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Bio-inspired Fillers for Mechanical Enhancement

LASHANDA KORLEY, Case Western Reserve University

An examination of natural materials has offered a new perspective on the development of multi-functional materials with enhanced mechanical properties. One important lesson from nature is the utilization of composite structures to impart improved mechanical behavior and enhanced functionality using nanofillers. A relatively unexplored expansion of this bio-inspired, nanoscale filler approach to high performance materials is the incorporation of responsive, multi-functional reinforcing elements in polymeric composites with the goal of combining superior mechanical behavior that can be tuned with additional functionality, such as sensing and bioactivity. One approach is the use of self-assembling small molecules that form uniform, one-dimensional nanostructures as an emerging class of filler components. Another pathway toward mechanical enhancement is the incorporation of stimuli-responsive and high-modulus electrospun nanofibers. We have probed the utilization of high-aspect ratio, self-assembled small molecules and responsive electrospun nanofibers as all-organic nanofillers to achieve significant modulus changes within elastomeric matrices. The influence of matrix-filler interactions and the role of hierarchical organization in these nature-inspired composites will be discussed. Potential applications in barrier technology and drug delivery have also been explored.