INCREASING THERMAL CONDUCTIVITY OF ENGINEERED FLOORING THROUGH EXFOLIATED GRAPHITE COMPOSITES FOR BUILDING ENERGY CONSERVATION

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1. Introduction

Wood-based flooring is common used for floor finish materials of residential building in Korea. There are three types of wood flooring: laminate flooring, engineered flooring and solid wood flooring.[1] However, thermal conductivity of these floorings is very low, so decrease efficiency of under floor heating system.

To overcome the low thermal conductivity problem of building materials, studies have been carried out, dispersing high conductivity particles and inserting materials into wood flooring.

Expanded graphite(EG) is generally produced by using H_2SO_4–graphite intercalation compounds (GICs). H_2SO_4–GICs are widely used for the exfoliation process, because they can give a high expansion volume during the thermal treatment. The electro chemical intercalation of H_2SO_4 as well as the chemical one were described in the Tryba's works [2,3]. The EG maintains the layered structures similar to natural graphite flake but produces tremendously different sizes of pores and nanosheets with very high aspect ratio [4,5]. Research in the Drzal group has shown that exfoliated graphite nanoplatelets (xGnPTM), which combine the layered structure and low price of nanoclays with the superior mechanical, electrical and thermal properties of carbon nanotubes, are very cost effective and can simultaneously provide a multitude of physical and chemical property enhancements [6]. Nanocomposites prepared with xGnP in thermosetting and thermoplastic polymer systems showed excellent mechanical properties and electrical conductivity [7,8].

In this study, to increase thermal conductivity, xGnP is used with adhesives for surface bonding of wood-based flooring. The study is aimed at investigating the effect and dispersion of xGnP in adhesive, and bond strength and thermal conductivity.

2. Experimental

2.1 Materials

Exfoliated graphite nanoplatelets (xGnP™) are prepared from sulfuric acid-intercalated expandable graphite (3772), which are obtained from Asbury Graphite Mills, Inc. (NJ, USA) The time effective exfoliation process is proposed by Drzal's group [9].

The epoxy resin(EP-1) was purchased by SamChang Tech co. LTD in South Korea. The other epoxy resin(EP-2) for flooring board installation was supplied by the Okong Adhesives Company in South Korea. Both epoxy resin consist base with hardener, and the mixture ratio is 1:1. The melamine-formaldehyde (MF-1) resin for making plywood was supplied by the Eagon Industrial Co., Ltd. The standard ratio of weight is MF resin(100%) : flour(10%): diatomite(5%): hardener(0.1%). In this study put xGnPs instead of flour by a ratio of the weight.

2.2 Processing of resin/xGnP

First epoxy resin was mixed with 100 wt% hardener. Next, xGnPs were added and mixed using a shearing stirrer for 10min. Then, the resins were cured at room temperature for 48 hours. The EP-1 were added xGnPs 1%, 3%, 5% and EP-2 were

added xGnPs 1%, 2%, 3%. The MF-1 was added xGnPs 1%, 3%, 5%. Samples' height was 10mm and a diameter was 30mm for measuring of thermal conductivity. Resin/xGnP composite samples for measuring of thermal conductivity are shown in Fig. 1. All the samples were getting darker with xGnP loading content, but there is no smear of xGnP.

2.3 Viscosity measurement

The viscosity was measured using a Brookfield Viscometer Model HADV-Ⅱ+PRO. The viscosity was measured (spindle No. 7, 60RPM) after stirrer for 10min.

2.3 Thermal conductivity measurement

Thermal conductivity was measured by TCi thermal conductivity analyzer in C-thermal Inc. All samples were measured under the condition of room temperature. Fig. 2 shows the thermal conductivity analyzer.

3. Results and Discussion

The thermal conductivity of resins/xGnP composites by xGnP loading content is shown in Table 1 and Fig 3. The thermal conductivity of xGnP/EP-1 loading samples was increased, especially the composite of 5% xGnP loading content was higher than the rate of reference to 1% xGnP loading content. However, xGnPs were not added more than 5% because it has very low weight density. The thermal conductivity of EP-2/xGnP composites varies in the range of 1.113~1.255 W/mK. The thermal conductivity of MF-1/xGnP composites was increased proportionally.
The thermal conductivity and viscosity of EP-2/xGnP and MF-1/xGnP composites are shown in Fig. 4-5. The thermal conductivity of EP-2/xGnP composites increased linearly depending on xGnP loading content, and also viscosity grew up linearly. Because of low weight density of the xGnP, the viscosity should be considered when applied to the field. On the other hand, the viscosity of MF-1/xGnP composites did not increase because the flour has high viscosity compared with xGnP.

