Reserchers find new method for manipulating liquid crystals

February 11 2010, by Ryan A. Garcia

(PhysOrg.com) -- A new method for manipulating the molecules of liquid crystals in ways previously unachieved could result in more effective industrial sealants, improved food packaging and even enhanced electronic displays, says Zhengdong Cheng, a Texas A&M University assistant professor of chemical engineering and member of a team of researchers whose recent findings hail a significant advancement in working with liquid crystals.

The findings, which appear in the scientific journal *Physical Review E*, detail how Cheng and his colleagues were able to orient the disc-shaped molecules of liquid crystals into distinct and separate layers - a phenomenon labeled by scientists as a "smectic phase." This layering phase, Cheng explains, is common with rod-shaped liquid crystal molecules but had never been recorded with their disc-shaped counterparts - until now.

"Before this, no discotic smectic phase was known to exist," Cheng said. "For some time, people have been really puzzled as to why the discs don't form layers."
The discovery could mean expanded possibilities for the already popular material.

Liquid crystals are a state of matter between that of a conventional liquid and that of a solid crystal. Possessing inherent properties that are ideal for working with light as well as a molecular structure that can be easily controlled by electric fields, liquid crystals are commonly used in the electronic displays of televisions, cell phones and portable gaming devices. Liquid crystals are also found in soaps and detergents as well as in the proteins and cell membranes within the human body.

These areas as well as many more that employ liquid crystal technology, Cheng says, stand to benefit from the new finding. Key to Cheng's discovery is the shape of the liquid crystal molecules he used. The disc-shaped nature of the platelets in combination with the layered structure they form help to create a near-impermeable sealant.

Integrating such a sealant into food packaging would translate into foods staying fresher for longer periods of time, Cheng says. What's more, utilizing this liquid-crystal technology in materials such as paint and industrial sealants could produce more effective protections for pipelines, safeguarding them from corrosion.
Even fuel-cell technology could be enhanced, Cheng adds.

"A problematic aspect of fuel-cell technology occurs when methanol passes through a polymer membrane inside of the cell, but if these discs can be added to the makeup of this polymer film, a membrane can be created that does not allow the methanol to escape through it, instead forcing the methanol to pass through the desired area," Cheng says.

And because these layered liquid-crystal molecules are easier to manipulate and more sensitive to electric fields than the rod-shaped liquid crystal molecules currently used in television displays, Cheng speculates that future LCD televisions might boast improved visual properties while being more energy efficient if this liquid crystal technology is utilized.

In Cheng's experiment, each disc, composed of millions of atoms, is a single layer of inorganic crystals with an identical thickness of 2.68 nanometers and a diameter around 2,000 nanometers. As a matter of perspective, the width of a human hair is about 100,000 nanometers.

These discs, Cheng explains, are created by exfoliating crystals of compound of Zirconium Phosphate, which is a type of synthetic crystal that is manufactured to help remove nuclear waste because of its chemical properties. It’s also used in the manufacturing of fuel cells.

Placing the discs suspension between two light polarizers, Cheng was able to first confirm that the suspension was indeed in a liquid crystal form. Then using X-ray technology, he observed how the discs arranged themselves through a process called self-assembly.

Through self-assembly, these individual discs move around and interact with their neighboring discs due to collisions with surrounding water molecules. After some time, the discs reach a stable state - usually aligning to form column-like structures, Cheng says.

However, in Cheng’s experiment the discs behaved in an atypical manner, assembling themselves into separate layers. It’s a behavior that Cheng’s team has attributed to the three main factors. The first of those is the thickness of each liquid crystal disc. Each disc, he notes, must have an identical thickness, in this case 2.68 nanometers. The second factor, Cheng says, is that the diameter of the discs must vary. The final factor, he says, is that the aspect ratio between disc diameter and disc thickness must be large. Previous studies have synthesized discs with ratios that were too small, possibly accounting for a lack of layer formation.

Provided by Texas A&M University