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# The role of the organic matrix for the compressive strength of nacre

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## Abstract

Nacre, a natural composite with a brick-and-mortar microstructure of aragonite platelets embedded in an organic matrix, exhibits an intriguing mechanical response. Notably, its high compressive strength contrasts sharply with its relatively lower tensile resistance, an observation often attributed to asperities between the platelets and calcitic bridges ensuring a direct mechanical connection. Numerous studies have investigated nacre's morphology and mechanical properties, both at the macroscopic and microscopic levels, providing detailed analytical and numerical analyses. However, the mechanical origin of its properties remains somewhat elusive. This study proposes an alternative explanation focused solely on the hyperelastic nature of the organic matrix.

We incorporate a phase-field damage model for both the matrix and the platelets within a multiscale framework. This approach allows us to apply boundary conditions in terms of components of a remote macroscopic deformation field, effectively analyzing a single representative volume element (RVE) of nacre to reproduce experimental uniaxial test results. By focusing on a limited-sized RVE, we are able to understand the origin and development of damage within the material. Our findings demonstrate that the hyperelastic behavior of the organic matrix is sufficient to explain the observed disparity between compressive and tensile strengths. The model predicts the material's strength accurately, both qualitatively and quantitatively, aligning well with existing experimental data.

This three-dimensional micromechanical model offers a new perspective on the mechanical properties of nacre, emphasizing the significant role of the hyperelastic matrix. It provides an alternative to the conventional explanation based on platelet asperities and bridges, deepening our understanding of the underlying mechanisms that contribute to the material's remarkable mechanical behavior.

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