4bp Smart Nanotechnology in Biomaterials, Sensors, Actuators and Textiles

Hong Chen

Smart materials can be defined as materials that sense and react to environmental conditions or stimuli (e.g. mechanical, chemical, electrical, or magnetic signals). In the last decade, a wide range of novel smart materials have been produced for aerospace, transportation, telecommunications, and domestic applications. This research program integrates smart materials with nanotechnology to develop novel materials for the applications in biomaterials, sensors, actuators, and textiles. The focus is on smart nano-fibers. Based on the advantages over the other forms of materials, such as high specific area, superior mechanical and handling properties, fibers are finding more and more applications in different areas.

In my previous work, smart nano-fibers have been successfully prepared by different methods. For instance, temperature- and pH-dual sensitive hydrogel nano-fibers were prepared by electrospinning technique1,2. The nano-scale size decreased the response time of the smart hydrogel from several hours to a few seconds. In addition, the fibrous mat form provided the hydrogel nano-fibers much easier handling properties than do the conventional hydrogel nano-particles. These hydrogel nano-fibers should be suitable for the applications in sensors/actuators, biomaterials, etc. An alternative to synthesize smart nano-fibers was explored by surface-grafting of nano-fibers with smart polymers3-5. Adsorption of protein on these smart fibers could be actuated by the pH of the environment, e.g., more than 5 times higher adsorption at pHs above 5. These smart nano-fibers have also been demonstrated to be excellent supports for enzyme immobilization as a result of ultra-high specific area. In recent years, smart nano-fibers have also become fast-growing scaffolds for tissue engineering.

My recent work on chemical/biological protective clothing reveals a promising approach to prepare selective and responsive barriers6. This barrier is based on a polymer-polymer nanocomposite of a smart polymer grafted or a smart nano-fiber imbedded within a porous or dense hydrophobic polymer host matrix. The hydrophobic host matrix provides mechanical strength, durability, flexibility, and barrier properties, while the smart polymer/fiber provides high water vapor permeability with stimuli-responsive traits for size-exclusion of toxic chemicals. Preliminary results on poly(ethylene terephthalate) (PET) and poly(methacrylic acid) or poly(2-acrylamido-2-methyl-1-propanesulfonic acid) showed that, selective transport of water vapor over dimethyl methylphosphonate vapor was increased by 12 times for both nanocomposites in comparison to the PET dense membrane.

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