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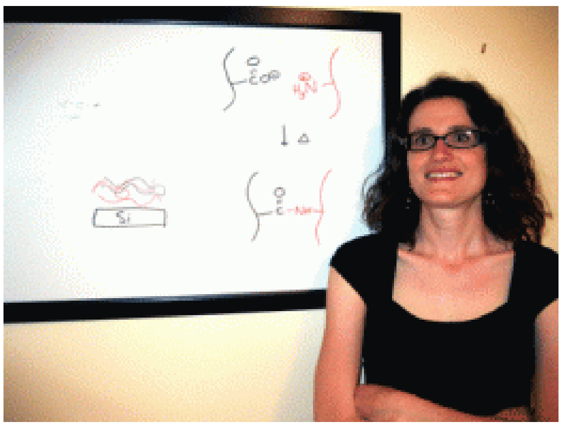
Research shows heat increases stability of thin-film coatings

June 4 2010



Assistant Professor Jodie Lutkenhaus demonstrates the reaction by which nylon-like crosslinks are formed when layers of oppositely charged polymers are heated.

(PhysOrg.com) -- Understanding how thin-film coatings react to temperature changes could lead to more effective and durable sensors, solar-energy converters, safer medical implants and a host of other applications, says Jodie Lutkenhaus, assistant professor in the Artie McFerrin Department of Chemical Engineering at Texas A&M University, who has found that heating some of these films can increase their stability.

The findings, which appear in an upcoming issue of *Soft Matter*, a scientific journal published by the Royal Society of Chemistry, represent a significant step forward in the study of multilayer polymer thin-film coatings — material gaining increased interest for its potential versatility in a number of applications ranging from biomedical to industrial.

Much like how a person uses Saran wrap to cover a dish, scientists envision utilizing these ultra-thin coatings to encompass a wide variety of sensitive and very small materials — for example, drug molecules being delivered to a target area within the human body. The electrostatic properties of the films would allow the coating to stay intact until the drug reaches the precise area inside the body. At that point, the coating could be deconstructed, allowing the drug to reach the targeted area.

This structural manipulability also makes the films attractive options for use in fuel cells, sensors and even solar energy cells, but before researchers can proceed with these applications, they need to know more about the material properties of these films, says Lutkenhaus, who conducted the research with graduate student Lin Shao.

“If people want to use these films for applications in the real world where temperature is a factor, then we’ve got to understand the films’ thermal properties,” Lutkenhaus says.

Isolating a sample of these thin films, Lutkenhaus found that as these films are heated, they react by undergoing a curing process in which they form nylon-like linkages. These linkages, she explains, help to enhance the film’s stability, warding off long-term degradation. Conversely, this crosslinking that results from heating would not be beneficial in instances where a film is required to possess more flexibility, she says.

Understanding this reactivity, Lutkenhaus says, is critical in advancing the technology, which is still in its infancy. For instance, she notes, if this type of film is going to be used in the desert for solar energy applications, it is important to understand how it behaves in desert-like conditions.

This knowledge is also valuable in terms of designing other types of technology that could make use of a thermally responsive thin film. Armed with her latest findings, Lutkenhaus says she hopes to develop a thermally responsive film that can switch between hydrophobic and hydrophilic states with a shift in temperature. Such a film would attract water at one temperature and repel it at another temperature, making it useful in heating and cooling applications, she notes.

Characterizing the thermochemical properties of these films required isolating them from the material which they coat, but that's not an easy thing to do, given how these films are manufactured, Lutkenhaus explains.

Made from a technique known as layer-by-layer assembly, these incredibly small films consist of alternating layers of polymers — long chains of atoms that have been linked together. Think of it as a strand of spaghetti on a molecular level. A single polymer can be less than 10 nanometers in size.

Each polymer layer has either a positive or negative charge. As a layer surrounds the surface of the particular material it is coating, a new, oppositely charged layer is then added on top of it so that the layers adhere to one another until a relatively thick film is formed, Lutkenhaus explains.

Although these films have been traditionally difficult to separate from the material which they coat, Lutkenhaus developed a technique whereby she was able to achieve separation, isolating large quantities of the film for study. Soon after, she began testing the films against changes in temperature.

“We can now characterize a model system for free-standing electrostatic layer-by-layer assemblies,” Lutkenhaus says. “With this system we have been able to characterize the thermochemical properties of these films, measuring their response to changes in temperature.”

Provided by Texas A&M University