Formation of Hydrogels from Plant-based Nanofibers

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Social concerns for sustainable green products are encouraging the efficient exploitation of cellulose, the most abundant renewable biopolymer on earth. Because cellulose exists in plant cell walls as highly crystalline nanofibers with several nanometers width, the plant-based cellulose nanofibers display strong mechanical properties and have great potential for reinforcing polymer matrices. Currently the nanofibers can be isolated from various plant sources and we have also found an isolation method in which plant sources are ground in an undried state [1]. The resultant nanofibers had a uniform width of approximately 15nm and a length of more than several micrometers (Figure 1).

Cellulose nanofibers homogeneously dispersed in water without sedimentation and the suspension exhibited a very high viscosity even with 1wt% nanofiber because of the large hydrophilic surface area and entanglement (Figure 2). We focused on the unique properties of nanofiber suspension and found that the novel hydrogels are formed from the cellulose nanofibers by soaking in alkaline aqueous solutions and then neutralization [2]. In general, when making hydrogels from any polymers, they need to be dissolved using suitable solvents. However, because fine cellulose nanofibers behave in water like dissolved polymers, the nanofibers are easily formed into hydrogels while maintaining high crystallinity (Figure 3).

The nanofiber suspensions were converted into two kinds of hydrogels with different crystal forms in response to the increasing concentration of sodium hydroxide (NaOH) and FE-SEM observations demonstrated that both hydrogels formed similar three-dimensional network structures with micro- and nanopores. When treated in 6–9 wt% NaOH, a hydrogel was formed by aggregating the nanofibers with the original morphology and the original crystal form, cellulose I. However, the hydrogel prepared at 15 wt% NaOH had a network formed by the coalescence of cellulose nanofibers and exhibited a highly crystalline cellulose II structure. This gelation process seems to be caused by the axial shrinkage of the cellulose nanofibers in aqueous alkaline solutions.

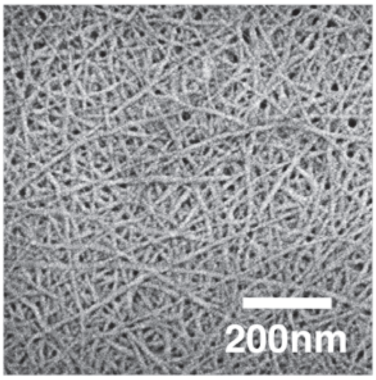

Figure 1. FE-SEM image of cellulose nanofibers isolated from wood

Figure 2. Aqueous suspension of cellulose nanofibers (1 wt%).

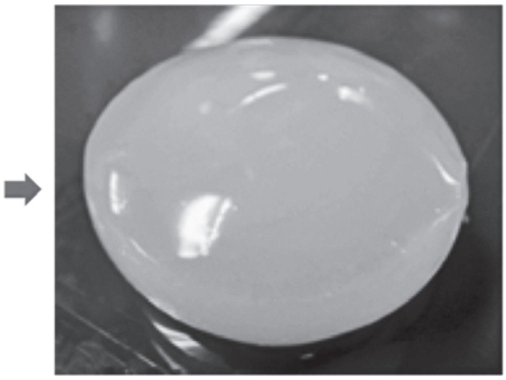

Figure 3. Hydrogel based on the cellulose nanofiber (9wt% NaOH)

References

[1] Abe, K., Iwamoto, S. and Yano, H, "Obtaining cellulose nanofibers with a uniform width of 15 nm from wood", *Biomacromolecules*, vol. 8, no. 10, pp. 3276-3278, 2007.

[2] Abe, K. and Yano, H, "Formation of hydrogels from cellulose nanofibers", *Carbohydrate Polymers*, vol. 85, no. 4, pp. 733-737, 2011.