Study of Amphiphilic Gold-Dendrimer Nanocomposite Monolayers

Y.-S. Seo[1], K.-S. Kim[1], K. Shin[1], H. White[1], M. Rafailovich[1], J. Sokolov[1], B. Lin[2], H.J. Kim[3], C. Zhang[4], and L. Balogh[4]

[1]SUNY at Stony Brook; [2]University of Chicago; [3]Argonne National Laboratory; [4]University of Michigan

Dendrimer-based nanocomposites are novel organic-inorganic hybrid molecular structures that are synthesized by dispersing very small inorganic molecules in nano-scaled branched polymeric networks and could be applied in catalysis and drug delivery. Since these nanocmomposites are often used both in aqueous media as well as coatings on solid substrates, we tried to determine how they respond to changes in their physical environment by using x-ray reflectivity. We find that the behavior of these structures significantly changes between aqueous and attractive solid substrates and that these structures are very sensitive to whether the solution is acidic or basic, so that they can be used either as sensors or drug delivery agents.

Authors (from left, top): Lajos Balogh, Miriam Rafailovich, Young-Soo Seo, Jonathan Sokolov, and Henry White

A dendrimer is a macromolecular structure containing connectors and branching units built around a small molecule or a linear polymer core, creating stepwise attachment of layers, called generations, that are nearly spherical. This highly symmetrical structure contains a large number of regularly spaced internal and external functional groups that interact with the molecular environment.

One well-studied dendrimer is poly(amidoamine) (PAMAM), which could be used as a building block for molecular-sized medical devices because it contains beta-alanine repeat units (which are amino acids, or basic units of proteins), and thus can be considered as spherical artificial proteins. The interaction of PAMAM with a biological object may be adjusted by modifying the dendrimer's surface properties. But it is extremely difficult to observe PAMAM dendrimers directly in cells or in tissue, because they do not easily give rise to color in organic substances.

Instead, another type of dendrimer, called dendrimer nanocomposite (DNC), can easily be observed by transmission electron microscopy and by other optical methods, so they are promising materials for biomedical nanotechnology.

We synthesized amphiphilic DNCs made of gold and PAMAM by dispersing gold atoms without covalent bonds inside dendrimer molecules (**Figure 1**). We investigated the properties of the DNC monolayer at the air/water interface at NSLS beamline X19C (**Figure 2a**) and on a solid substrate made of a Langmuir-Blodgett film (monomolecular layer containing molecules that are both water-loving and water-repelling) at NSLS beamline X10B (**Figure 2b**) using x-ray reflectivity.

Because of the small amount of gold present in the DNCs and the refractive index contrast between the gold domains and the water substrate, we successfully conducted *in situ* x-ray reflectivity measurements of the DNC. We found that the dendrimer layer is hydrated and the gold is uniformly distributed within the dendrimer body. The second-generation dendrimer was spherical on the water surface, while

BEAMLINE
X19C, X10B

Funding
Materials Research Science and Engineering Center, National Science Foundation; U.S. Department of Energy; Korea Science & Engineering Foundation (KOSEF)

Publication
Young-Soo Seo et al., "Morphology of Amphiphilic Gold-Dendrimer Nanocomposite Monolayers," *Langmuir*, 18, 5927-5932 (2002).

Contact information
Young-Soo Seo, Department of Materials Science, Stony Brook University, NY

Email: ysseo@nist.gov

the fourth-generation had a pancake-like, or oblate, structure at high pressures.

We also found that the shape of the DNCs was very sensitive to the acidity of the solution, indicating that these DNC could be used as detectors of biological activity or drug delivery systems.

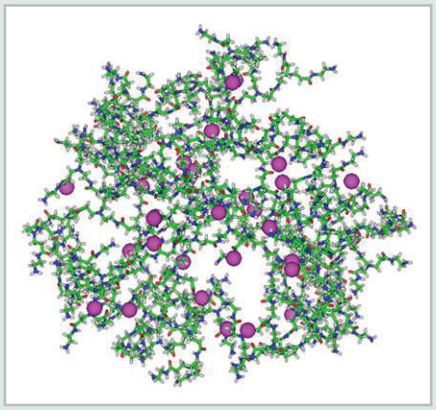

Figure 1. Computer simulation of the gold atom distribution in a dendrimer nanocomposite. (Courtesy of Inhan Lee, University of Michigan in Ann Arbor.)

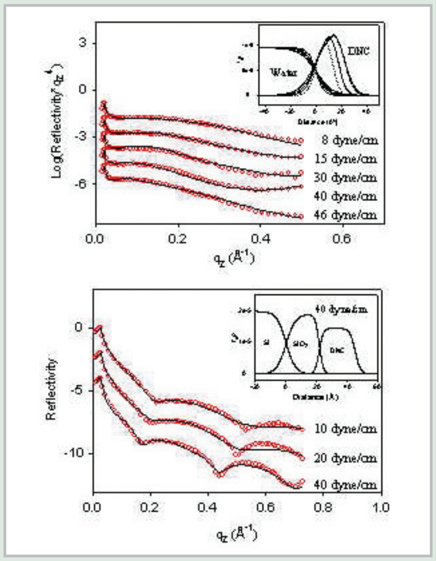

Figure 2. (a) X-reflectivity profiles of DNC monolayer at the air/water interface and (b) Langmuir-Blodgett films as a function of surface pressure and their corresponding scattering length density profiles in inset.