Processing of Bombxy mori Silk Using Ionic Liquids

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As a biomaterial, silk has remarkable strength and toughness properties, rivaling those of high-performance, synthetic polymers. Processing of silk materials is challenging and requires harsh conditions and solvents. Yamada et al. outline several methods for preparing silk fibroin solutions, which involve stripping the sericin in a Na_2CO_3 wash, rinsing and drying the silk followed by dissolution in a high concentration, aqueous Li salt solution or a $CaCl_2$/ethanol/water solution [1]. These solutions are subsequently dialyzed, and have a shelf life of about 1 week before the onset of gelation. However, stable fibroin solutions can be created by lyophilizing the dialyzed solutions and dissolving the cake in another solvent such as 1,1,1,3,3,3-hexafluoro-2-propanol or hexafluoroacetone [2].

Ionic liquids have been utilized to dissolve other biological macromolecules, such as cellulose [3,4]. Swatloski et al. found that the 1-butyl-3-methylimidizolium (BMIM) cation coupled with a chloride anion produced solutions of 25% (w/w) cellulose [3]. They also found that cellulose was soluble in BMIM with bromide and thiocyanate anions, but in less than half the amount of the chloride anion. The success of BMIM Cl was attributed to the ability of the chloride anion to disrupt the hydrogen-bonding present in the cellulose chain.

We have recently discovered that ionic liquids can alos be used to dissolve Bombyx mori (silkworm) silk. The solubility of Bombyx mori silk has been determined in a variety of ionic liquids including: BMIM Cl, 1-butyl-2,3-dimethylimidazolium (DMBIM) chloride, and 1-ethyl-3-methylimidazolium (EMIM) chloride. Ionic liquids based on the BMIM cation with Br^-, I^-, and BF_4^- anions have also been evaluated as solvents. In addition, silk films have been cast from the resultant solutions. These films with and without subsequent treatments have been characterized in order to understand the effect of processing conditions on the silk films.

References

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