Production of moldable cellulose nanofiber-reinforced phenolic resin composites

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Microfibrillated cellulose obtained by the mechanical fibrillation of pulp is expected to be an alternative nano filler to realize high-strength and low-thermal expansion composites. Although an increase in filler content increases the strength of composites, a strong aggregation of cellulose nanofibers generated by hydrogen bonds deteriorates the moldability of the composites at high fiber contents. Therefore, the optimum condition to attain high strength as well as good moldability was studied using phenolic resin as the matrix substance and microfibrillated chemi-thermomechanical pulp(CTMP) containing high amounts of lignin as the filler. The lignin is expected to suppress hydrogen bonding among cellulose nanofibers and act as a compatibilizer between cellulose and PF resin.

Materials and methods

A 1wt% water suspension of CTMP (Quesnel River Company, Q250 and B75) was processed with a grinder (Super Mascolloider, Masuko Industrial) at 1500 rpm. The water soluble low molecular weight phenol formaldehyde (PF) resin (DIC, IG-1002) was mixed to the CTMP slurry to obtain 10 to 70wt% fiber content at oven-dried condition. The mixtures were dried at 50 ℃ to remove water. The dried-mixtures were crushed and molded to disk-shaped samples, The samples were set between hot plates at 120℃ and compressed under 5MPa for one minute. The changes of the distance between the hot plates were used to evaluate the thickness changes of the samples, a measure of moldability. Then, the samples were heated at 150℃ for eight minutes to assure full curing of the PF resin.

Results and discussion

The table and figure show the effects of the fiber content on the mechanical property of the samples. The CTMP nanofibers reinforced PF resin composites exhibited good moldability up to a fiber content of 30%. The flexural strength of PF resin doubled by adding only 10wt% of CTMP nanofibers, although the increase of the Young's modulus was around 60%. The flexural strength reached values around 160MPa at a 20wt% fiber content.

On the basis of these results, transfer molding of the CTMP nanofibers mixed PF resin compounds was studied at a 20wt% fiber content. The transfer molding of the compound was successful, and the Young's modulus and flexural strength of the molded composite were 5.3 GPa and 115.3 MPa, respectively. Considering that the Young's modulus and flexural strength of the transfer molded composites reinforced by CTMP pulp were 4.5GPa and 69.5 MPa, respectively, it is concluded that the reinforcement by microfibrillated CTMP pulp can improve the strength of PF significantly, while enabling transfer molding.

Table 1. Mechanical properties of CTMP nanofibers reinforced PF resin

CTMP content (wt%)	Density (g/cm^3)	Frexural strength (MPa)	Young's modulus (GPa)
0	1.24	77.4	4.1
10	1.33	147.1	6.6
20	1.35	156.2	7.1
30	1.36	134.5	6.4

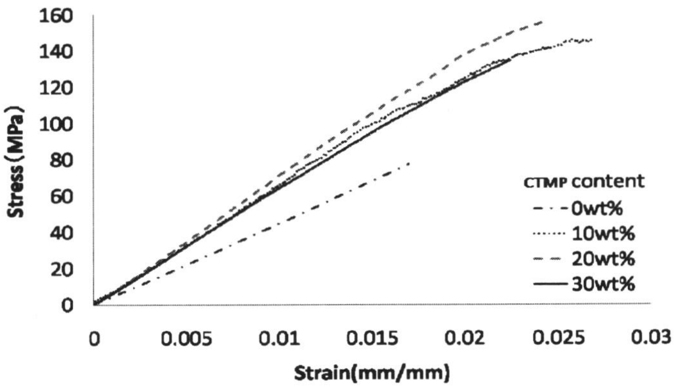

Figure 1. Stress-strain curves of CTMP nanofibers reinforced PF resin