Review
Received December 9, 2013
Accepted for Publication February 20, 2014

Artificial Silk Materials with Enhanced Mechanical Properties and Controllable Structures

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Spider and silkworm produce animal silks exhibiting outstanding mechanical properties by using smart spinning method. In this paper, a biomimetic spinning of spider silk and silkworm silk was studied from various routes. Regenerated silk fibroin (RSF) aqueous solution was firstly dry-spun to artificial fiber in air at room temperature as the animal silks were made naturally. The conformation transition of the silk fibroin was then induced by post-drawing in ethanol aqueous solution. The oriented crystalline and amorphous regions of the silk fibers contribute to the remarkable mechanical properties of the artificial silk, which exceed those of natural silkworm silk. By mimicking the functions of the spinning apparatus of spider and silkworm, ion and protein concentrations in the RSF aqueous solution were adjusted in microfluidic chips with multiple channels. Inspired by the shape and dimensions of the natural spinning apparatus, a microfluidic chip was designed and applied to the studies of aggregation mechanism of silk fibroin in micro-channel. Moreover, the supermolecular structures of silk fibroin were effectively controlled to reinforce dry-spun/electrospun fibers of RSF by mimicking the core-shell structure of natural animal silks, adding silk sericin or carbon nanotube in spinning solutions and changing the collecting method in electrospinning process.

Key Words : Silk fibroin, Silk fiber, Dry-spinning, Electro-spinning, Microfluidic