THERMAL CONDUCTIVITY BEHAVIOR OF NATURAL FIBER-REINFORCED COMPOSITES

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1. Introduction

Various products around us are made from plastics. One of them is fiber-reinforced plastics (FRP). Advantages of FRP are that specific strength is bigger than that of alminium plate, and weight of FRP is lighter than that of alminium plate, etc. Therefore, FRP are used in wide range of fields, For example, automobile field, aerospace field, sport field, and so on. Glass-fiber reinforced plastic (GFRP) in FRP has a lot of excellent functions such as high-strength, lightness, and chemical stability. But, this GFRP has a serious environmental fault that disposal and recycling are difficult after usage[1]. Recently there is study of ”green” composites (the biodegradable composite materials or eco-composites)[2], which are composed of a biodegradable resin and high-strength natural fibers have been developed. There are various Reinforced fiber. Advantages of natural fiber are low weight, they are recyclable and biodegradable. They are also renewable and have relatively high strength and stiffness. On the other hand, there are also some disadvantages: moisture uptake, quality variations and thermal stability[3]. And, in fact, the mechanical property of natural fiber was much more inferior than that of glass fiber. Therefore, essential functional strength for structural materials, or progress of strength and toughness of green composites and securement of reliability are not enough. Because it is necessary that the mechanical property of natural fiber approach that of glass fiber, and natural fiber have the optional functions[4]. One of the optional functions is that natural fibers have lumen. Lumen is hollow portion in fibers. Glass fiber and carbon fiber have used in the past don’t have lumen. These properties indicate that green composite have great thermal insulation property. However, a lot of current studies relate to mechanical property, few studies relate to functional property. So, we focus attention on hollow portion of natural fiber, and examine thermal conductive property of natural fiber-reinforced composites.

2. Experemental Methods

In our study, Manila hemp fiber was used as a reinforcing fiber. This fiber has high strength and excellent thermal stability[5]. A poly lactic acid (PLA) (Miyoshi Oil & Fat Co. Ltd., Randyi PL-1000) and epoxy resin (Refine Tec Ltd., Epomount base resin, 9022) were used as a matrix material. In the case of PLA, Manila hemp fiber was arrenged in one direction to preserve the lumen. Then, the samples were prepared by mixing with PLA resin. Next, the samples were dried for 20 hours at 70 degrees C using a circulation type oven (Toyo Seisakusho Co. Ltd., DRX420DA). Finally, the samples were hot pressed using a hot pressing machine (Imoto machinery Co. Ltd., IMC-16EF). The molding was performed for 10 min at 160 degrees C and was pressured for 10 min at 10 MPa. The samples were fabricated by altering the fiber content, and the size of samples was 100x100x10 mm. Figure 1 shows a photograph of PLA composite sample.

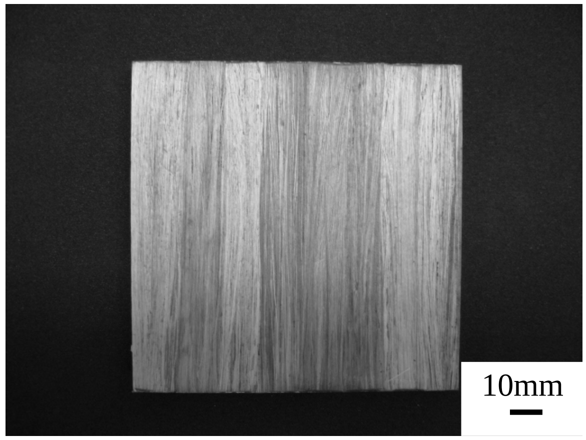

Figure 1 Photograph of PLA composites sample.

In the case of epoxy resin, Manila hemp fiber was arranged in one direction in a mold. Then, epoxy resin was poured into the mold. The samples were unidirectional composites and the size of sample was 100x100x10 mm. Finally, the samples were dried for 24 hours at 30 degrees C using a circulation type oven. Thermal conductivity was measured using a steady-state method, and perpendicular to the fiber direction. At the steady-state condition, thermal conductivity, λ was calculated by the following equation:

$$\lambda = \frac{\delta}{T_H - T_L} \cdot \frac{Q_H + Q_L}{2}, \qquad (1)$$

where δ is a sample thickness, Q is a heat flux, and T is a temperature. The subscripts H and L denote high temperature part and low temperature part, respectively.

3. Results and Discussion

Figure 2 illustrates thermal conductivity of samples of PLA as a function of sample's fiber content. The thermal conductivity decreases with increasing fiber content. It is because hollow portion of reinforced fiber contains the air. Figure 3 shows a cross-sectional view of PLA-bsed composites sample. Thermal conductivity of the air is 0.026 [W/(m·K)] at 25 degrees C. It has an excellent heat insulation effect. The volume percent of the air increases with increasing fiber content. Therefore, thermal conductivity decreases with increasing fiber content. The thermal conductivity of the composites with fiber content of 76wt.% is 0.190 [W/(m·K)].

4. Conclusions

Naturl fiber-reinforced composites has an excellent thermal insulation properties. The thermal conductivity of Manila hemp fiber reinforced composites decreases with increasing fiber content.

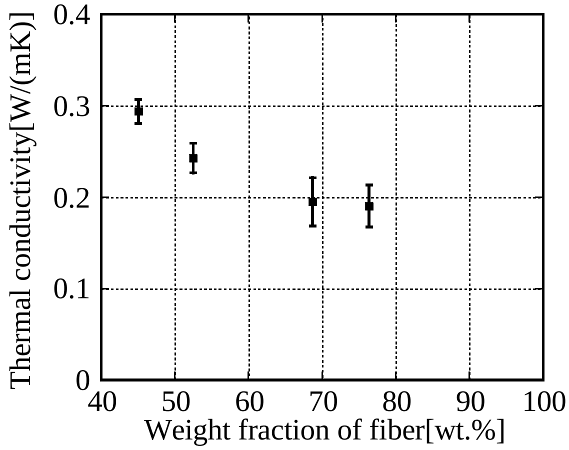

Figure 2 Variation of thermal conductivity of PLA composites with weight fraction of fiber.

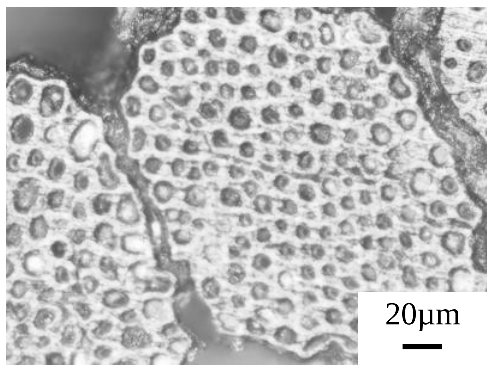

Figure 3 Cross-sectional view of Manila hemp fiber in PLA composites.

5. References

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