

Mechanical properties of wood pulp/Poly Lactic Acid green-nano composites

Atsuhiko Iwatake

Laboratory of Sustainable Resources, RISH, Kyoto University

Introduction

Recently 'green-composites' have been focused on materials made from plant fibers and bio-based resins. Plant fibers are not only renewable but also have low density and high strength when compared to glass fibers, which are in common use for making FRP (Fiber Reinforced Plastics). Hence, nano-sized plant fibers are recognized as a potential reinforcing material. Fibrillation of wood pulp fibers is one of the ways to obtain nano-sized plant fibers. There are many reports describing that mechanical and thermal properties of composites are highly enhanced by utilizing such plant nanofibers as reinforcing material. However, most of these nanocomposites were made by special methods, such as film casting, not by melt mixing process, which is quite common in the plastics industry. Melt mixing can be used for general purposes, therefore in this study we applied this method to produce nanocomposites reinforced with plant nanofibers.

The main purpose of this research is to obtain fibrillated wood pulp/PLA nanocomposites by the melt-mixing method and to estimate the influence of degree of fibrillation of wood pulp on the mechanical and thermal properties of the composites.

Materials and Method

Soft wood kraft pulp (PULP), the same pulp treated by 8 passes through a refiner (8 passes refiner PULP), and pulp treated by 30 passes through a refiner and additional passes through a high-pressure homogenizer (Micro Fibrillated Cellulose, MFC) were used as fillers. PLA (LACEA H-280, Mitsui Chemical) was used as the matrix. As shown in Fig. 1, the degree of fibrillation decreases as MFC > 8 passes refiner PULP > PULP. These materials were pre-mixed in PLA dissolved in acetone, and after the mixture was dried, melt mixing was performed on a Laboplasto-Mill with a twin rotary roller mixer (Toyo Seiki). The mixing was carried out for 12.5 min at a rotary speed of 40 rpm at 140°C. The compound was pressed into a square shape at 160°C. Specimens were cut from this board into 5 mm (width), 40 mm (length), and 0.3 mm (thickness) pieces. Tensile test of the composites was performed with an Instron 3365 and dynamic viscoelastic measurements was obtained with a Rheovibron (Orientec). The dispersion of fibers and the fracture surface of the composites were observed through an optical microscope and a Scanning Electronic Microscope (JEOL6700F).

Results and Discussion

By premixing filler and matrix in the solvent, we could make well dispersed fiber composites and improve strength and Young's modulus of the composites over the neat PLA. Without premixing, fiber aggregation was formed in the composites and it became more brittle than neat PLA. This premixing is effective for preventing fiber aggregation and making well fiber dispersed composites.

Young's modulus and strength of the composites containing 5wt% MFC were increased almost 20 wt% compared to those of neat PLA, and yield strain was almost the same as that of neat PLA. Otherwise, the composite containing 5wt% PULP had lower strength and also less yield elongation, and became more brittle than neat PLA.

From the results of thermal analysis, it was found that fibrillation of PULP improved the filler-matrix interaction. Thus, we could surmise that fibrillation of PULP enlarged the contact surface area between fibers and PLA, then mechanical properties were enhanced.

Furthermore, we aimed a better improvement of the mechanical properties of the composite, increasing the fiber content of MFC up to 20wt%. As a result, Young's modulus and strength of 10wt% MFC composites were increased 1.4 fold and 1.3 fold respectively. However, strength and yield elongation of composites containing more than 15wt% of MFC were decreased. We conjecture that it was because of fiber aggregation.

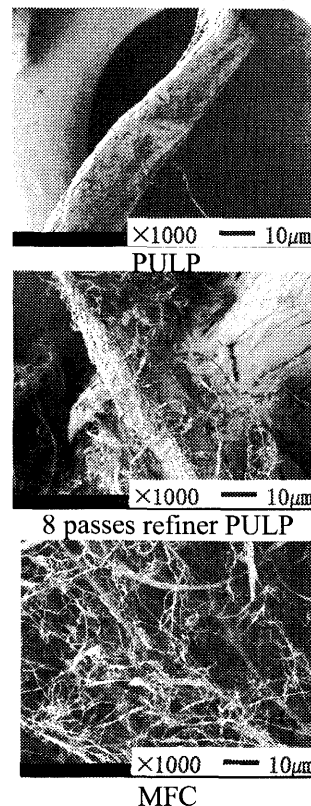


Fig.1 Shapes of each filler