Synthetic materials that behave like mollusk shells

Nacre, commonly known as mother-of-pearl, is the iridescent material lining many mollusk shells. It is part of a two-layer armor system that protects the animal from predators. The brittle outer layer of the shell absorbs the initial impact, but is prone to cracking. To prevent these cracks from catastrophically propagating through the shell to the animal itself, the nacreous layer is surprisingly strong and tough, with outstanding crack arresting properties. Thus it acts as a lining to maintain the integrity of the shell in the event of cracking of the outer layer.

"What makes this natural material unique is that it is composed of relatively weak constituents," said Owen Loh, a graduate student at Northwestern University. At the microscale, brittle calcite tablets are stacked in a brick-and-mortar-like structure with thin layers of biopolymer lining the interfaces between tablets. This results in a material that well outperforms its individual constituents. For example, the toughness of nacre is orders of magnitudes greater than the individual constituents.

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"We published these results before but it took atomic scales experiments to confirm our hypothesis on the origin of toughness in these biomaterials," Espinosa said.

"We took what we learned from natural nacre and designed a scaled-up artificial composite material with an interlocking tablet structure," said Pablo Zavattieri, a co-author of the paper and assistant professor of civil engineering at Purdue University. "By applying nacre's highly effective toughening mechanism to this material, we were able to achieve a remarkable improvement in energy dissipation."

"We believe these findings may hold a key to realizing the outstanding potential of nanocomposites," Espinosa said.


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