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Department of Chemistry

Etter Memorial Lecture

9:45 a.m. Thursday, October 20 • 331 Smith Hall

Professor

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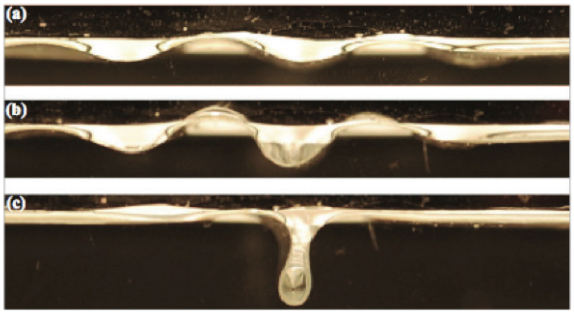
Institute for Biophysical Dynamics & James Franck Institute
University of Chicago

Beyond Wrinkling: Stress Relaxation in Lung Surfactant Monolayers and Other Thin Films

Research interest:
focuses on lipid-protein interactions, with projects on understanding the proper functioning of the lung, the targeting selectivity of antimicrobial peptides, the mechanism of membrane sealing by block copolymers, the interactions between phospholipids and cholesterol, as well as a new project on biomimetic self-healing and adhesive materials.
Website: http://chemistry.uchicago.edu/faculty/faculty/person/member/ka-yee-c-lee.html

Abstract

Lung surfactant is a mixture of lipids and proteins that coats the alveoli, and its main mechanical function is to reduce the work of breathing by reducing the surface tension. Insufficient amount of lung surfactant in premature infants leads to neonatal respiratory distress syndrome, while lung trauma can result in acute respiratory distress syndrome. In order to develop effective treatment for these conditions, a better understanding of the interactions between lung surfactant lipids and proteins is needed. Utilizing optical and atomic force microscopy techniques, we have examined the collapse process in lung surfactant, and have examined how the presence of lung surfactant peptide, SP-$B_{1\text{-}25}$, induces a reversible collapse in lung surfactant monolayers. Our observation indicates that SP-$B_{1\text{-}25}$ in simple phospholipid and model lung surfactant monolayers promote the protrusion of folds into the subphase at low surface tensions. The folds remain attached to the monolayer and reversibly reincorporated upon expansion. Without SP-B, an unsaturated lipid-rich phase is irreversibly "squeezed-out" of the monolayer at higher surface tensions. These folded reservoirs reconcile how lung surfactant can achieve both low surface tensions upon compression and rapid respreading upon expansion, and have important implications concerning the design of replacement lung surfactants. The onset of this folding instability can be understood in terms of the mechanical properties of the film. Statistics of the folding events will be presented and the link between folding on monolayers of nm thickness and that on polyester films that are 3 orders of magnitude thicker will be discussed. By studying different types of monolayers, we have shown that this folding transition in monolayers is not limited to lung surfactant films, but rather represents a much more general type of stress relaxation mechanism. Our study indicates that collapse modes are found most closely linked to in-plane rigidity. We characterize the rigidity of the monolayer by analyzing in-plane morphology on numerous length scales. More rigid monolayers collapse out-of-plane via a hard elastic mode similar to an elastic membrane, with the folded state being the final collapse state, while softer monolayers relax in-plane by shearing. For the hard elastic mode of collapse, we have further demonstrated experimentally and theoretically that the folded state is preceded by a wrinkled state.



Host: Associate Professor T. Andrew Taton Refreshments will be served.

Ka Yee Christina Lee was born in Hong Kong. She came to the United States for her undergraduate education at Brown University. After graduating with honors in electrical engineering in 1986, she attended Harvard University and obtained her master's (1987) and doctorate (1992) degrees in applied shysics. She did her first postdoctoral training at Stanford in the Department of Chemistry, and her second at the University of California, Santa Barbara. Since 1998, Lee has been a faculty member of the Department of Chemistry, the Institute for Biophysical Dynamics, the James Franck Institute, and the College at the University of Chicago. She has received many prestigious national awards for her research.

Margaret C. Etter Memorial Lecture in Materials Chemistry

Margaret "Peggy" Cairns Etter was born on September 12, 1943.She died on June 10, 1992, from cancer. In 1974, she received her doctorate in chemistry from the University of Minnesota under the direction of Jack Gougoutas. She taught organic chemistry at Augsburg College in 1975-76, and worked at the 3M Company from 1976 to 1983. She returned to the University of Minnesota as a postdoctoral fellow with Robert Bryant in 1984 and, within a year, had secured an independent academic appointment. Peggy rose rapidly through the ranks and in 1990 was promoted to full professor. Peggy's outstanding characteristics as a scientist were her infectious enthusiasm, uncompromising scientific standards, and creativity. Her research group made major contributions in the applications of solid-state nuclear magnetic resonance spectroscopy, the design and properties of organic non-linear optical materials, and most significantly, in the understanding and utilization of hydrogen-bonding interactions in crystals. This was reflected in nearly 80 research papers and in several landmark review articles in prestigious journals. Outside recognition in the form of fellowships from the Sloan and Bush Foundations and an Iota Sigma Pi Award for Excellence in Chemistry represent incomplete reflections of the impact of this work. One of her extramural "side projects" was to found a company called "Rochelle Crystal Corporation," for which Peggy was named St. Paul Businessperson of the Year in 1986.