ScienceDaily (Feb. 2, 2011) — Nacre, commonly known as mother-of-pearl, is the iridescent lining many mollusk shells. It is part of a two-layer armor system that protects the animal from The brittle outer layer of the shell absorbs the initial impact, but is prone to cracking. To prevent 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 ligament 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 Loh, a graduate student at Northwestern University. At the microscale, brittle calcite tablets a brick-and-mortar-like structure with thin layers of biopolymer lining the interfaces between them. This results in a material that well outperforms its individual constituents. For example, the toughness is orders of magnitude greater than that of the tablet material itself. In addition, nacre is at once tough, a combination that is generally mutually exclusive in engineering materials. As a result, the object of significant interest within the materials community and serves as a model for numerous man-made composite materials are designed. This includes composites for lightweight systems and structural elements in transportation and aerospace applications. Nacre’s outstanding performance has long been attributed to its brick-and-mortar microstructure. However, the specific attributes of this hierarchical structure, which contribute to the toughness of nacre, have been the subject of debate. As a result, efforts to translate deformation mechanisms observed in nacre into m
composite materials have been widespread but mostly unsuccessful. In a paper published or
journal Nature Communications, Horacio Espinosa, the James N. and Nancy J. Farley Profe
Manufacturing and Entrepreneurship at the McCormick School of Engineering and Applied S
Northwestern, Loh and colleagues report the identification of specific characteristics of the m
microstructure that enable its outstanding performance. By performing detailed fracture exper
atomic force microscope, the group was able to directly visualize and quantify the way the
relative to each other as the material is deformed. The group previously found that the tablets
perfectly flat but instead have an inherent waviness in their surfaces. As a result, they tend to
they slide relative to each other, spreading damage and dissipating energy over large areas.
published these results before but it took atomic scales experiments to confirm our hypothesi
origin of toughness in these biomaterials," Espinosa said. The group then applied the findings
design of artificial composites. "We took what we learned from natural nacre and designed a
artificial composite material with an interlocking tablet structure," said Pablo Zavattieri, a co-a
paper and assistant professor of civil engineering at Purdue University. "By applying nacre's effec
tive toughening mechanism to this material, we were able to achieve a remarkable impr
energy dissipation." The findings have important implications for future design of high-perfor
composite materials. "We believe these findings may hold a key to realizing the outstanding p
nanocomposites," Espinosa said. "While carbon nanotubes and other nanoscale reinforcement
these materials have unprecedented properties, their performance has yet to be translated to
composites. By implementing toughening mechanisms such as those we found in natural nac
to be able to achieve this." In addition to Espinosa, Loh and Zavattieri, the paper was co-author
Juster, Felix Latourte and David Gregoire

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