

Dynamic Nanoindentation and Fourier Transform Infrared Spectroscopic Study of Nacre

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Abstract

Nacre, the inner shiny layer of many seashells is a model biomimetic system composed of 95% of inorganic (aragonite) phase and 5% of organic phase. Nacre exhibits an interlocked layered “brick and mortar” structure where the bricks are made up of aragonitic calcium carbonate and mortar is an organic phase. Here, we studied the role of indentation load and penetration depth on measurement of nanomechanical properties of nacre. A range of loads from 10 μN to 10,000 μN were applied to obtain the response from different depths of nacre. We observed variations in the elastic modulus and indentation hardness values. And these variations were larger at lower loads and gradually decreased at higher loads. Our results show that, the microarchitecture and the composition of nacre affect the nanoindentation tests performed at lower loads. We also studied the dynamic nanomechanical behavior of nacre using dynamic nanoindentation. The tests were performed at three different frequencies (25Hz, 50Hz and 100Hz). Increase in the values of loss modulus and loss factor was observed with increase in depth of penetration. We also observed significant increase in the values of $\tan \delta$ with increase in frequency. Photoacoustic Fourier transform infrared spectroscopy (PAS-FTIR) experiments of undisturbed and nacre powder suggest, the act of powdering nacre disturb the interfacial interactions between aragonite and organic matrix. The powdering of nacre may also cause relaxation of residual stresses in the nacre. PAS-FTIR results also indicate the presence of bulk water in nacre. This bulk water is bonded to aragonite and organic matrix in different ways. Most of the bulk water is oriented in such a way that the plane containing H-O-H bonds is perpendicular to c-axis of aragonite platelets.

