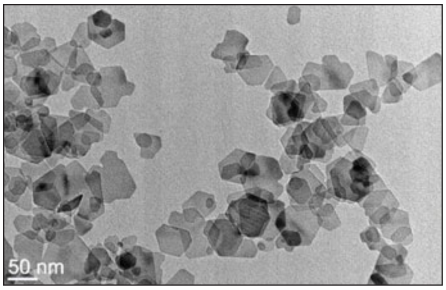
Ferromagnetism revealed in suspensions of magnetic nanoplatelets in liquid crystal

Inspired by their beautiful color patterns viewed in an optical microscope and their intriguing behavior, Alenka Mertelj from the J. Stefan Institute in Ljubljana, Slovenia, developed an interest in the dynamics of complex fluids. Now she and her colleagues at the Institute—Darja Lisjak, Miha Drofenik, and Martin Čopič—have added a new dimension to that complexity: ferromagnetism.



Transmission electron microscope image of magnetic nanoplatelets. Image credit: Alenka Mertelj.

Previous to their work, ferromagnetic complex fluids had only been observed at either liquid helium temperatures or above 1000 K. By mixing nanoparticles in a nematic liquid crystal, the research team succeeded in making a room-temperature fluid ferromagnetic phase, thereby solving a 40-year-old problem. The issue at hand: avoid aggregation of the nanoparticles while maintaining sufficient magnetic interaction between them. Their trick: the use of magnetic nanoplatelets. As reported in the December 12, 2013 issue of *Nature* (DOI:10.1038/nature12863; p. 237), the researchers found that the platelet shape of barium hexaferrite particles allows for a suitable interplay between the magnetic and nematic-elastic interactions, and combined with quench-cooling of the suspension from the isotropic into the nematic phase, stable, aggregate-free samples are formed.

Proving that the concept works, their samples showed hysteretic magnetization switching at very low magnetic fields. Furthermore, depending on the fabrication procedure employed, mono-domain behavior (for samples cooled in a magnetic field) or multi-domain behavior with domain wall motion was observed.

Adding ferromagnetism to the well-established electro-optical properties of liquid crystals means these materials represent a new class of multiferroics. They may enable many new applications, especially in magneto-optic devices. Mertelj said, "Whereas in liquid crystals one can control the propagation of light by an electric field, this new material may allow similar control by a magnetic field. Or they can be used to image the magnetic field with a liquid crystal."

The use of other (chiral or smectic order) types of liquid crystals has the potential to further open up a completely new research field.

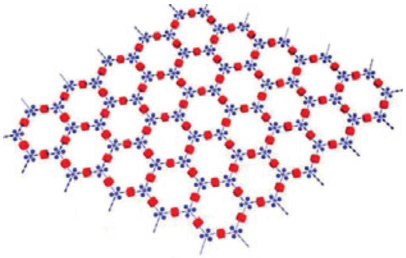
Dirk Wouters

Soluble 2D supramolecular organic frameworks created

Supramolecular chemistry, in which molecules and molecular complexes are held together by noncovalent bonds, is just beginning to come into its own with the emergence of nanotechnology. Metal–organic frameworks (MOFs) are commanding much of the attention because of their appetite for greenhouse gases, but a new player has joined the field—supramolecular organic frameworks (SOFs). Researchers with Lawrence Berkeley National Laboratory (Berkeley Lab) have unveiled the first known two-dimensional (2D) SOFs that self-assemble in solution, an important breakthrough that holds implications for sensing and separation technologies, energy sciences, and, perhaps most importantly, biomimetics. The researchers report their work in the September 30, 2013 online edition of the *Journal of the American Chemical Society* (DOI: 10.1021/ja4086935).

Traditional molecular chemistry involves strong covalent bonds formed by the sharing or exchange of electrons between the atoms comprising a molecular system. Supramolecular chemistry involves systems that are held together by weaker, noncovalent connections, such as hydrogen bonds, electrostatic, and van der Waals forces. While nature uses supramolecular chemistry to form the double-helix of DNA or to fold proteins, this research team believes that these ideas could also be translated to nanotechnology, where single layers of 2D structurally ordered materials—such as graphene—could fulfill many requirements. The key is that they should be processed in solution.

"Solution-based processing allows for mass production and reduced manufacturing costs, and is an important step for transferring materials to a dry state without losing their structural integrity," said Yi Liu, who oversees the supramolecular electronics research group at Berkeley Lab's Molecular Foundry.



Supramolecular organic frameworks feature a porous framework with honeycomb periodicity similar to a metal–organic framework.

"Solution-based processing also allows for bio-related applications such as biomimetic sensing, where the framework structure is advantageous for the capturing of guest molecules and the amplification of chemical signals."

However, the self-assembly of well-defined 2D supramolecular systems polymers in solution has been a challenge because such polymers tend to precipitate out of solution, making them difficult to manipulate and characterize. To meet this challenge, co-researcher

https://doi.org/10.1557/mrs.2014.13 Published online by Cambridge University Press