Emerging trends in 2D nanotechnology that are redefining our understanding of nanocomposites

by

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Abstract

Graphene and other two-dimensional (2D) materials possess desirable mechanical, electrical, and optical properties for incorporation into polymer materials, potentially granting them unique structural and functional reinforcements. Notably, the emergence of large-area, high-quality 2D materials provides a means of the exact positioning atoms at specific locations and to arrange molecules in desired structures, at the surface and interface for example, which would give access to novel nanocomposites with versatile properties at a minuscule addition of nanoinclusions. Herein I will present (1) Layered and scrolled nanocomposites with aligned semi-infinite 2D inclusions: we have developed a successive stacking/folding method to generate aligned graphene/polymer composites, and an analogous transverse shear scrolling method to generate Archimedean spiral fibers. The unique topology of these composites with continuous 2D materials demonstrates substantial mechanical and functional reinforcement at highly reduced volume fraction of nanofillers. (2) Autoperforation of 2D materials for generating particulate electronic devices: we have recently developed an “autoperforation” technology providing a means of spontaneous assembly for colloidal microparticles comprised of 2D molecular surfaces and polymer matrix. Such particles demonstrate remarkable chemical, mechanical, and thermal stability. They can function as aerosolizable electronic cells with built-in memristor arrays capable of storing and transferring digital information, as well as dispersible and recoverable microprobes for large-scale collection of chemical information in water and soil. (3) A controlled polymerization technique named Reversible Polycondensation-Termination (RPT) for the synthesis of 2D covalent organic frameworks, and we have achieved the one-pot synthesis of highly ordered COFs with high crystallinity, controlled morphologies, and sizes up to centimeter scale, including spheres, fibers, and films consisting of interweaved 2D nanoflakes. The RPT approach allows an in-situ growth of COF film on given surfaces, enabling continuous flow microreactions with high catalytic activity and durability and thin-film gas sensors with good sensitivity and repeatability.

Bio

Dr. Pingwei Liu currently is a "hundred talents program" distinguished research fellow (assistant professor) of Zhejiang University, China. He worked as a postdoctoral associate at Massachusetts Institute of Technology in the group of Prof. Michael Strano during 2014-2018. He received his Ph.D. degree from Chemical Engineering Department at Zhejiang University in 2014. His research interests lie at the nexus of polymers and two-dimensional (2D) materials and the study of their applications in nanocomposites, microrobots, and nanocatalysis. He has published more than 30 articles in the journals of Science, Nature Materials, Nature Nanotechnology, and others. He has obtained one international invention patent authorization and two US invention patent applications. Some of his results have been reported by major media including Nature Mater., MIT News, Angew. Chem. Int. Ed., Nano Today, Mater. Today. Today. He serviced as the chair at 2D Nanocomposite Session of AIChE Annual Meeting 2017 and 2018.

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