Optical properties of nanoscale biogenic spherulites and their assemblies

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Recently, opal-like photonic structures made from spherical, core-shell nanoparticles of crystalline isoxanthopterin have been reported in the eyes of decapod crustaceans (Figure 1a) [1, 2]. Crystalline isoxanthopterin exhibits optical anisotropy, and the low index axis of isoxanthopterin crystals within each spherical shell is radially oriented, projecting away from the surface of the sphere. Therefore, each spherical shell is a spherulite and exhibits the same rotational symmetry as an isotropic sphere. Our calculations show that such spherulitic shells exhibit significantly enhanced optical properties in comparison to their optically isotropic counterparts, including enhanced back scattering (Figure 1b) and enhanced reflectivity from close-packed arrays (Figure 1c) [1]. Further calculations have shown that this enhanced reflectivity results from pseudogaps in the photonic band structure that are absent in opals made of optically isotropic spheres (Figure 1d) [3].

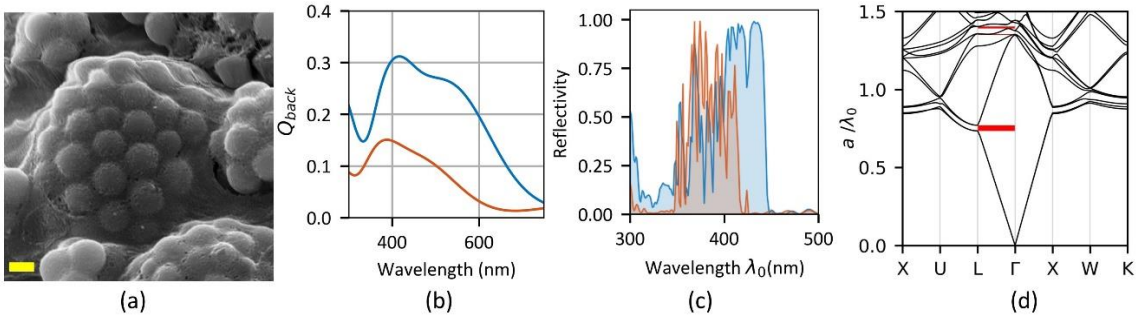

Figure 1 *A CryoSEM image of the photonic crystal that constitutes the tapetum. (b) Enhanced backward scattering efficiency from a single spherulitic shell (blue) compared to an isotropic shell (red) (c) Enhanced reflectivity in longer wavelengths in a closed packed assembly of spherulitic particles (blue) compared to isotropic case (red) (d) Photonic band structure of a spherulite opal (a is the lattice constant). The upper pseudogaps (red) are responsible for the enhanced reflectivity.*

The photonic system in the decapod crustacean eye therefore offers genuine inspiration for the design of photonic crystals constructed from spherically symmetric birefringent particles, particularly for applications requiring thin reflective layers and non-iridescent structural colours. It also provides motivation to study light propagation in media with spatially varying optical anisotropy, and biomaterials which offer novel routes to tailoring optical properties.

References

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