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The Synthesis of a Chemical Stimuli Nanowhiskers of Cellulose (CNWs) Composite Hydrogel

Jiufang Duan[1]*, Yuxue Gao[1]

[1]MOE Engineering Research Center of Forestry Biomass Materials and Bioenergy, Beijing Forestry University, Beijing 100083, China

Abstract. Long aspect-ratio CNWs derived from non-toxicity, sustainable, biocompatibility cellulose has high mechanical properties and often be applicated as strengthening agents in composites and hydrogels. N, N'-bis (propionyl) cystamine and acrylamide can form chemical stimuli hydrogel through copolymerization in water solution. Disulfide bond in N, N'-bis (propionyl) cystamine may perform link/ break transition in response to chemical stimuli. CNWs were performed as reinforce agent of acrylamide- N, N'-bis (propionyl) cystamine hydrogel. A series of CNWs composite hydrogels were prepared by acrylamide, N, N'-bis (propionyl) cystamine solution with CNWs suspensions homogeneously dispersed. The structure of the composite hydrogel was characterized by fourier transform infrared spectroscopy (FTIR).

1. Introduction

Hydrogel is a kind of three-dimensional crosslinked hydrophilic polymer networks that can swellen in water and can hold on a large volume of water in swollen state. Hydrogels have received considerable attention since 1954 [1], for it has wide applications, such as water treatment, agriculture products [2], drug control and delivery systems [3, 4], tissue engineering [5], pharmaceuticals [6], wound dressing [7] and so on.

Stimuli-responsive hydrogels [8] have recently gained attention owing to its smart nature in potential use in control and release of micro-fluidics. This kind of hydrogels has the ability of change their volume when meet certain environmental parameters, during volume change the absorption and release of aqueous solution could be realized. Disulfide bond is an ideal reversible connection chemical bond that has the ability of chemical stimuli properity. Acrylamide copolymerize with N, N'-bis (propionyl) cystamine can introduce disulfide bond into the hydrogel system and got a chemical stimuli hydrogel. At the same time, biodegradable CNWs are attractive as reinforce agent to make environmentally friendly bio-based composites hydrogels [9]. In sequence, CNWs were used to reinforce this hydrogel. The structure, crystal properties and swelling behavior of the hydrogel composite were examined.

2. Experimental

2.1. Material

Acrylamide, N, N'-bis (propionyl) cystamine, ethanol, ammonium persulfate, N, N, N', N'-tetramethylethylenediamine (TEMED) were of analytical grade and used without further purification.

2.2. Preparation of CNWs nanocomposite hydrogels

CNWs (CNWs here used were isolated from cotton) [10] is uniformly dispersed in an aqueous solution and prepared into solutions of concentration 0.09 g/ml, 0.067 g/ml, 0.045 g/ml, 0.03 g/ml, 0.011g/ml, 0.006 g/ml. 19g anhydrous ethanol, 0.4368g N, N'-bis (propionyl) cystamine, 3.724 g acrylamide and 4500 μL TEMED were added into 57g CNWs solution. The solution was stirred until fully dissolved. 9100 μL freshly prepared 10% w / v ammonium persulfate were added to initiate the polymerization reaction. This reaction was maintained at room temperature for 15 h to get the hydrogel.

2.3. Methods

IR spectra were recorded by FTIR (Nicolet iN10Thermo Fisher Scientific China) in the region of 400–4000 cm−1. The gravimetric method was employed to measure the swelling ratios of the hydrogels in distilled water at 25°C. After immersion in distilled water for about 48 hr to reach swelling equilibrium, the gel samples were taken out and weighed after removing the excess water on the surfaces. Each data was measured three samples, and the average value of three measurements was taken. The equilibrium swelling ratio (SR) was calculated as SR = Ws/Wd, where Ws is the weight of the swollen gel and Wd is the weight of the hydrogel at the dry state.

