Nanorods could greatly improve visual display of information (w/ Video)

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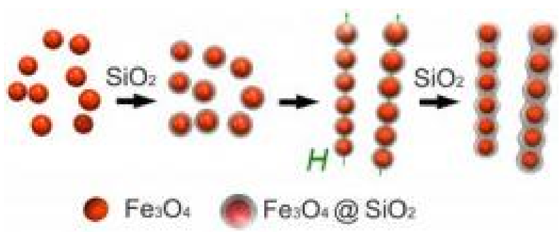


From left to right: Iron oxide (Fe_3O_4) particles are coated with silica (SiO_2) to form tiny linear chains that grow into robust peapod-like structures with the application of more silica. Credit: Yin lab, UC Riverside.

Chemists at the University of California, Riverside have developed tiny, nanoscale-size rods of iron oxide particles in the lab that respond to an external magnetic field in a way that could dramatically improve how visual information is displayed in the future.

Previously, Yadong Yin's lab showed that when an external magnetic field is applied to iron oxide particles in solution, the solution changes color in response to the strength and orientation of the magnetic field. Now his lab has succeeded in applying a coating of silica (silicon dioxide) to the iron oxide particles so that when they come together in solution, like linearly connected spheres, they eventually form tiny rods – or "nanorods" – that permanently retain their peapod-like structure.

When an external magnetic field is applied to the solution of nanorods, they align themselves parallel to one another like a set of tiny flashlights turned in one direction, and display a brilliant color.

"We have essentially developed tunable photonic materials whose properties can be manipulated by changing their orientation with external fields," said Yin, an assistant professor of chemistry. "These nanorods with configurable internal periodicity represent the smallest possible photonic structures that can effectively diffract visible light. This work paves the way for fabricating magnetically responsive photonic structures with significantly reduced dimensions so that color manipulation with higher resolution can be realized."

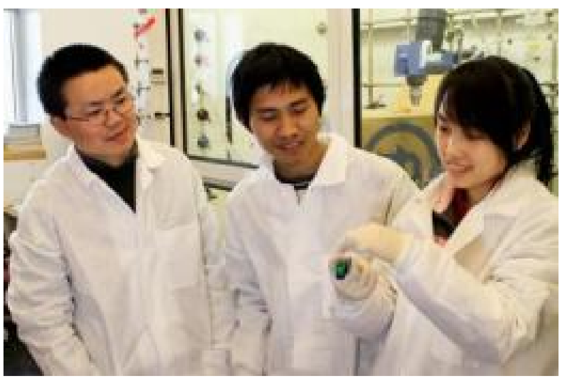
Applications of the technology include high-definition pattern formation, posters, pictures, energy efficient color displays, and devices like traffic signals that routinely use a set of colors. Other applications are in bio- and chemical sensing as well as biomedical labeling and imaging. Color displays that currently cannot be seen easily in sunlight – for example, a laptop screen – will be seen more clearly and brightly on devices that utilize the nanorod technology since the rods simply diffract a color from the visible light incident on them.

Study results appear online today (March 14) in *Angewandte Chemie*. The research will be highlighted on the back cover of an upcoming print issue.

In the lab, Yin and his graduate students Yongxing Hu and Le He initially coated the magnetic iron oxide molecules with a thin layer of silica. Then they applied a magnetic field to assemble the particles into chains. Next, they coated the chains with an additional layer of silica to allow for a silica shell to form around and stabilize the chain structure.

According to the researchers, the timing of magnetic field exposure is critically important to the success of the chain formation because it allows for fine-tuning the "interparticle" spacing – the distance between any two particles – within photonic chains. They report that the chaining of the magnetic particles needs to be induced by brief exposure to external fields during the silica coating process so that the particles temporarily stay connected, allowing additional silica deposition to then fix the chains into mechanically robust rods or wires.

They also report in the research paper that the interparticle spacing within the chains in a sample can be fine-tuned by adjusting the timing of the magnetic field exposure; the length of the individual chains, which does not affect the color displayed, can be controlled by changing the duration of the magnetic field exposure.



Yadong Yin (left), Le He (center) and Yongxing Hu examine a solution of iron oxide particles that changes color when an external magnetic field is applied to it. Credit: Yin lab, UC Riverside.

"The photonic nanorods that we developed disperse randomly in solution in the absence of a magnetic field, but align themselves and show diffraction color instantly when an external field is applied," Yin said. "It is the periodic arrangement of the iron oxide particles that effectively diffracts visible light and displays brilliant colors."

He explained that all the one-dimensional photonic rods within a sample show a single color because the particles arrange themselves with uniform periodicity – that is, the interparticle spacing within all the chains is the same, regardless of the length of the individual chains. Further, the photonic chains remain separated from each other in magnetic fields due to the magnetic repulsive force that acts perpendicular to the direction of the magnetic field.

The researchers note that a simple and convenient way to change the periodicity in the rods is to use iron oxide clusters of different sizes. This, they argue, would make it possible to produce photonic rods with diffraction wavelengths across a wide range of spectrum from near ultraviolet to near infrared.

"One major advantage of the new technology is that it hardly requires any energy to change the orientation of the nanorods and achieve brightness or a color," Yin said. "A current drawback, however, is that the interparticle spacing within the chains gets fixed once the silica coating is applied, allowing for no flexibility and only one color to be displayed."

His lab is working now on achieving bistability for the nanorods. If the lab is successful, the nanorods would be capable of diffracting two colors, one at a time.

"This would allow the same device or pixel to display one color for a while and a different color later," said Yin, a Cottrell Scholar.

Provided by University of California - Riverside

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