Characterization of Composite Films Prepared by in-Situ Polymerization of Styrene/Butyl Acrylate in Nanoporous Cellulose Gels

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Abstract

Polymer/cellulose composites have attracted lots of interest because they can have high strength to weight ratios, low thermal expansion coefficients, cost competitiveness, and eco-friendliness. To prepare a high performance polymer/cellulose composite the chemical modification of cellulose would be essentially carried out via the hydroxyl groups of cellulose to make the hydrophilic cellulose more compatible to the generally hydrophobic polymer. However, manufacturing a high performance polymer/cellulose composite is still a challenge because of the poor dispersion and distribution of cellulose fillers in a hydrophobic polymer matrix and poor interfacial adhesion between cellulose and the polymer matrix. Most of the published studies on polymer/cellulose composites used natural cellulose fillers (fibers or particles) with native molecular structure. However, nanoporous cellulose gels (NCGs) with regenerated molecular structure can be prepared by dissolution and coagulation of native cellulose molecules and used as fillers to reinforce polymers. Therefore, in this study, film-shape NCGs were prepared first using microcrystalline cellulose powder via (1) dissolution of cellulose chains in an aqueous alkali hydroxide/urea solution and (2) crosslinking of cellulose chains by adding epichlorohydrin to (1). Then, poly(styrene-co-butyl acrylate)/NCG composite films were prepared by in-situ polymerization of each styrene/butyl acrylate (St/BA=3/7~7/3) monomer mixture with benzoyl peroxide 1% as an initiator in the NCGs. A monomer mixture was imbedded in the cavities of an NCG first then in-situ polymerized at 50 °C for 12 h. The NCG contents in the composite films were controlled from 16 vol.% to 44 vol.% by controlling the dewatering level of the pristine nanoporous cellulose hydrogel using different compression forces. The composite film prepared with St/BA=3/7 monomer mixture was highly transparent (~ 82%) in the visible region and showed excellent tensile and dynamic mechanical properties.

Image

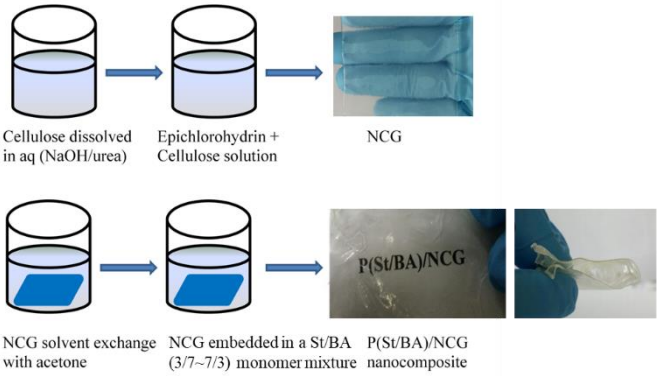
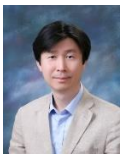


Figure 1. Preparation of a NCG and a poly(styrene-co-butyl acrylate)/NCG composite.

Recent Publications

1. Jang S Y, Kim D S (2016) Physical properties of polypropylene composites with hydrophobized cellulose powder by soybean oil. J Appl Polym Sci 133:42929.
2. Xu C, Lu Q, Wu D, Wang Z (2017) Polylactide/cellulose nanocrystal composites: a. comparative study on cold and melt crystallization. Cellulose 24:2163-2175.
3. Tanaka S, Iwata T, Iji M (2016) Solvent effects on heterogeneous synthesis of cardanol- bonded cellulose thermoplastics. Polymer 99:307-314.
4. Cai J, Kimura S, Wada M, Kuga S (2009) Nanoporous cellulose as metal nanoparticles support. Biomacromolecules 10: 87-94.
5. Chang C, Zhang L (2011) Cellulose-based hydrogels: Present status and application prospects. Carbohydrate Polymers 84:40-53.



Biography

Dae Su Kim is a Professor in the Department of Chemical Engineering at Chungbuk National University in Korea. He received his B.S. degree (Seoul National University, Korea), M.S. degree (KAIST, Korea), and Ph.D. degree (KAIST, Korea) all in Chemical Engineering and was a postdoctoral fellow at the University of Minnesota at Twin cities. He worked as a senior researcher in the Laboratory of Polymer Composites at the Korea Research Institute of Chemical Technologies before joining Chungbuk National University in 1994. He was a visiting professor at the University of California at Davis, Queensland University and Hokkaido University. His research interests include processing and physical properties of polymer composites and nanocomposites, polymer-filler interfacial interactions, modification of fillers, and green polymer composites and nanocomposites with biomass based fillers.

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Notes/Comments: