LIGHT SCATTERING AND COLOR ADAPTATION THAT ORIGINATE FROM A NATURAL NANOMATERIAL

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Color is ubiquitous in nature; however, the ability to rapidly change color in response to environmental cues is unique to few biological systems. Cephalopods, including squid, octopus, and cuttlefish, are one such system; they use sophisticated optical organs that assist in color adaptation in different environments. While several attempts have been made to explore, understand, and exploit the adaptive coloration of cephalopods for materials applications, much of the progress to date has relied on modeling with assumptions that all light not reflected or transmitted is absorbed, which ignores the contribution of light scattering in the skin. We believe that scattering plays a significant role in color perception and should be included in discussions of new colors and color-changing materials. We argue that both forward and backward scattering must be accounted for in the optical analysis of a sample; otherwise, an incorrect absorption spectrum and resulting color analysis may be deduced from the experimental data.

To test these hypotheses, we fabricated films comprising a distribution of bio-derived pigmented nanoparticles with multiple thicknesses. To achieve these different thicknesses, we casted a suspension (0.16 - 2.45 mg/ml) of nanoparticles which were first isolated and purified from squid *Doryteuthis pealeii* skin onto functionalized surfaces. We chose squid particles in our model system due to their unique refractive index (n =1.92) and ability to potentiate color change via translocation in the skin. The color quality and consistency of the films were measured using the International Commission on Illumination (CIE) tristimulus values. We observed that that both color and brightness in mimetic films could be controlled by varying particle layer thicknesses and by combining a back-reflector with a specific band pass, illustrating new materials applications for these biological nanostructures. Diffuse and specular scattering of the granules was also measured using experimental and theoretical approaches. We observed that the squid-derived pigments not only provide rich color but they can also scatter attenuated light. Combined, these characteristics make such bio-derived materials interesting candidates for future topical materials such as cosmetics and coatings designed to provide color or color-matching to a specific environment.