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Opinion

Functional Spherical Polymer Brushes: An Overview

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A polymer brush is made up of a number of polymer chains that are assembled, with one end of which fixed to a surface or interface. The distances between the polymer chains are generally smaller than their radius of gyration. The free ends of the polymer chains extend away from the surface or interface due to a strong steric hindrance. According to the substrate curvature, polymer brush could be divided into three categories: flat polymer brush, spherical polymer brush and star polymer brush, among them spherical polymer brush is easy to be functionalized both for the core and the brush shell and could be applied both in solid and aqueous circumstances. Thus, spherical polymer brushes have been systematically investigated in aspects like structure design, preparation strategy, and potential applications in many fields. Typically, core materials could be inorganic like silica or organic like polystyrene or another polymer. The polymer brush forms the shell layer, and polyelectrolyte, i.e., charged polymer brush, is also employed to make the shell layer more extended and with better dispersity in aqueous systems. Functional spherical polymer brushes have attracted more attention in the last decade, which can respond specifically to external stimuli. Common external stimuli include pH, temperature, ionic strength, magnetic field, fluorescence, etc. With external stimuli, the configuration or conformation of polymer brush will be changed, and corresponding behaviors are also different. In general, the intrinsic properties of polymer brushed are determined by introducing functional polymeric monomers. Different functional monomers can be introduced into the spherical polymer brush system to make it respond to different external stimuli. Polymer brushes can be introduced by grafting-to, grafting-from, and grafting-through strategies, among which grafting from is the most used method. The grafting-from method could be carried out by newly developed surface-initiated controlled radical polymerization, or traditional polymerization. The former method can control the polymer molecular weight and molecular weight distribution, which then give homogeneous brush chains and particle size. Furthermore, multiple monomers could be introduced in a regular way to increase the controlled conformation variation under set conditions. Diblock polymer brushes, or even triblock polymer brush with different monomer sequence have also been prepared in the literature. However, it also has the disadvantages of having fewer types of functional monomers available. The spherical polymer brushes made by this method are easy to be manipulated for further applications. While in some cases, the brush chain length is not the critical factor, while the particle size and size distribution are more important. The later method of conventional polymerization is employed in some practical applications since there are more monomers can be used and large-scale production can be realized. In addition to introducing different functional monomers, the solid core can also be functionalized by introducing magnetic materials, fluorescent molecules or other materials into the matrix. Especially for the systems with poor compatibility between different components, or using some toxic molecules in biomedical fields, encapsulation of such materials in the core matrix is the most applied strategy to enhance the compatibility or reduce the toxicity. For example, dyes or pigments are typically encapsulated by polymer shells to make colored nanoparticles with low toxicity.

Today, functional spherical polymer brushes could be applied in many fields. This functional material has antibacterial, stain resistance, acid-base response and temperature response. And they could be used in functional coatings, catalytic carriers, detections and sensors, etc. For example, spherical polyelectrolyte brushes could adsorb heavy metal ions in sewage with high selectivity and efficiency, and they could be recycled for many times maintaining a high performance. This is extremely important for protecting the environment and keeping our life healthy. Spherical polymer brushes with antibodies attached on the brush structure are also an excellent carrier for the transportation and release of drugs to target locations in vivo. Spherical polymer brushes could also play an important role in cell detection and protein labeling if fluorescent molecules are introduced other in the core matrix or in the brush structure. They can also be used as a solid surfactant to control the stability of Pickering emulsion and bring more flexible properties. In the future, multi-functionality, environmentally friendly, and a large-scale production are the main trends of development of functional spherical polymer brushes. They are expected to address some important technical issues in nanomaterials science and pave a way to the applications in critical fields like clinical medicine and life science, etc.

