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Bio-assembled nano-composites as high-density energy storage materials

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ABSTRACT

Novel physics and properties have been discovered in different assembled nanomaterials synthesized by the bottom-up technique, which enables us to make and build new electronic, photonic, and magnetic devices based on these properties. Nature has long used bottom-up synthesis to fabricate nano-materials that exhibit much better physical properties than their man-made counterparts. For example, superior optical properties are observed in the nanometer-scale architectures of Brittlestars, butterflies, and many insects; super-hydrophobic effects are evident in lotus plants and water bugs. Superior mechanical properties are found in seashells, which are composed of well aligned and highly packed aragonite nano-laminas glued together by biopolymers. Although the strength and toughness of the nano-composites in seashells have been extensively studied, their other extraordinary physical properties have not been described. Here, we show that conch shells, with bio-assembled, hierarchical architectures of nano-CaCO3 laminas sandwiched between biopolymers, exhibit ferroelectret behavior: ferroelectric-like hysteresis loops. Their remanent electrical polarization (2–4 kμCcm-2) is one order of magnitude higher than the largest electrical polarization reported in man-made ferroelectric materials (146 μCcm-2) and several orders of magnitude higher than that in electrets, as obtained from square polarization-electric-field hysteresis loops. This novel property suggests the possibility of developing nanocomposites with high electrical polarization using the bottom-up technique for applications of high performance of electret motors/generators and of high-density energy storage.