

EFFECTS OF DEFORMATION RATE ON TENSILE PROPERTIES OF RAMIE FIBER/PLA/PBAT COMPOSITES

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Abstract

The effects of deformation rate on tensile properties of ramie fiber/PLA/PBAT composites were examined. Composites consisting of poly(lactic acid) (PLA) and poly(butylenes adipate-co-terephthalate) (PBAT) polymer blends reinforced with unidirectional ramie fibers were made. Tensile properties were examined at several deformation rates. Fracture surfaces were observed by scanning electron microscopes. PLA and PBAT polymer blends were used for the matrix. Because PLA is brittle, PBAT with high ductility were used for increasing elongation at break. An additive was used as a crosslinking agent for grafting PLA and PBAT to improve tensile properties of the composites. The weight ratio of PLA/PBAT/additive was 60/40/2.25 [wt%]. Ramie fibers were treated with 5 wt% NaOH and 20 wt% NaOH. The tensile strength clearly increased with deformation rate. When the 20 wt% NaOH ramie fibers were used, elongation at break significantly increased with deformation rate.

1. Introduction

Many plastic products have been manufactured from petroleum and continuously discarded for approximately the last 100 years. In order to stop the ongoing destruction of the global environment caused by the use of plastic products and to contribute to the realization of sustainable development, investigations have been carried out on renewable resource-based biodegradable materials that can be derived from plants. Green composites are one of renewable resource-based biodegradable materials.

Poly(lactic acid) (PLA) is a typical bio-based (plant-derived) and biodegradable polymer. Because PLA are brittle and has low impact strength, its mechanical properties have been improved by adding elastomer particles and blending with ductile polymers. Many attempts have been reported on the creation of polymer blends of PLA and ductile polymers; for example, poly(ϵ -caprolactone) (PCL), poly (butylene succinate) (PBS), poly(butylene succinate-co-lactate) (PBSL), poly(butylene succinate-co- ϵ -caprolactone) (PBSC) and poly(butylene adipate-co-terephthalate) (PBAT). The authors' group are using PBAT as a ductile polymer [1]. When ductile polymers show low strength, natural fiber addition is a good method to increase the material strength [2-4].

In this study, we used PBAT as a ductile polymer and made PLA/PBAT polymer blends. In order to increase mechanical properties of the polymer blends, we used a crosslinking agent for grafting PLA and PBAT. By adding the ramie fibers, PLA/PBAT polymer blends were reinforced with unidirectional ramie fibers. Ramie fibers were treated with NaOH to increase adhesive strength. The effects of deformation rate on tensile properties were examined for ramie fiber/PLA/PBAT composites.

2. Experimental Methods

2.1. Materials

We used PLA (Nature Works, 3052D) and PBAT (BASF, Ecoflex). An additive, 2,5-Dimethyl 2,5-di(tert-butylperoxy) hexane (NOF Corporation, PERHEXA 25B-40) was added as a crosslinking agent for grafting PLA and PBAT to improve mechanical properties of the composites. The weight ratio of PLA/PBAT/PERHEXA25B-40 was 60/40/2.25 [wt%]. Ramie fibers were treated with 5 wt% NaOH and 20 wt% NaOH for 3 hours at room temperature. Untreated ramie fibers were also used for composites. We made three types of composites and results were compared with PLA/PBAT polymer blends without ramie fibers. Ramie fibers after vacuum drying were used as a reinforcement material. Using thin films of PLA/PBAT polymer blends, composites were made by hot press methods. We used a weight of 100g so as to keep ramie fibers straight.

2.2. Specimen Shapes

Dog bone shape tensile test specimens were made by machine processing from ramie fiber/PLA/PBAT composite plates made by hot press methods. Fig. 1 shows the shape of tensile test specimens.

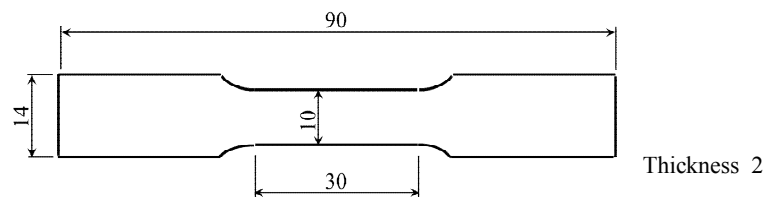


Figure 1. Size of tensile test specimens [unit: mm].

2.3. Tensile Tests

Static tensile tests were carried out at room temperature using a universal testing machine (Shimadzu, AGS-X). The tensile speed was decided as 0.2 mm/min, 2 mm/min and 20 mm/min to examine the effects of deformation rate.

