Nano-fibrillation of wood pulp using a high-speed blender

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Cellulose microfibril bundles is known to be obtained as cellulose nanofibers (CNF) with diameters of 15-20 nm by mechanical fibrillation.[1)] CNF having prospective mechanical properties such as high Young's modulus, high strength and very low coefficient of thermal expansion is expected to be utilized as a filler of next-gen nanocomposites.[2)] We developed a novel and convenient preparation method to obtain CNF from wood pulp using a high-speed blender.

Experiment

The 30-60 mesh never-dried pulp, which α-cellulose content was 72.5 wt% and Klason lignin content was 0.1 wt%, was prepared by the WISE method of a cyclic treatment 10 times with a sodium chlorite ($NaClO_2$) solution under acidic condition (PH 4-5) at 80 ℃ for one hour. The suspensions of pulp fibers were agitated using a high-speed blender at different concentrations of pulp. As a reference, the suspension at a fiber content of 0.7 wt% passed one time through the grinder at 1500 rpm.

Result and discussion

The degree of fibrillation was evaluated indirectly by the transparency of their sheets after resin impregnation. The blender could fibrillate pulp to the same degree by the grinding method and the mechanical damage of fibers evaluated by XRD seems to be lesser. This agitating fibrillation method has several advantages allowing not only the control of the degree of fibrillation of pulp but also the observation of how the pulps are disintegrated into totally uniform nanofibers. The observation of the treatment process revealed that the straw-like pulp is fibrillated through a very characteristic way, by forming many "balloon like structures" as shown in Fig. 1. These balloons swelled more than twice as the original straw pulp and disintegrated to CNF in burst.

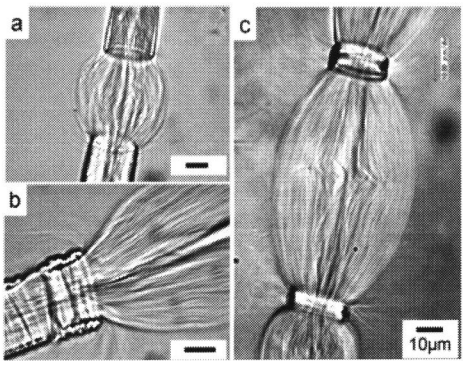

Figure 1. Digital micrographs of balloons occurring in the pulp fiber agitated at the concentration of 0.7 wt% with 37000 rpm.

The fibrillation with changing parameters in agitation indicates that the optimum condition of fibrillation is pulp concentration of 0.7 wt % at 37000 rpm (see Fig.2). At each concentration, the agitating speed affects the degree of fibrillation. The faster speed makes pulp fibrillate faster. On the other hand, the degree of fibrillation proportionally increases up to the pulp concentration of 0.7 wt%, then decreases above 1.1 wt%. The degree or speed of fibrillation is affected by the pulp concentration.

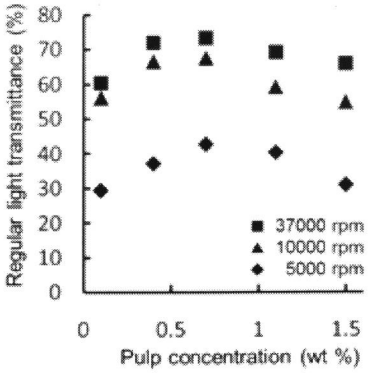

Figure 2. The regular light transmittance at 600 nm of 15 composites made of acrylic resin and 10 min agitated pulp at various agitating speed for pulp suspension of 0.1, 0.4, 0.7, 1.1 and 1.5 wt%.

References

[1] Abe, K.; Iwamoto, S.; Yano, H. *Biomacromolecules*, vol.8, pp.3276-3278, 2007.

[2] Berglund, L. A.; In *Natural Fibers, Biopolymers and Their Biocomposites*; Mohanty, A. K., Misra, M., Drzal, L. T., Eds.; *CRC Press Boca Raton*, FL, pp.807-832, 2005.