THE DEVELOPMENT OF THERMAL CONDUCTIVE COMPOSITE MATERIAL FOR HEATSINK

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1. Introduction

Commonly used plastics, such as polyethylene and polyamide are excellent electrical insulators with a low thermal conductivity. However, for the energy saving, metal have being replaced by plastic in light weight. Some applications, like heat sinks in electronic packaging, require composites with higher thermal conductivity[1,2].
By the addition of fillers to plastics the thermal behavior of polymers can be increased remarkably. Current interest to improve the thermal conductivity of polymers is focused on the selective addition of nano-fillers with high thermal conductivity. However, the dispersion of nano-filler is required. Micro size filler is well dispersed, but the properties are lower than composite with nano-filler. Depending on the application of composite, the choice of filler is needed.
Several methods, as reviewed elsewhere [3,4], have been proposed and used for measurement of the thermal conductivity of polymers and composites. Classical steady state method measure the temperature difference across the specimens in response to an applied heating power, either as an absolute value or by comparison with a reference material put in series or in parallel to the sample to be measured. However, these methods are often time consuming and require relatively bulky specimens. Several non steady-state methods have also been developed, including hot wire and hot plate methods, temperature wave method and laser flash techniques [4,5].
Therefore, micro size fillers used in this study was to increase the thermal conductivity of the composites were prepared. The thermal conductivity was measured by heat flow method.

2. Experimental

2.1 Materials & Composite preparation

Polyamide(PA) and Polyphenylene sulfide (PPS) were used as the matrix made in Korean companies. And the h-BN and graphite were used as fillers.
Matrix and fillers were dried at 60℃. And the composite materials by the twin extruder used side feeder were fabricated. Composite with filler concentrations ranging between 0~40 wt% by weight was prepared.
Composite specimens were manufactured in the standard injection mold.

2.2 Characterization

According to standard ASTM D792, specific gravity of each specimen was measured by ALFA Mirage's electronic Densimeter / MD300S. And the filler Particle Size and Size Distribution were analyzed by Beckman Coulter's LS™ 200 Series.The mechanical properties were measured as UTM(United Co. SFM-10) by ASTM D638 and D790.
Thermal conductivity of the composites was measured using a thermal conductivity meter. The thermal conductivity meter made by Anter Corporation's Unitherm™ Model 2022 according to the ASTM E1530 guarded heat flow meter method.
Morphological observations on the composite were done by means of optical microscope.

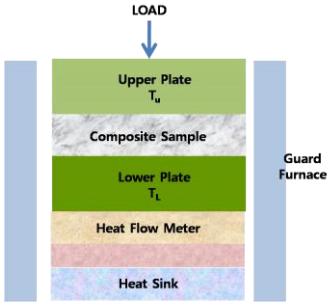
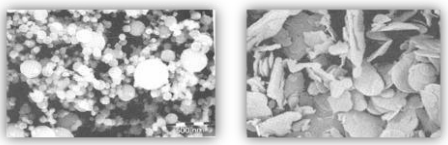


Fig. 1 Thermal Conductivity test section

3. Results and discussion

3.1 Materials & Composite

For improved thermal property of polymer composite, important point is to improving connectivity of filler in composites. The connectivity of filler in composites affect by the shape and array. For lower filler concentration of high thermal conductivity efficiency requires the optimization of composite conditions.



(a) Sphere (b) Plane

Fig. 2 Networking of fillers in composite.

PA with Boron Nitride filler composites and PPS GF30 reinforced with graphite filler composites were prepared. BN filler(made by Korea company) was prepared in a dozen micro size. And TIMCAL TIMEX ® graphite, the particle size of less than 180 ㎛ KS150 and 900 ㎛ KS500 were used.

