A new way to make biaxial nematic phase liquid crystals

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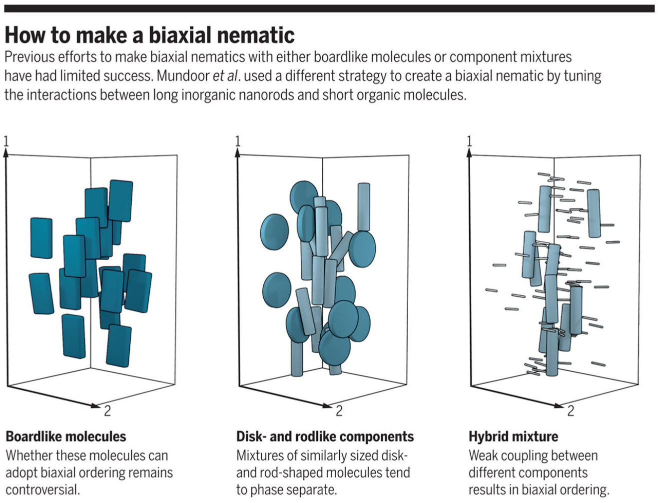

How to make a biaxial nematic. Previous efforts to make biaxial nematics with either boardlike molecules or component mixtures have had limited success. Mundoor et al. used a different strategy to create a biaxial nematic by tuning the interactions between long inorganic nanorods and short organic molecules. Credit: V. ALTOUNIAN/SCIENCE

A team of researchers from the University of Colorado in the U.S. and Université Paris-Saclay, in France has developed a new way to make biaxial nematic phase liquid crystals. In their paper published in the journal *Science*, the group describes the technique they developed and possible uses for the results. Philippe Poulin, with CNRS, University of Bordeaux offers a Perspective piece on the work done by the team in the same journal issue.

Liquid crystals have become hugely important over the past half-century due to their use in phones, television sets and other screened devices. The type of crystals used in such devices are known as nematic phase liquid crystals, because their molecules line up in a certain way. They are also generally uniaxial, which means they line up in the same direction, but not necessarily in the same plane. But in recent years, scientists have begun to see that biaxial nematic phase crystals could offer additional benefits. Prior research has shown that because they would have fast switching speeds, they could serve an important role in the development of new electro-optical applications. Unfortunately, the development of such crystals has not met with much success. Some researchers have tried using board-like molecules while others have tried mixing rod-like molecules with disk-shaped molecules. Neither approach has produced the desired results. In this new effort, the researchers tried a new tactic—one that overcomes problems seen with the other methods.

The new technique involves combining and mixing two types and sizes of nanorods—one organic the other inorganic. The inorganic nanorods were 1000 nanometers, while the organic nanorods were just two nanometers long on average. But there was more—the researchers had to tinker with the mixture to get the smaller rods to rest perpendicular to the larger rods, thus creating two planes. The researchers also found that the resultant biaxial nematic is not simply a superposition of the two nematics—the anisotropic properties between the two kinds of rods caused the smaller rods to be distributed in a way that resulted in biaxiality without the need for additional ingredients. This, the team notes, suggests the properties of the new liquid crystals are even richer than expected.

More information: Haridas Mundoor et al. Hybrid molecular-colloidal liquid crystals, *Science* (2018). DOI: 10.1126/science.aap9359

Abstract
Order and fluidity often coexist, with examples ranging from biological membranes to liquid crystals, but the symmetry of these soft-matter systems is typically higher than that of the constituent building blocks. We dispersed micrometer-long inorganic colloidal rods in a

nematic liquid crystalline fluid of molecular rods. Both types of uniaxial building blocks, while freely diffusing, interact to form an orthorhombic nematic fluid, in which like-sized rods are roughly parallel to each other and the molecular ordering direction is orthogonal to that of colloidal rods. A coarse-grained model explains the experimental temperature-concentration phase diagram with one biaxial and two uniaxial nematic phases, as well as the orientational distributions of rods. Displaying properties of biaxial optical crystals, these hybrid molecular-colloidal fluids can be switched by electric and magnetic fields.