# Next generation nanofilms created

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With the human genome in hand, biochemists have cataloged the 3-D structures of thousands of proteins isolated from living cells. But one important class of proteins -- those stuck in the cell membranes -- has proven difficult to extract and study in 3-D crystals. Now an international team of scientists has developed a way to train such molecules to line up neatly on the surface of water in thin, tissue-like layers called nanofilms. This technique should allow biochemists to better see and study the molecules and may lead to a new generation of molecular electronics and ultra-thin materials only one molecule thick.

"To the best of our knowledge, this is the first time aligned films less than a nanometer thick have been produced," say Iftach Nevo, a Marie Curie fellow at the University of Aarhus in Denmark, and Leslie Leiserowitz of the Weizmann Institute of Science in Israel. Together with their colleagues at these institutions and at the Max-Planck Institute of Colloids and Interfaces in Germany and Northwestern University in Evanston, they describe their research in the 14 April 2009 issue of The *Journal of Chemical Physics*, published by the American Institute of Physics.

One way of creating a nanofilm is to build it on the surface of water. First, the building blocks of the film are dissolved in a volatile substance. When a drop of this solution is splashed onto water, the solvent evaporates. The building blocks left floating on the water interact with each other and spontaneously come together -- like soap scum in a bathtub -- to create a thin crystalline layer.

The shortcoming of this technique is that the thin crystals in the film created will be a mess. Like a mob in a dance club, molecules floating on a surface tend to spin around chaotically with little regard for order. Different patches of molecules will point different, random directions. Because the orientation of these molecules dictates the electrical, magnetic, and optical properties of the final film, these jumbled regions are difficult to develop into useful technologies. They are also difficult to analyze using imaging techniques like X-ray diffraction.

To force the molecules to line up, the team blasted them with nanosecond laser pulses. These pulses create an electric field that interacts with the molecules, rotating them slowly. The electric field associated with these laser pulses is polarized, filtered so that all of the light waves vibrate in the same direction. Molecules caught in the laser feel most stable when they line up along this direction, a process analogous to the needle in a compass swinging to line up with the Earth's magnetic field. Eventually, this forms an aligned film with long range order.

The technique has not been completely perfected yet. Its success rate is about 30 percent, but the group believes that a better understanding of what is happening during the evaporation process and how the molecules interact with each other just before solidifying into a film will improve the efficiency.

When these molecules line up in a stable 2-D layer, their structures can be seen with X-ray imaging techniques normally used on 3-D crystals. "Alignment should enhance the X-ray diffraction intensity by more than two orders of magnitude allowing more detailed structure elucidations," say Nevo and Leiserowitz. The technique could be useful for studying molecules that cannot be easily crystallized in three dimensions -- cell membrane proteins are only one example.

It could also be useful for creating 3-D crystals with aligned structures. The 2-D layer can be used to seed the growth of these crystals, providing a stage on which this growth can be monitored using X-ray diffraction.

Another application is molecular electronics, like field-effect transistors, that require ordered molecules. Also interesting is an emerging class of solar cell technologies that are trying to copy nature by reverse-engineering photosynthesis. The ability to align the molecules in these devices will be important to their effectiveness, explains team member Tamar Seideman of Northwestern University.

Because the technique should work with a variety of molecules, it may pave the way for brand new kinds of self-assembling nanomaterials. "The international team that produced this paper is outstanding, and this is one of those papers that will likely spawn a number of novel applications that haven't been discovered yet," says Edward Castner of Rutgers University, Associate Editor for The *Journal of Chemical Physics*.

More information: The article "Laser-Induced Self Assembly on Water Surfaces" by Iftach Nevo et al will be published online on April 14, 2009. jcp.aip.org

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