4. Conclusions

The thermal conductivity of EP-1/xGnP composites increased from 0.597 to 0.772 W/mK with adding xGnP. Also, the thermal conductivity of EP-2/xGnP composites increased from 1.043 to 1.255 W/mK. Both of the epoxy resins have a different value that the thermal conductivity of EP-2 is about twice as high than that of EP-1. In general, it is fact that the use of high thermal conductivity resin causes high increasing of thermal conductivity. That is because the thermal conductivity increases in the proportion of percentage. Therefore, it is important to choose high-thermal-conductivity-resin in field.
The epoxy and MF-1/xGnP composite showed improved thermal conductivity by xGnP loading. This study demonstrates that it is possible for the xGnP-resin to show thermal conductivity with only 1~3 wt%. The thermal conductivity increases 14%~28% by 3% xGnP. It can save energy of the building. Through this study, it is fact that the thermal conductivity of resin was improved by using building floor finishing material through xGnPs.

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Fig. 1. Resin/xGnP composite samples for measuring of thermal conductivity.

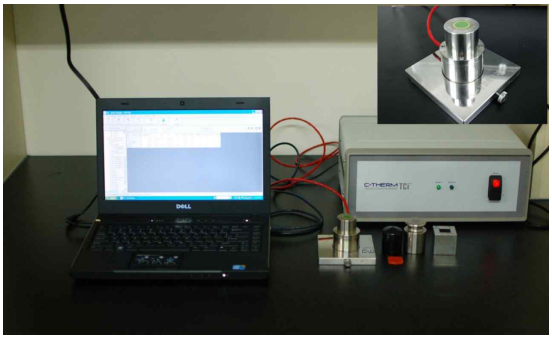

Fig. 2. TCi Thermal Conductivity Analyzer.

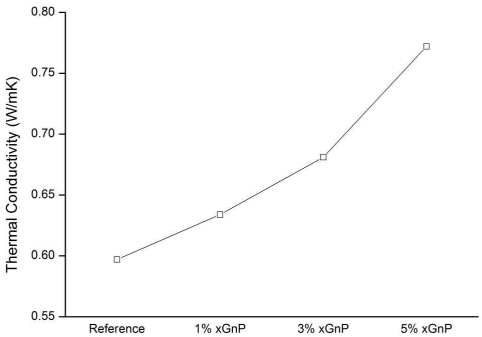

Fig. 3. Thermal conductivity of EP-1/xGnP composites.

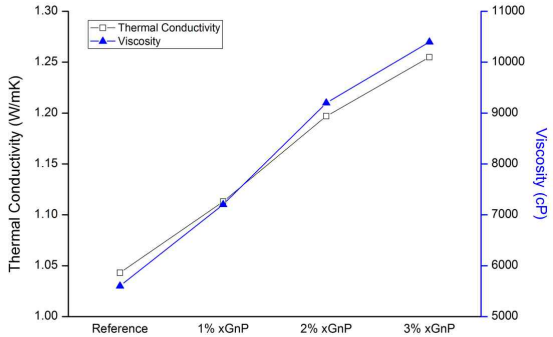

Fig. 4. Thermal conductivity and viscosity of EP-2/xGnP composites.

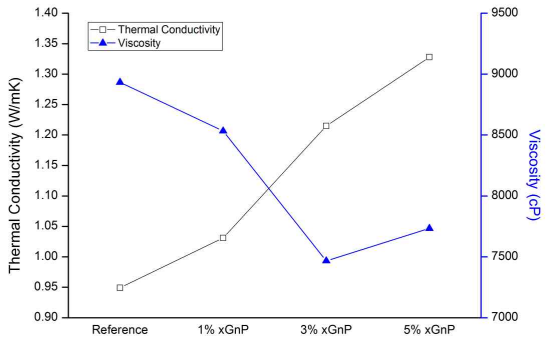

Fig. 5. Thermal conductivity of MF-1/xGnP composites.

Table 1. Thermal Conductivity of resin/xGnP composites

Samples	xGnP loading content	Reference	1%	3% (EP-2 is 2%)	5% (EP-2 is 3%)
EP-1/xGnP composites	Thermal Conductivity (W/mK)	0.597	0.634	0.681	0.772
	Increase Rate	-	6.2%	14.1%	29.3%
EP-2/xGnP composites	Thermal Conductivity (W/mK)	1.043	1.113	1.197	1.255
	Increase Rate	-	6.7%	14.7%	20.3%
MF-1/xGnP composites	Thermal Conductivity (W/mK)	0.949	1.031	1.215	1.328

	Increase Rate	-	8.64%	28.05%	39.97%

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