Hybrid Gel-materials: from Design, Function to Its Fiber Application

Kai Hou, Guoyin Chen, Peiling Wei, Tao Chen, Meifang Zhu*

State Key Lab for Modification of Chemical Fibers & Polymer Materials, College of Materials Science & Engineering, Donghua University, Shanghai 201620, China

Abstract

Hydrogels, consisting of three-dimensional cross-linked hydrophilic polymers and large amount of water, are biocompatible, soft and flexible, which have attracted much attention as frequently used biomaterials and intelligent devices. Benefiting from the recently organic (polymers)/inorganic (nano-particles NPs) hybrid strategy, hybrid hydrogels (H-gels) have been developed with diverse functions, scales and dimensions. Our research group have long-term devoted in designing application-oriented H-gels with surprising mechanical properties, multiple dimensions and specific functions. First, using clay as physical cross-linker, the obtained H-gels exhibited excellent mechanical properties. Based on the regulation of interaction between organic and inorganic clay sheets, H-gels with double volume phase transition temperatures including an upper critical solution temperature (UCST) and a lower critical solution temperature (LCST) between 5 and 85 °C was obtained for promising smart optical switches. Second, functional NPs like magnetic and photothermal ones, could be introduced into H-gels as functional crosslinking point to fabricate H-gels with external stimuli responsive properties, which could be applied as drug release system or smart micro-channel valves. Recently, advances in hydrogel design are yielding hydrogel fibers, a new class of hydrogel material with unique spatiotemporal properties such as great aspect ratio, orientation and knittability, for specific applications. We have successfully established a facile dynamic-crosslinking-spinning (DCS) method without any additional complex facility for direct continuous fabrication of size-controllable chemical crosslinked hydrogel fibers from monomer solution. Based on the functional and structural regulation, the above hydrogel fibers with adjustable optical transmittance property have been investigated for photodynamics therapy and optogenetics. Moreover, a tough nanocomposite hydrogel fiber with enhanced mechanical performance has been fabricated by post-stretching process, ~67 times higher than corresponding bulk hydrogel due to the drawing-induced orientation of polymer chain and clay sheets. It is believed that hydrogel fiber is a great promising 1-dimensional smart material for designing intelligent bionics, soft robots, interactive materials and so on.

Keywords: hybrids, hydrogel fiber, design, function, application
Acknowledgement: This work is financially supported by National Natural Science Foundation of China (51733002, 51803022); National Key Research and Development Program of China (2016YFA0201702/2016YFA0201700); The Fundamental Research Funds for The Central Universities (2232018A3-01); Science and Technology Commission of Shanghai Municipality(16JC1400700) and Innovation Program of Shanghai Municipal Education Commission (2017-01-07-00-03-E00055).