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Nanotech start-up story

Plasmonic structural colour paint gets commercial attention

Present colour paints are based on pigments made with organic dyes. These have the great advantage of being economical to produce and give customers a large choice of hues. However, they tend to fade over time under light exposure and in many cases are not environmentally friendly to make. Moreover, they usually need to be applied multiple times to achieve the required brightness. This adds weight to the structure, which can become a problem in certain applications. On the contrary, the primary colour-generating mechanism of many flowers, birds, butterflies and underwater creatures is due to the structural arrangement of typically two colourless nanomaterials.

Here is where Debashis Chanda, a professor at the University of Central Florida (USA), saw an opportunity for his bio-inspired plasmonic structural colour materials to make a difference in the real-world. Unlike dyes, where light is absorbed and re-emitted or reflected based on the material's inherent electronic properties, structural coloured material exploits the absorption and scattering of light purely based on the size of nanoscale features. Hence, a simple change in structural size or shape produces a new colour.

"For us, the real breakthrough came when we figured out how to make nanoscale structures, whose colour can also be seen when looking at any angle, and not just when viewed from the perpendicular direction" recounts Chanda. The problem of colour angular dependence has always been an issue in the quest for structural colours, but Chanda's group overcame this challenge by arranging nanoscale materials with completely aperiodic patterns. Their architecture consists of a highly packed monolayer of self-assembled aluminium nanoparticles on a thin aluminium oxide film, which serves as a spacer from an aluminium back-mirror. Lifting-off the multi-layer structure results in a self-standing 'plasmonic paint'. Further, the architecture is the result of a natural nucleation process occurring directly in an electron beam evaporator, making it particularly attractive for high-throughput fabrication methodologies.

The size and density of the self-assembled nanoparticles control the plasmonic resonance and, in turn, the resultant colour. In their publication, the group demonstrated a fairly wide CMY colour gamut. With an eye on practical applications, they also made a sprayable paint (P. Cencillo-Abad et al. *Sci. Adv.* **9**, eadf7207; 2023). The related patent (D. Chanda et al. US Patent 11,655,377 B2; 2023) has attracted attention from various car, electronics and paint manufacturers.

An added advantage of structural colour painting is the fact that they reflect infrared light, keeping the object cooler under intense sunlight. Since their initial paper, the group has perfected the formulation of the sprayable paint and applied it to small-scale projects, like a small house, to demonstrate the potential for energy efficient buildings. Chanda is optimistic that his paint will finally bring to commercial fruition the vast amount of fundamental research in plasmonic colours that he and the nanophotonics community more broadly have been invested in over the past 15–20 years.

An important advantage of this structural colour formulation is its light weight when compared to dye-based paints. A single monolayer of composite nanoparticles (~100 nm thick) is sufficient to generate the desired colour. This property is key for applications where weight is a concern, like the aviation industry. A plasmonic paint would help reducing fuel consumption and CO_2 emissions.

Chanda is a founder of a start-up, called E-Skin Displays Inc. (http://www.eskindisplays.com/), to which he hopes the University of Central Florida will grant licensing rights to develop his patented technology, rather than selling the patent to big players. Chanda, however, remains cautious of the hurdles still ahead. The main drawback for structural colour materials is the colour gamut that can be achieved. "There is certainly a good palette available, but, compared with organic dye-based paints, the choice is still a bit limited. Further research is needed to expand the colour gamut," Chanda said.

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