Cellulose nanofibers from plant sources

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The fabrication of nanofibers, generally defined as fibers with a diameter below 100 nm, is presently the subject of much attention because of their unique characteristics such as a very large surface-to volume ratio and the formation of a highly porous mesh as compared with other commercial fibers. Therefore, these nanofibrous materials are prime candidates for many momentous applications such as reinforcement in nanocomposites, tissue engineering scaffolds, and filtration media. A large number of synthesis and fabrication methods for producing these nanofibers have already been reported. In particular, electrospinning has been the subject of much attention over the past decade.

It is well-known that nanofibers are produced in nature, for example, collagen fibrils in tendons and ligaments and silk fibroin. Among the variety of natural nanofibers, cellulose microfibrils, which are the major constituent of plant cell walls and are also produced by some bacteria, are the most abundant natural nanofiber on earth. The microfibrils, having a width ranging from 5 to 30 nm, are highly crystalline materials formed by laterally packing long cellulose molecules with hydrogen bonding. The resultant stable structure has outstanding mechanical properties, including a high Young's modulus (138 GPa in the crystal region along the longitudinal direction) and a very low coefficient of thermal expansion (10^{-7} K^{-1} along the longitudinal direction). Therefore, cellulose whiskers and fibrils have great potential for use as reinforcement in nanocomposites and have attracted a great deal of interest recently.

Here we report on an efficient extraction of wood cellulose nanofibers by a very simple mechanical treatment. In cell walls, cellulose microfibril aggregates exist encased by the embedding matrix substances such as hemicellulose and lignin. However, the drying process in typical pulp production generates strong hydrogen bonding between the aggregates after the removal of the matrix, which seems to make it difficult to obtain thin and uniform cellulose nanofibers. Hence we kept the material in the water-swollen state after the removal of the matrix. The undried sample was subjected to a grinding treatment and we obtained cellulose nanofibers with a uniform width of approximately 15nm (Fig. 1a).

This study demonstrates a powerful yet quite simple method for the production of the nanofibers from plant fibers. More stable mass production of the nanofibers can be realized because this method is applicable to other plant sources such as wheat and rice straws (Fig 1b), flax, sugarcane bagasse, and potato pulp (Fig. 1c). We hoped that this result will further stimulate interest in environmentally friendly natural nanomaterials.

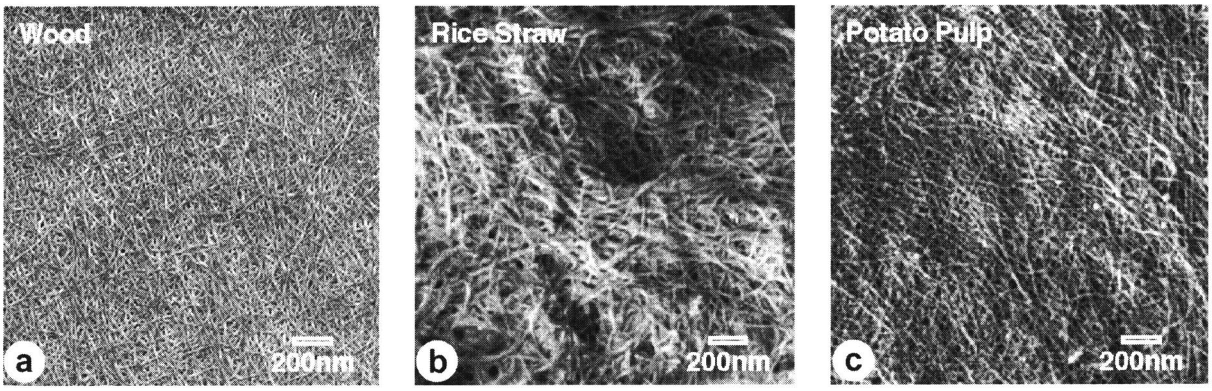

Figure 1. cellulose nanofibers isolated form wood (a), rice straw (b), and potato pulp (c).