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THE UNIVERSITY of WISCONSIN MADISON

PHYSICS COLLOQUIUM

Ingersoll Lecture

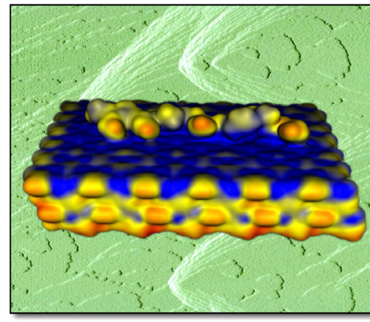
Exploiting protein-crystal interactions to build "switches, throttles and brakes"

What shells, bones and kidney stones can teach us about managing CO_2

James J. De Yoreo

Molecular Foundry
LBNL

Host: Gilbert



Abstract: Coal is the major source of energy for electrical generation across the globe. In the United States, it provides about a third of our electricity, while in China, where coal accounts for over 75% of electrical generation, a new coal-burning power plant comes on line every week. But coal is amongst the most intense sources of greenhouse gases, producing nearly three tons of CO2 for every ton of coal consumed and contributing 40% of all anthropogenic CO_2. Moreover, coal is an essential constituent in about 65% of all steel production. With oil nearing peak production, nuclear energy likely to be slow in coming on line, solar and other renewables still in their infancy, and no obvious substitute for coking steel, the world will continue to rely on coal for decades to come. So what are we going to do with all of that carbon? The answer may lie in the workings of tiny marine organisms, which transform CO_2 into structural materials made of calcium carbonate through a process known as biomineralization. Similar processes direct the growth of bones and teeth and prevent formation of kidney stones. The interaction of proteins with inorganic constituents is a defining feature of biomineralization. An understanding of the structural relationships, adsorption dynamics and resulting control mechanisms may one day enable us to mimic the process. In this talk I will present results from in situ AFM investigations of peptide and protein interactions with growing crystal surfaces in which cantilevers designed to maximize tip-sharpness while minimizing contact force were used to obtain true single-molecule resolution. Analysis of the results reveals how the slow adsorption dynamics, strong electrostatic interactions and tendency towards aggregation peculiar to macromolecules lead to unexpected and varied controls on crystal growth. For example, when the timescales for peptide adsorption and step advancement overlap, minute changes in growth conditions lead to rapid switching between two stable states of growth. Physical models based on the thermodynamics of steps on crystal surfaces and the dynamics of peptide adsorption provide an understanding of the observed behavior. The findings suggest strategies for sequestering CO_2 by directing the timing and rate of carbonate formation in subsurface reservoirs through the use of protein-like molecules as "switches, throttles and brakes".

2241 Chamberlin Hall • Friday, February 6, 2009 • 4:00 P.M.

cookies & coffee served at 3:30 p.m.