Better structural color with the help of a computer

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The beautiful coloration observed in the natural world is often based on the interaction of light with defined nanostructures within butterfly wings, bird feather, insect exosceletons, etc.
Such colors can be recreated by mankind using self-assembly. In this respect, colloidal particles are interesting tools, as they can be synthesized with high control of sizes and be self-assembled into desired nanostructures. However, self-assembly inherently produces defects, which can compromise the observable color as random scattering is superimposed on the photonic properties of the material. Broadband absorbers are often added to increase the color saturation. In the natural world, this absorber addition is realized by incorporation of melanin, which can be synthetically mimicked by polydopamine. While this strategy has been applied to create more vivid structurally colored materials, little is known about the optimal amount of absorber, nor about the best possible position to add this absorber within the colloidal photonic crystals.
Here, we use a predictive design approach to optimize structural coloration. We use mathematical structure optimization to let the computer produce blueprints with ideal structural arrangements that produce structural color with the highest possible chroma. We experimentally control the self-assembly process to realize these structural predictions and investigate the color properties as a function of absorber content and position.
The potential of predictive design reaches beyond the scope of mere chroma optimization and may provide new strategies to optimize the properties of particulate systems more generally, provided that the physics underpinning the size- or shape-dependent properties are established.