Bio-inspired Photonic Microspheres: Controlling Light with a New Optical Technology

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The phenomenon of structural color is based on photonic arrays found in biological designs like scales of butterfly wings. Photonic particles are finely tuneable materials, custom designed to scatter light at specific wavelengths. This offers fine control of light in a wide range of applications. Traditional pigments and dyes exhibit color via light absorption and reflection, relying on chemical structure. Structural colorants exhibit color via light interference effects, relying on physical structure instead of chemical structure. Structural colorants are found in nature, for instance, in bird feathers, butterfly wings, and certain gemstones. This extraordinary phenomenon in nature evolved millions of years ago and has inspired scientists to mimic these effects by the creation of many different materials, methods, and processes. These biological designs by scientists are materials containing microscopically structured surfaces fine enough to interfere with visible light and produce color. Such materials may be based on photonic materials such as opals, inverse opals, photonic shards, photonic spheres [1], or composite photonic crystals. The materials have a degree of periodic variations in its structure, such as having periodic alternating high dielectric constant and low dielectric constant regions that affect light propagation. We have developed a tuneable technology allowing the production of advanced photonic particles to scatter light which can be custom designed to provide optical effects or to scatter light at specific wavelengths. This offers fine control of light in a wide range of applications. For instance, light can be tuned within the visible range to create structural colorants. Modeling tools including experimental learning loops were also developed to predict properties [2] of the photonic particles. Structural colorants may exhibit high stability, lightfastness, and may contain no undesired heavy metals. Given the particle morphology, such structural colorants may be formulated in consumer products as a replacement for less stable and/or less environmentally friendly pigments or dyes. In addition to the particles' formulatability, the materials are made entirely of metal oxides which offer a significant advantage over microplastics from a sustainability perspective. Offering tailor-made materials with different optical performances will allow a widespread use of such particles.

References

[1] V. Rastogi, S. Melle, O.G. Calderon, et al., *Adv. Mater*., 20(22), 2008, 4263-4268.
[2] A.B. Stephenson, M. Xiao, V. Hwang, et al., *ACS Photonics*, 10(1), 2023, 58-70.

Figures

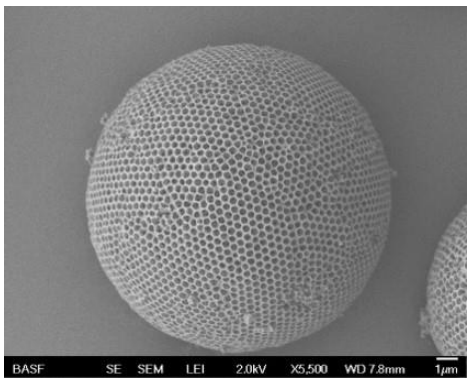

Figure 1: Scanning electron micrograph of an advanced photonic particle.