Microcantilevers are masters of measurement

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(PhysOrg.com) -- Devices that look like tiny diving boards are a launching platform for research that could improve detergents and advance understanding of disease.

Rice University researcher Sibani Lisa Biswal and Kai-Wei Liu, a graduate student in Biswal's lab who recently earned her doctorate at Rice, used microcantilevers as ultrasensitive measuring devices to study how lipid bilayers interact with surfactants.

Their results were reported online this month in the American Chemical Society journal *Analytical Chemistry*.

Lipid bilayers are membranes that surround the cells of every living organism. Along with specific membrane proteins, they act as gatekeepers that allow ions, proteins and other essential molecules to pass into the cell. Individual lipid molecules in the bilayer have a hydrophilic head and two hydrophobic tails. They naturally aggregate into two-layered sheets, with the heads pointed out and the water-avoiding tails pointed inward.

Liu and Biswal, an assistant professor in chemical and biomolecular engineering, described in a previous paper how to attach lipid bilayers to microcantilevers, which have traditionally been used as analytical biosensors. A protective coating on the thin gold layer makes the top of the "diving board" inert, so the membranes attach themselves to and spread out over the silicon dioxide bottom. The exchange of energy as the membrane meets the solid platform changes the surface tension and bends the cantilever enough to be measured by a laser sensor. Any change to the membrane will alter the bend, which can be measured with nanometer resolution, Biswal said.

In the new work, the researchers introduced varying concentrations of lysolipids to the supported lipid bilayers. Lysolipids are surfactants, compounds that lower the surface tension of liquids and can act as detergents, among other things. Like the molecules that make up lipid bilayers, lysolipid molecules have a hydrophilic head but only one hydrophobic tail.

Liu and Biswal found that in low concentrations, lysolipid molecules wedged themselves into the bilayer as their water-hating tails cozied up to the membrane's hydrophobic inner ring; this changed the surface tension on the cantilever.

All of these forces can be measured, Biswal said. "The cantilever naturally wants to bend with whatever force the membrane puts on it," she said.

In high concentrations, lysolipid monomers form micelles, rings of molecules that interact with the membranes and disrupt the hydrophobic interactions that keep them together.

Depending on their strength (determined by the chemical makeup of their hydrophobic tails), the micelles can either weaken the membranes by pulling lipid molecules away or destroy the membranes completely.

That is precisely what you want a detergent to do to a stain, and the new technique would be very useful for fine-tuning cleaning agents, Biswal said.

"A vast amount of research has gone into detergency," she said. "There are a lot of detergencies based on enzymes, the biomolecules that cleave peptide bonds. A lot of stains are organic molecules. If you can cleave them, you can clean surfaces much better."

Biswal sees other potential for the technique. "We're interested in using this as a general platform for looking at small molecules," she said.

Liu is pursuing one such path. She is studying how hepatitis C peptides behave in the presence of a microcantilever-mounted membrane. "This could be a way to probe how viruses are able to enter cell membranes or disrupt proteins on their surfaces," she said.

Biswal suggested that carbon-60 atoms -- the buckyballs discovered at Rice in 1985 -- might also be a good subject. "We don't know enough about how nanomaterials interact with cell membranes, and since buckyballs are naturally hydrophobic, they might be interesting to investigate."

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