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Mueller-matrix ellipsometry studies of optically active structures in scarab beetles

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Abstract. The complexity of multilayers, photonic crystals, metamaterials and other artificial materials has promoted the use of spectroscopic, variable angle, generalized and Mueller-matrix ellipsometry. Naturally occurring structures may show even higher complexity than artificial structures but with a more narrow range of constituent materials. Fascinating reflection properties result from intricate photonic structures in, for instance, the wing scales and cuticles of insects. Currently there is a large interest to explore such functional supramolecular architectures for exploitation in nanotechnology. In this study, Mueller-matrix spectroscopic ellipsometry is applied in the spectral range of 250 to 1000 nm to investigate optical response and structures of the cuticle of Scarab beetles of the Cetoniinae subfamily. The cuticle of Cetonia aurata (the rose chafer, la cétoine dorée) is green with a metallic appearance and reflects left-handed circular/elliptically polarized light. It has been suggested that the polarization of this metallic gloss is caused by a helical structure in the chitinous cuticle. We find that the polarization effect is limited to the narrow spectral range 470-550 nm whereas for shorter or longer wavelengths the reflection properties are similar to those from a near-dielectric material. Model calculations and parameterization of the nanostructure employing a heliocoidal structure are discussed. As a comparison the polarization effects from light reflected from two other beetles will be presented. Coptomia laevis has a similar appearance as Cetonia aurata but has very different polarization properties. The golden Plusiotis argentiola has very interesting properties showing both left and right-handed polarization depending on incidence angle and wavelength.