3. Results and discussion

3.1. The synthesis of the CNWs composite hydrogels

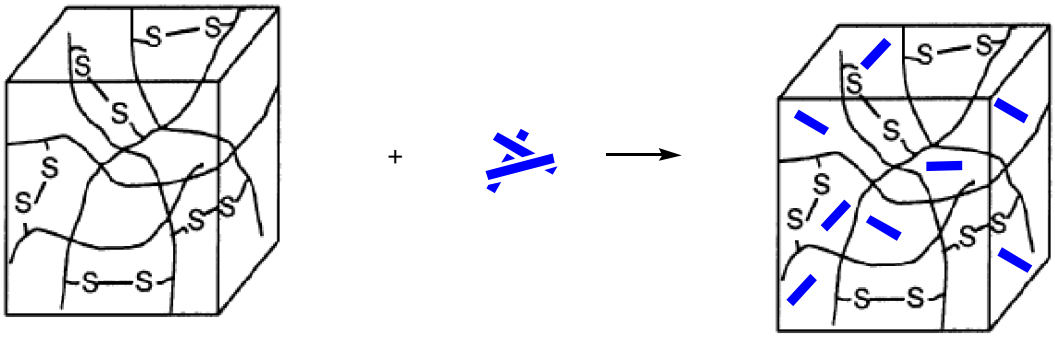

Figure 1. Acrylamide- N,N’-bis(acryloyl)-cystamine CNWs composite hydrogels equation.

CNWs here used were isolated from cotton. As seen in figure 1, CNWs dispersed in the hydrogel, except for the covalent bonds inacrylamide / N, N'-bis (propionyl) cystamine hydrogel, the disulfide bonds act as multifunctional cross-links and bridges at the adjacent molecular chain. Thus, the above disulfide bonds in hydrogels network contribute to the chemical stimuli behaviors.

3.2. Characterization of the CNWS composite hydrogels

Figure 2 shows the FTIR spectra of the CNWS composite hydrogels. As shown in figure 2, absorption peaks at 3430cm-1 is attributable to OH, peak at 2890 cm-1 corresponding to the band CH_2, peak at 1440 cm-1 due to the amide C-N and N-H stretching, peak at 1720 cm-1 is assigned to the C=O stretching vibration of the amide group.

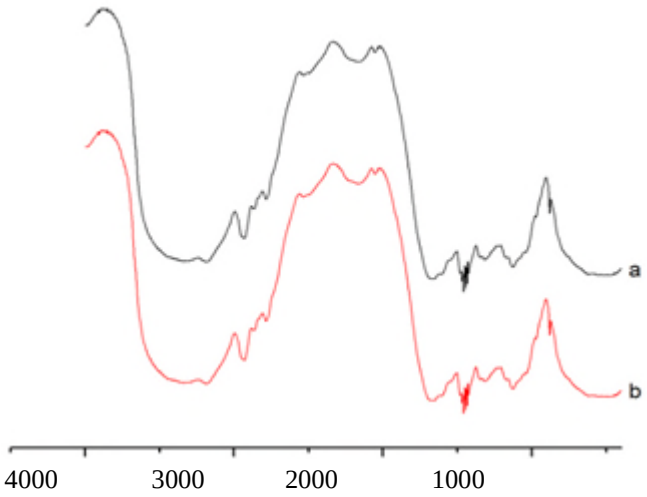

Figure 2. IR spectra of Acrylamide- N,N'-bis(acryloyl)-cystamine CNWs composite hydrogels (nanocellulose concentration a:0.09 g/ml, b:0.006 g/ml).

4. Conclusion

Hydrogels mechanical propertie is important to its application. CNW is an excellent reinforcing agent. Disulfide bond is an ideal reversible connection chemical bond that has the ability of chemical stimuli properity. In this study, CNWs were performed as reinforce agent of acrylamide- N, N'-bis (propionyl) cystamine hydrogel, and the same time disulfide bond has been designed into this hydrogel. A series of CNWs composite hydrogels were prepared by acrylamide, N, N'-bis (propionyl) cystamine solution with CNWs suspensions homogeneously dispersed. Acrylamide- N,N'-bis(acryloyl)-cystamine composite hydrogels with CNWS were successfully prepared in aqueous solution at 25°C by simple method. The structure of the composite hydrogel was characterized by infrared Spectroscopy (IR). The CNWs concentration affects the water absorption of the hydrogel.

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