Mechanics on hierarchical chirality transfer in biological materials and nanomaterials

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Abstract

Chirality exists at different length scales in a hierarchical way in many biological materials and nanomaterials such as climbing tendrils, bacteria flagella and polymer lamellae. The transfer of chirality among different structural levels is crucial for the morphologies, properties and even functions of these materials. Here, we experimentally and theoretically investigate the chirality transfer from microscale to macroscale, which may occur during the growth or assembly process of biological materials and nanomaterials. The physical mechanisms underlying these chirality transfer phenomena are presented. Through the modelling, we demonstrate that the chirality of constituent elements at the microscale can induce the twisting of higher-level structures, which may further transfer into the macroscopic morphology, rendering the formation of hierarchically chiral structures in biological materials and nanomaterials. The hierarchical transfer of chirality may provide a limit for the macroscopic size of biological materials through the accumulative contribution of twisting. The results of the study is useful not only for understanding various interesting phenomena associated with chirality such as the chiral growth in biological world but also for optimal design and fabrication of novel materials and devices with enhanced properties and functions.

Keywords: biological materials, nanomaterials, chirality transfer, size effects