



## ***OPTICALLY FUNCTIONAL ORGANIC CRYSTALS IN ANIMALS***

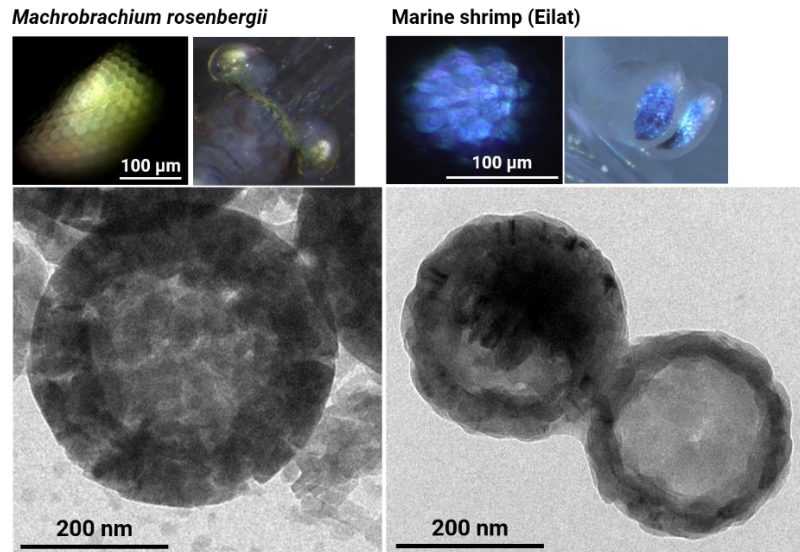
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Highly reflective organic crystals are widely used in animal coloration and vision [1]. Guanine crystals, for example, have been studied for over 100 years and their role in structural coloration is well-established. We discuss the less-studied pteridine molecules which are used, in crystalline form, in animal eyes.

In the eyes of adult decapod crustaceans, isoxanthopterin crystals form a tapetum reflector which enhances photon-capture by back-scattering transmitted photons to the overlying retina [2]. The isoxanthopterin crystals are arranged in nanoparticles constructed from a shell of crystal plates arranged in concentric lamellae around an aqueous core. The reflectors are formed from dense assemblies of these nanoparticles. Isoxanthopterin crystals are characterized by planar layers of H-bonded molecules, and the reflectivity of the material derives from the extreme refractive index ( $n=1.96$ ) parallel to these layers. We show how the reflectivity and scattering of the particles are enhanced by their radial birefringence and an optimized core-shell ratio [3].

Finally, we present the recent discovery of a camouflage device in the eyes of transparent crustacean larvae, which is used to conceal conspicuous retinal pigments. The reflector is constructed from similar isoxanthopterin nanoparticles and its colour is controlled by the size and packing density of the particles. We show how the reflector colour is spectrally matched to the water colour in the native habitats of different crustacean species. This enables the organisms to avoid predation by remaining inconspicuous against the background.



**Figure 1.** Green and blue eyeshine reflectors (upper) in the eyes of the two shrimp larvae, together with the nanoparticles composing the reflectors (lower). *M. rosenbergii* inhabits green-yellow rivers in Asia whereas the marine shrimp was collected in the deep blue waters of Eilat.

[1] B. A. Palmer, D. Gur, S. Weiner, L. Addadi, D. Oron, *Adv. Mater.*, 30, 1800006 (2018).

[2] B.A. Palmer, A. Hirsch, V. Brumfeld, E.D. Aflalo, I. Pinkas, A. Sagi, S. Rozenne, D. Oron, L. Leiserowitz, L. Kronik, S. Weiner and L. Addadi, *PNAS*, 115, 10, 2299–2304 (2018).

[3] B.A. Palmer, V.-J. Yallapragada, N. Schiffmann, E. Merary Wormser, N. Elad, E.D. Aflalo, A. Sagi, S. Weiner, L. Addadi, D. Oron, *Nature Nanotechnology* 15, 138–144 (2020).