Chameleon crystals could enable active camouflage (w/ video)

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(Phys.org) —The ability to control crystals with light and chemistry could lead to chameleon-style color-changing camouflage for vehicle bodies and other surfaces.

Michigan Engineering researchers discovered a template-free method for growing shaped crystals that allows for changeable structures that could appear as different colors and patterns.

One source of color in crystal structures is the spacing between the particles that make up the crystal. The spacing can determine which colors of light the crystal absorbs and which it reflects, resulting in the visible color. By changing the spacing and other aspects of the crystal structure, it is possible to change the color.

The researchers have found a way to control a crystal on the fly as it forms in a solution of latex paint microparticles, around 0.001 millimeters in diameter, in a kerosene-like fluid.

"We can shine the light in a certain region, and the particles create a crystalline region where they all come together and create this crystal structure," said Youngri Kim, a doctoral student in chemical engineering, who led the study. When the light was off, the crystal dissolved back into the solution.

By shining shaped ultraviolet light into the fluid, Kim was able to make the microparticles arrange into the Michigan Block M. Ordinarily, to get a shape like a Block M, the crystal would have to be built on top of a template. A template can make crystals of one shape only, but the new method can produce crystals in any shape that light can assume.

The team found that the key to this flexible crystal formation is a light-induced chemical reaction. It occurs between the layer of indium tin oxide at the bottom of the tiny pool of solution and the kerosene-like fluid.

The reaction generates a current of ions in the fluid. If the microparticles are negatively charged, they are attracted to illuminated area of indium tin oxide. There, they arrange into a crystal structure that mirrors the shape of the spot, and their spacing depends on the wavelength of the light. If the particles are positively charged, they flow away from the illuminated area, creating a void in the shape of the light.

"We have understood why this happens in a way that is not specific to this one system," said Mike Solomon, professor of chemical engineering and Kim's advisor. "Anyone who wants to work on these materials now can use light to manipulate them without a template."

Solomon and Kim would most like to see a thin film system in which the crystals can be modified on demand, changing the color and pattern of an object for the ultimate camouflage. Such a system could also lead to new ways to update images on e-readers and large displays such as billboards.

Aayush Shah, a former doctoral candidate in Solomon's lab (now at Dow Chemical), saw the first hints of this phenomenon when he was assembling crystals using electric fields. He noticed that sometimes, the particles seemed drawn to the laser spots.

When Shah convinced Solomon that he was seeing a real effect, Solomon asked Kim, a new group member at the time, if she would take on the project. The morning that Kim told Solomon her hypothesis – about two years later – she proposed that she could probably arrange the particles into the Michigan Block M with the scanning UV light.

"I thought 'That's cool, we should try that.' I was just talking into the air I think. Then I came into the lab at 4 o'clock that afternoon and she'd already done it," said Solomon. "There's no way that would have worked if she didn't understand the mechanism. I've never been involved in something that definitive in all my years of doing science and engineering."

Now that the group has revealed the way to create crystals using light alone as the template, the team hopes that other researchers will apply the technique in their fields. In addition to color-adjustable coatings, they imagine sensors that change color depending on the composition of the fluid around it, detecting molecules that are important for medical or environmental monitoring.

With conductive particles, the technique may also enable the development of reconfigurable electrical circuits.

This work is to be published in *Nature Communications*, in an article titled "Spatially and temporally reconfigurable assembly of colloidal crystals."

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Solomon is also a professor of macromolecular science and engineering.

Provided by University of Michigan

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