CASNS research program was initiated, there were no established methods to monitor the rheological properties of ore pulps, which typically have a wide size and specific gravity distribution, due to difficulties caused by the rapid settling of coarse and heavy particles. These techniques are based on sedimentation and determination of various rheological parameters such as viscosity, yield stress and torque values at high shear rate. Findings should have significant scientific and technological impacts, leading to the derivation of pathways to enhance selective separation of valuable minerals from complex ores containing slimes and develop a robust solution to the long-standing slimes problem.

> **Economic Impact:** This advance will make smelting more energy efficient, and utilize waste products. Most importantly, This work will result in the design of greener, sustainable solutions for the mining industry: new processes that consume less water and energy, and use green reagents, thus significantly reducing the overall mining environmental footprint and making the

industry more economically productive. It should extend the lifetime of existing mining operations, saving jobs and resources.

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Novel Technologies for Superior and More Sustainable Consumer Products

In the past few years, CASNS has studied complicated systems with interaction among multiple ingredients including surfactants, polymers, enzymes, solid particles, solvents and electrolytes in water and with substrates such as skin and fabric materials. This work provides a knowledge base and framework of learning for industrial applications. In personal care sector, the application of the learning in products such as soaps and shampoos led to milder, less irritative skin care products. In household cleaning and laundry care segments, the learning led to higher performing products with less environmental footprint and cost.

The project examined the industrial systems as the benchmark through the lens of sustainability. Using greener materials based on their profile in the supply chain, the researchers examined novel materials and commercial ingredients and searched for synergy. Through investigation of the physical properties and micro-structure of the surfactant systems and their correlation with the performance, the center were able to provide solid learning toward a new generation of product formulations with higher performance and less cost and footprint.

This research provided systematic learning that helped the development of a newer generation of laundry detergent formulation with better textile skin feel, greater resistance to pH variation, more robust profile of stain removal in laundry washing process, and greater cost effectiveness. Another example is the use of cationic polymers in skin wash products. The research project led to enhanced skin mildness and more effective use of surfactants in cleansing.

Economic Impact: The learning developed at CASNS provides further opportunities for member companies in their R&D efforts to develop products with higher performance and less cost and environmental footprint.

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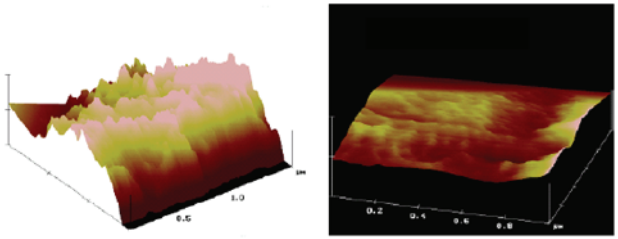
Enhanced Silicone Coatings: Improved Fabric Care

Interaction of silicones with surfactants are very important for better performance of the products in cosmetic and personal care industry, but very little is known about the mechanism by which these polymers interact with various substrates. Generally, improved silicone coating results in better softness, handle, feel and bounce. Results provide quantitative measures for qualitative properties such as softness, bounciness of fiber; important considerations for the fabric care industry.



One area of application is that enhanced silicone coatings enable industry to use much wider varieties of cotton, while getting comparable end-product performance. Thus short fiber length cotton can be used with expected performance comparable to long fiber length cotton. This advance means that higher yielding cotton and cellulosic fibers can also be utilized for quality durable garments even if they are of lower quality.

It has enabled Center collaborators such as Elkay Chemicals to better understand and design silicone chemistries. Impact of this approach is significant to environment and ecology as much wider areas of farmland can be made available for cotton farming.

> **Economic Impact:** This research has produced significant economic impacts in a broad area of surfactant science due to applications in the chemical, cosmetics, mineral, petroleum, and pharmaceutical industries.

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Advances in Basic Science of Skin Cleansing

Washing and cleansing can be a damaging process for skin, so the choice of surfactant becomes very critical in order to minimize damage. Insights on surfactant blends are critically important in deciding what kind of blends to incorporate into product formulations.

Fundamental research at the Center for Advanced Studies in Novel Surfactants (CASNS) on surfactant binding to proteins has benefited development of skin cleansing and skin care products at a center sponsor's main R&D center for skin research. One of the key factors is surfactant micelle charge density, which affects the irritation potential of surfactants. The goal is to minimize charge density up to a point, because with zero charge density, as in non-ionic surfactants, there is usually not enough lather and foam to satisfy customer demand. Formulation science focuses on how to blend components to achieve the desired balance.

Researchers at CASNS have examined how surfactants bind to proteins. They have investigated how and when protein denaturation occurs, how the surfactant binds, how reversible the binding is, and how it may be affected by variables such as cleanser pH and temperature.

> **Economic Impact:** Insights gained from this research are being used by a center sponsor in skin cleansing and skin care products.

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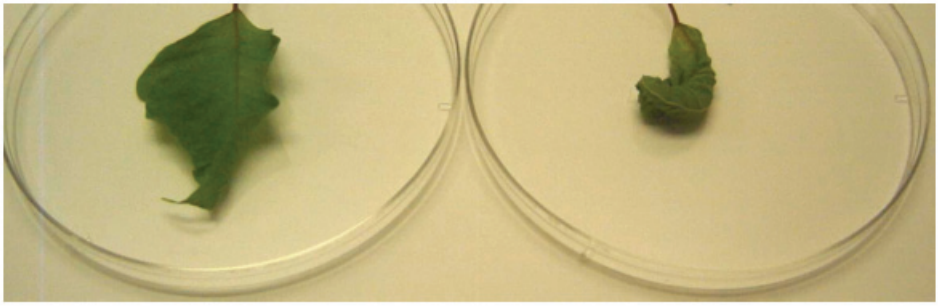

Mild surfactant treated leaf after exposure to open air for 48 hours-barrier in better condition limiting water loss (left); Harsh surfactant treated leaf after exposure to open air for 48 hours-damage to barrier leads to rapid water loss (right).