

New type of liquid crystal promises to improve performance of digital displays

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Chemists at Vanderbilt University have created a new class of liquid crystals with unique electrical properties that could improve the performance of digital displays used on everything from digital watches to flat panel televisions.

The achievement, which is the result of more than five years of effort, is described by Professor of Chemistry Piotr Kaszynski and graduate student Bryan Ringstrand in a pair of articles published online on Sept. 24 and Sept. 28 in the Journal of Materials Chemistry.

"We have created liquid crystals with an unprecedented electric dipole, more than twice that of existing liquid crystals," says Kaszynski.

Electric dipoles are created in molecules by the separation of positive and negative charges. The stronger the charges and the greater the distance between them, the larger the electric dipole they produce.

In liquid crystals, the electric dipole is associated with the threshold voltage: the minimum voltage at which the liquid crystal operates. Higher dipoles allow lower threshold voltages. In addition, the dipole is a key factor in how fast liquid crystals can switch between bright and dark states. At a given voltage, liquid crystals with higher dipoles switch faster than those with lower dipoles.

Commercial potential

Vanderbilt has applied for a patent on the new class of materials. Some of the companies that manufacture liquid crystals for commercial applications have expressed interest and are currently evaluating it.

"Our liquid crystals have basic properties that make them suitable for practical applications, but they must be tested for durability, lifetime and similar characteristics before they can be used in commercial products," Kaszynski says. If it passes commercial testing, the new class of liquid crystals will be added to the complex molecular mixtures that are used in liquid crystal displays. These blends combine different types of liquid crystals and other additives that are used to fine-tune their characteristics, including viscosity, temperature range, optical properties, electrical properties and chemical stability. There are dozens of different designs for liquid crystal displays and each requires a slightly different blend.

Scientific significance

The newly discovered liquid crystals are not only important commercially but they are also important scientifically.

Since 1888 when they were discovered, scientists have discovered more than 100,000 natural and synthetic compounds that have a liquid crystal state. They have determined that one of the prerequisites for such a state is that the molecule must be shaped like either a rod or a disc. A second requirement is that it must contain both rigid and flexible parts. It takes a delicate balance of two opposing factors or forces to produce a material halfway between a crystal and a liquid.

However, there is still a great deal about this unusual state that scientists do not yet understand.

For example, scientists are still trying to determine the effect that a liquid crystal's electric dipole has on the temperature at which it becomes an ordinary liquid. The current consensus has been that increasing the strength of the dipole typically raises this transition temperature. The way in which the new type of liquid crystals are synthesized allowed Kaszynski and Ringstrand to test this theory by creating pairs of liquid crystals with the same geometry but different electric dipoles and measuring their transition temperatures. They found that subtle structural differences have a much greater effect on the transition temperature than do variations in the strength of the electric dipole.

Unique "zwitterionic" structure

What distinguishes the new class of liquid crystals is its "zwitterionic" structure. Zwitterions are chemical compounds that have a total net electrical charge of zero but contain positively and negatively charged groups. The newly developed liquid crystals contain a zwitterion made up of a negatively charged inorganic portion and a positively charged organic portion. Kaszynski first got the idea of making zwitterionic liquid crystals nearly 17 years ago when he first arrived at Vanderbilt. However, a critical piece of chemistry required to do so was missing. It wasn't until 2002 when German chemists discovered the chemical procedure that made it possible for the Vanderbilt researchers to succeed in this effort.

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