3. Results and Discussion

Figs. 2(a)-(d) show nominal stress-strain curves for each deformation rate. Fig. 2(a) shows results of PLA/PBAT polymer blends without ramie fibers. When the deformation rate increased from 0.2 mm/min to 2 mm/min, maximum stress and elongation at break clearly increased. When the deformation rate increased from 2 mm/min to 20 mm/min, elongation at break significantly increased with deformation rate and maximum stress did not increase with deformation rate. When we used the composites using untreated ramie fibers and 5 wt% NaOH ramie fibers, in Fig. 2(b) and (c), maximum stress slightly increased with increasing deformation rate from 0.2 mm/min to 2 mm/min, and elongation at break hardly increased. When the deformation rate increased from 2 mm/min to 20 mm/min, maximum stress and elongation at break clearly increased with deformation rate. In the case of composites using 20 wt% NaOH ramie fibers of Fig. 2(d), maximum stress and elongation at break

gradually increased with increasing deformation rate from 0.2 mm/min to 20 mm/min. The main reason for this is the increase in elongation at break of PLA/PBAT polymer blends.

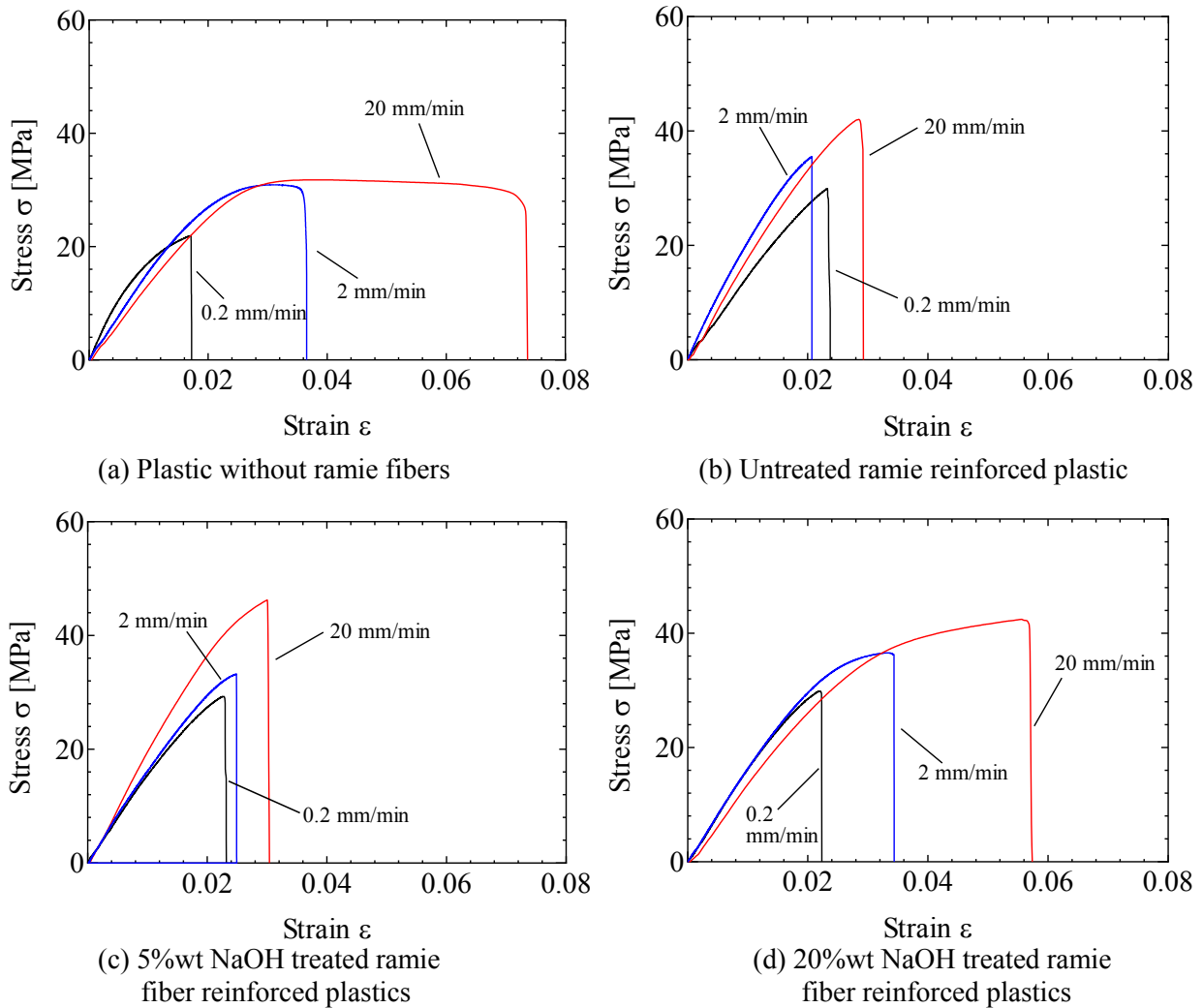


Figure 2. Nominal stress-strain curves of green composites.

4. Conclusions

When Ramie fibers were added to PLA/PBAT polymer blends, the maximum stress of the composites clearly increased as is expected. Ramie fiber addition did not affect elongation at break. When deformation rate increased, the maximum stress and elongation at break of composite clearly increased. In particular, when composites using 20 wt% NaOH ramie fibers were used, the elongation at break significantly increased.

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