High Performance Polymeric Materials and Their Applications

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Abstract

In general, strategy for improving polymeric materials performance includes 1) design and synthesis of novel structured polymers and 2) incorporation of functional inorganic filler into polymer matrix to form polymer composites. Compared to polymer synthesis, fabrication of advanced polymer composites for various applications is a straightforward and industry adoptable approach. In this talk, I will present research achievement of our group on polymer composites development, including inorganic filler design and functionalization, composite process and structure-property-performance relationship.

Inspired by the biosilification process of some marine organisms, we have successfully developed a method to synthesize PEGylated silica nanocapsules, polymer composites at nanoscale, at room temperature and near-neutral pH aqueous environment by using PEG-based block copolymer micelles as templates. The success of this approach lies on confining silica shell growth at the interfacial area between core and corona of polymeric micelles as a result of encapsulation of silica precursors inside the core of micelles. As a consequence, the synthesized silica nanocapsules are intrinsically perforated by PEG chains, which enable them to exhibit excellent colloidal stability and anti-fouling performance. The PEGylated silica nanocapsules are truly nanosized, which are ~15 nm in diameter, and demonstrated to be non-cytotoxic. These silica nanocapsules can be further functionalized by encapsulating hydrophobic ingredient inside their core.

Oxygen barrier of materials used to wrap food plays an important role in making sure the product reaches consumer in the best possible condition. In order to enhance the oxygen barrier, layered-silicate fillers with high aspect ratio such as montmorillonite (MTM) have been incorporated into plastic materials to form polymer composites. Although the oxygen barrier of polymer matrix can be enhanced through incorporating layered-silicate fillers, various studies have shown that the maximal improvement on oxygen barrier with layered-silicate/polymer composite fabricated through conventional compounding or mixing is about 2/3 in maximum. At our group, a facile approach has been successfully developed for preparing flexible and optically transparent hierarchical MTM polymer composite layer with excellent oxygen barrier through applying gelatinous MTM polymer suspension onto PET film. Laminated flexible food packaging is then fabricated through laminating the coated PET film with polyolefin film. Nano-structured Fe/carbon oxygen scavenging filler has developed for further reducing oxygen transmission.

Keywords: Polymeric materials; Silica nanocapsules; Hierarchical polymer composites; Oxygen scavenging filler.