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Research paper

Structure and mechanical properties of *Saxidomus purpuratus* biological shells

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ABSTRACT

The strength and fracture behavior of *Saxidomus purpuratus* shells were investigated and correlated with the structure. The shells show a crossed lamellar structure in the inner and middle layers and a fibrous/blocky and porous structure composed of nanoscaled particulates (∼100 nm diameter) in the outer layer. It was found that the flexure strength and fracture mode are a function of lamellar organization and orientation. The crossed lamellar structure of this shell is composed of domains of parallel lamellae with approximate thickness of 200–600 nm. These domains have approximate lateral dimensions of 10–70 μm with a minimum of two orientations of lamellae in the inner and middle layers. Neighboring domains are oriented at specific angles and thus the structure forms a crossed lamellar pattern. The microhardness across the thickness was lower in the outer layer because of the porosity and the absence of lamellae. The tensile (from flexure tests) and compressive strengths were analyzed by means of Weibull statistics. The mean tensile (flexure) strength at probability of 50%, 80–105 MPa, is on the same order as the compressive strength (∼50–150 MPa) and the Weibull moduli vary from 3.0 to 7.6. These values are significantly lower than abalone nacre, in spite of having the same aragonite structure. The lower strength can be attributed to a smaller fraction of the organic interlayer. The fracture path in the specimens is dominated by the orientation of the domains and proceeds preferentially along lamella boundaries. It also correlates with the color changes in the cross section of the shell. The cracks tend to undergo a considerable change in orientation when the color changes abruptly. The distributions of strengths, cracking paths, and fracture surfaces indicate that the mechanical properties of the shell are anisotropic with a hierarchical nature.

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