

ABSTRACTS (MASTER THESIS)

Production and application of high-thermal-durability cellulose nanofibers

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Introduction

Cellulose has poor thermal durability compared to inorganic materials, and degradation via depolymerization and discoloration starts around 230 °C. Therefore, the melt kneading of resins with cellulose is restricted to temperatures below 200 °C. In contrast, plastics such as polycarbonate and nylon 6 have high melting temperatures. By using chemical modification, we have succeeded in improving the thermal durability of cellulose nanofibers for reinforcement. Here, a new chemical modification method based on vinyl ester reagents was used to improve durability and for combining the modified cellulose nanofibers with polycarbonate resin at a processing temperature of 250 °C.

Experiment

Bleached kraft pulp (NBKP, moisture content of 10%) and bacterial cellulose (BC, water content of 91%) were used as material fibers. Acetylation and benzylation were performed at 70 °C with vinyl acetate and vinyl benzoate, respectively, dimethyl formamide solvent, and a K₂CO₃ catalyst. The degree of substitution (DS) was determined with Fourier transform infrared spectroscopy (peak at 1730 cm⁻¹). For the polycarbonate compound, nano-fibrillated NBKP or BC and polycarbonate resin powder (Mitsubishi Engineering Plastics, Iupilon) were dispersed in IPA solvent, and the filtrate was dried. Samples were then prepared by melt kneading at 240 °C using a twin-screw extruder, followed by injection molding at 260 °C. The physical properties were then evaluated.

Results and discussion

Acetylation of NBKP progressed more easily than benzylation, and, eventually, the DS became constant at 2.2 and 1.0, respectively. This can be attributed to the difference in steric hindrance. Thermal durability was evaluated via the 5% weight-loss temperature (5% WLT). It improved more from benzylation than from acetylation and depended on the structure of the ester group. The 5% WLT of NBKP by benzylation (DS 1.0) increased from 267 °C to 326 °C, and exhibited a similar heat resistance to that of benzyolated BC. It appeared that improved thermal durability of the hemicellulose was a factor. Similar results were obtained for acetylated BC.

By combining the polycarbonate resin with 5-wt-% benzyolated BC, the elastic modulus improved by a factor of 1.22 (Fig. 1), while maintaining the polycarbonate transparency (Fig. 2). The coefficient of linear thermal expansion decreased by 17.9%. When the benzyolated BC composite was compared to the acetylated BC composite, it was revealed that the degree of reinforcement depended on the structure of the ester group.

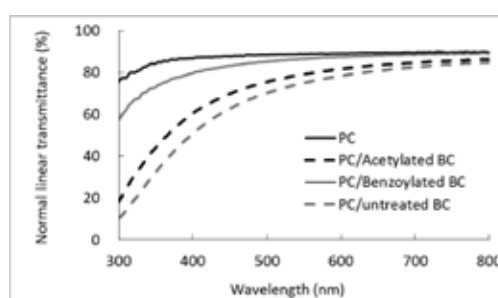
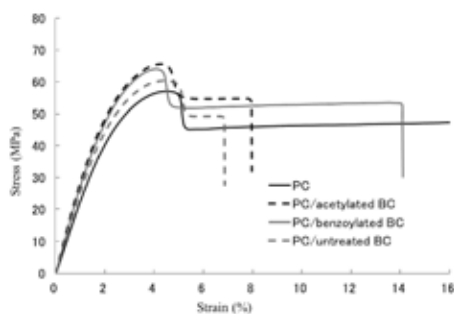


Fig. 1 Stress-strain curves of compounds. Fig. 2 Normal linear transmittance vs. wavelength.