May 2001 Meeting: Jeff Brinker on Self-Assembling Materials

by Dave Thomas

At our Wednesday, May 9th, 2001 meeting, we heard Dr. Jeff Brinker, UNM Physics Department and Sandia National Laboratories, speaking on "Self-assembled materials ... From Dishwashing to Nanostructures." Brinker is helping try out a novel collaboration between UNM and Sandia. So far, he said, it's produced some interesting results.

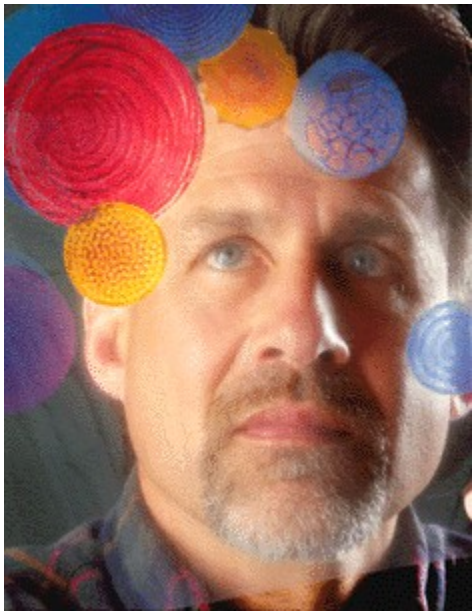
Brinker's goals are not overly ambitious. He simply wants to learn how to control matter on the nanometer scale, devising methods to impart life-like qualities to materials -- such as sensing and responding to their environments. Jeff also wants to learn how to make a material that can repair, replicate, or propel itself. The tricky part is doing this at nano-scales, anywhere from one to 100 nanometers (nm, billionths of a meter). [For comparison to familiar units, a 1-mil (1/1000 inch) garbage bag is a whopping 25,400 nm wide; the wavelength of yellow light is about 500 nm.] Brinker's experiments are on such small scales that he needs a Transmission Electron Microscope just to see what's happening.

At such small scales, photolithography, the method used to produce intricately detailed integrated circuits, is far too bulky and clumsy. With the wavelength of light many times larger than the desired work area, it's like trying to thread a needle with a rope. Brinker was thus led to study methods in which materials assemble themselves.

One remarkable self-organizing material is common dish detergent. Brinker said detergents are "pre-programmed for self-assembly." Detergents are mode of molecules that are hydrophilic (water-soluble) on one end, and hydrophobic (attracted to oils, but repelled by water) on the other end. When detergent is added to water, and energy is added (in the form of splashing or stirring), the detergent molecules naturally line up side-by-side on opposite sides of a thin film of water, creating a new structure (the thin film). Jeff works with silica mixtures; silica is abundant (sand), and silicic acid has many of the properties he needs to exploit.

` Brinker showed a triangular "phase diagram" with water at the lower left, a surfactant ("detergent") on top, and a hydrophobic substance at the lower right corner. He often uses alcohol as the hydrophobic material, and pluronic for the surfactant. Brinker brews up a wicked broth of silica, alcohol and water, and lets it evaporate. As the alcohol evolves, funny-looked studded spheres start to form. As the ratio of ethanol to pluronic and water decreases, the self-organizing reactions change, producing a succession of curious shapes: spheres, then cylinders, then hexagonal pipes, then cubes, and finally lamellar (sheeted) structures. This all happens within a few seconds in the lab.

What good is this nano-tinkering? Well, different-sized surfactants produce different-sized holes, and so this method can be used to make hexagonal arrays of very tiny, very uniform holes - just what is needed to make filters for specific molecules and gases. In addition, material properties such as dielectric constant can be altered; for example, Brinker's group can produce silica with half the dielectric constant of the normal material, making it a better insulator for integrated circuits and similar devices.



Jeff Brinker

Jeff showed many fascinating images of the complex and detailed structures his group and others have produced. Some of the structures looked like the Russian dolls-within-dolls, while others resembled sea-shells, with alternating layers creating strong materials. Brinker's group is now looking at polymerizable surfactants, something that leads to the possibilility of printing out exotic nano-materials using a common inkjet printer.

NMSR thanks Jeff Brinker for a very interesting talk.