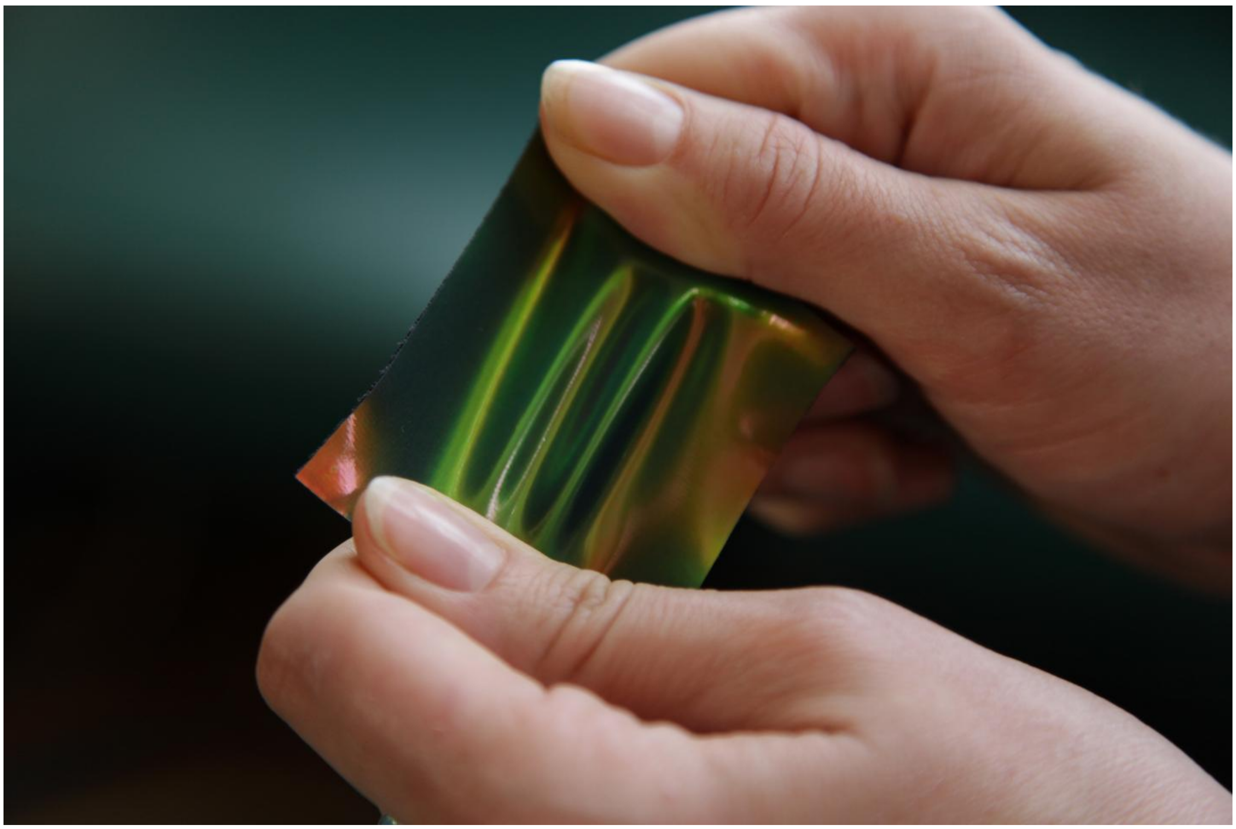
Squeezing out opal-like colors by the mile

June 3 2016



Researchers at the University of Cambridge have devised a method to produce "Polymer Opals" on an industrial scale. Credit: Nick Saffell/University of Cambridge

The team, led by the University of Cambridge, have invented a way to make such sheets on industrial scales, opening up applications ranging from smart clothing for people or buildings, to banknote security.

Using a new method called Bend-Induced-Oscillatory-Shearing (BIOS), the researchers are now able to produce hundreds of metres of these materials, known as 'polymer opals', on a roll-to-roll process. The results are reported in the journal *Nature Communications*.

Some of the brightest colours in nature can be found in opal gemstones, butterfly wings and beetles. These materials get their colour not from dyes or pigments, but from the systematically-ordered microstructures they contain.

The team behind the current research, based at Cambridge's Cavendish Laboratory, have been working on methods of artificially recreating this 'structural colour' for several years, but to date, it has been difficult to make these materials using techniques that are cheap enough to allow their widespread use.

In order to make the polymer opals, the team starts by growing vats of transparent plastic nano-spheres. Each tiny sphere is solid in the middle but sticky on the outside. The spheres are then dried out into a congealed mass. By bending sheets containing a sandwich of these spheres around successive rollers the balls are magically forced into perfectly arranged stacks, by which stage they have intense colour.

By changing the sizes of the starting nano-spheres, different colours (or wavelengths) of light are reflected. And since the material has a rubber-like consistency, when it is twisted and stretched, the spacing between the spheres changes, causing the material to change colour. When stretched, the material shifts into the blue range of the spectrum, and when compressed, the colour shifts towards red. When released, the material returns to its original colour. Such chameleon materials could find their way into colour-changing wallpapers, or building coatings that reflect away infrared thermal radiation.

"Finding a way to coax objects a billionth of a metre across into perfect formation over kilometre scales is a miracle," said Professor Jeremy Baumberg, the paper's senior author. "But spheres are only the first step, as it should be applicable to more complex architectures on tiny scales."

In order to make polymer opals in large quantities, the team first needed to understand their internal structure so that it could be replicated. Using a variety of techniques, including electron microscopy, x-ray scattering, rheology and optical spectroscopy, the researchers were able to see the three-dimensional position of the spheres within the material, measure how the spheres slide past each other, and how the colours change.

"It's wonderful to finally understand the secrets of these attractive films," said PhD student Qibin Zhao, the paper's lead author.

Cambridge Enterprise, the University's commercialisation arm which is helping to commercialise the material, has been contacted by more than 100 companies interested in using polymer opals, and a new spin-out Phomera Technologies has been founded. Phomera will look at ways of scaling up production of polymer opals, as well as selling the material to potential buyers. Possible applications the company is considering include coatings for buildings to reflect heat, smart clothing and footwear, or for banknote security and packaging applications.

More information: *Nature Communications*, DOI: 10.1038/ncomms11661

Provided by University of Cambridge