Center for Biologically Inspired Materials and Material Systems (CBIMMS)
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SEMINAR

…cally Inspired Low-Temperature Nanofabrication Yields Semiconductors for Photovoltaic and Other Applications”

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We discovered that the silicateins, a family of enzyme proteins occluded within the silica needles made by a marine sponge, can catalyze and structurally direct (i.e., template) the polymerization of silica, silsesquioxanes and a wide range of metal oxide semiconductors from the corresponding molecular precursors at neutral pH and low temperature. These are the first reported examples of enzyme-catalyzed, nanostructure-directed synthesis of semiconductors. Interaction with the template-like protein surface stabilizes polymorphs of these materials (e.g., the anatase form of titanium dioxide and the spinel polymorph of gallium oxide) otherwise not formed at low temperatures. In some cases, interaction between the condensing metallo-oxane and the protein results in preferential alignment of the resulting nanocrystallites, suggesting a pseudo-epitaxial relationship between the mineral crystallites and specific functional groups on the templating protein surface. Genetic engineering in conjunction with diffraction studies of the semiconductor products and the templating surface confirmed the mechanism of action and identified the functional groups responsible for the enzyme’s catalysis. This mechanistic understanding was confirmed and extended through the synthesis of a series of "biomimetic" peptides, polymers, small bifunctional organics and multifunctional self-assembled monolayers that display the functionalities identified as essential for catalysis, yielding new structure-directing catalysts of siloxane and metallo-oxane polycondensation from the corresponding molecular precursors at low temperature and neutral pH. We now have taken this biomimetic process a step further, translating the fundamental mechanisms underlying silicatein-mediated catalysis and templating to a process wholly controlled by chemistry and physics, without the use of any biochemical or organic molecules. As a first proof of principle, we have used this process for the low-temperature synthesis of a unique and strongly photoconductive cobalt hydroxide-based material never before attainable through conventional or high-temperature methods. This material exhibits attractive properties of high dopant density, high carrier density, high surface area, exceptionally long minority carrier density and strong absorption in the visible, appropriate for photovoltaic applications. Because no organics or biochemicals of any kind are used, the new biologically inspired synthesis method yields exceptionally pure inorganic semiconductors, and thus is fully integrable with conventional semiconductor manufacturing and processing.

Tuesday, Mar 29 – 203 Teer Building – 3:05 – 5:00pm