Chameleon for Optoelectronics

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A liquid that changes its color “on demand” and can take on any color of the rainbow one desires?

A research team headed by Yadong Yin at the University of California, Riverside (USA) has now shared the secret of their wonderful liquid with the journal *Angewandte Chemie*: Nanoscopic particles made of tiny magnetic crystals coated with a plastic shell self-assemble in solution to form photonic crystals—semiconductors for light. When a magnetic field is applied, the optical properties of the crystals change, allowing their color to be very precisely adjusted through variation of the strength of the field.

The crystals involved here are no “conventional” lattices of ions or molecules like the one we are familiar with for salt; instead they are colloidal crystals, periodic structures that form from uniform solid particles that are finely dispersed in a liquid. Colloidal crystals can be produced at little cost and on a large scale—and can be used as photonic crystals. Photonic crystals are the optical analogue of electronic semiconductor materials. Like their electronic counterparts, they have photonic band gaps, forbidden energy levels, or wavelengths, at which the photonic crystal does not transmit light. These optical properties depend on the spatial relationships within the crystal.

Current research is concerned with photonic crystals whose forbidden bands are variable and can be adjusted quickly and precisely in response to an external stimulus. These requirements have been impossible to meet until now.

One stimulus that could be used is a magnetic field, if the crystals are made of magnetic materials, such as iron oxide. The problem with this is that the magnetization is maintained when the particles grow into larger domains (ferromagnetism). Yin and his team have found a solution: They coated nanoscopic iron oxide particles with a plastic called polyacrylate.

This results in separate clusters of nanocrystals, which self-assemble in solution to form colloidal photonic crystals. The forces of the magnetic field affect every individual cluster, changing the cluster-to-cluster distances within the crystal lattice. Depending on the distance from the magnet and thus the field strength, the color of the colloidal crystal changes right across the whole visible spectrum.

This response is rapid and fully reversible because the nanocrystals in clusters are so small that they lose their magnetism when the magnetic field is shut off (superparamagnetism). Potential applications for these switchable "optical semiconductors" include novel optoelectronic components for telecommunications, displays, and sensors.

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