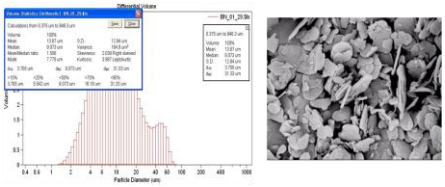
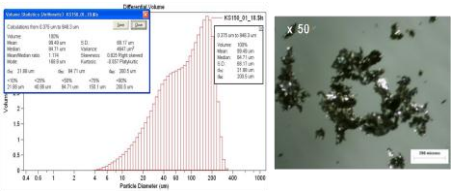
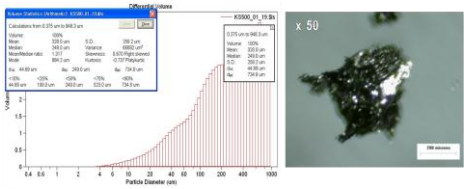


Fig. 3 Particle size and size distribution of BN



(a) KS 150 (less than 180μm)



(b) KS 500 (less than 900mm)

Fig. 4 Particle size and size distribution of graphite

Many applications would benefit from the use of polymers with enhanced thermal conductivity. For example, when used as heat sinks in electric or electronic systems, composite with a thermal conductivity approximately from 1 to 30W/mK are required. The thermal conductivity of polymers has been traditionally enhanced by the addition of thermally conductive fillers, including graphite, carbon black, carbon fibers, ceramic or metal particles. It is worth noticing that significant scatter of data are typically reported for thermal conductivity of fillers. High filler loadings (>30 vol.%) are typically necessary to achieve the appropriate level of thermal conductivity in thermally conductive polymer composites, which represents a significant processing challenge. Indeed, the processing requirements, such as possibility to be extruded and injection molded, often limit the amount of fillers in the formulation and, consequently, the thermal conductivity performance.

Preparation of a composite material thermal conductivity is very important to the combination. In particular, the filler content increases, lower miscibility between dissimilar materials will be difficult to extrusion of the material. PA6 composite with the h-BN content of about 50% easier to upset the increase will be possible. According to the presence GF reinforced, PPS represents a very large difference between the mechanical properties

In particular, because of latent heat during extrusion of graphite composite, heat control is very important factor.

In addition, the specific gravity of graphite because of the problems caused by the difference, feeding method is also important factor. Thus in the extrusion process, feeder speed and screw torque optimization is needed.

3.2 Physical Property

Because of energy-saving, lightweight is a very important factor. Comparison of the properties and should be increased specific gravity. The amount of filler is also important due to rising prices.

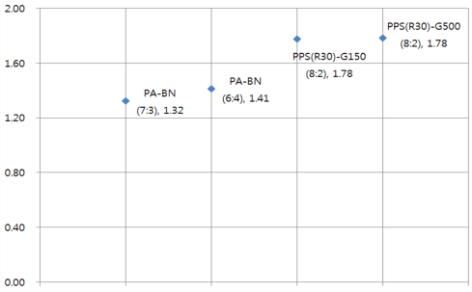


Fig. 5 Specific gravity of composites.

When the filler is increased, the tensile strength is decreased. The composite with the same filler content, the tensile strength is different by filler particle size. Larger size graphite filler, the tensile strength is lower. However, there is no difference in flexural strength by the particle size. However, the flexural modulus of PA material increased with the filler content. PPS also minor, but tended to increase.

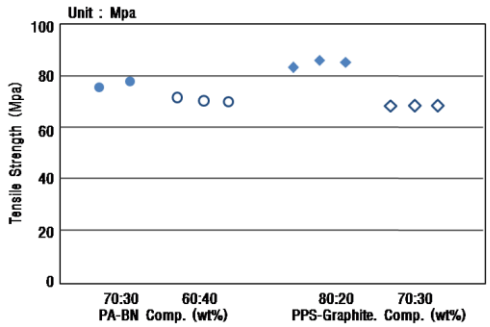


Fig. 6 The tensile strength of composites.

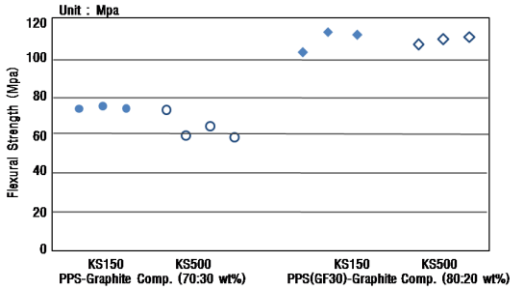


Fig. 72 The flexural strength of PPS-graphite composite.

Glass fiber reinforced PPS composites are superior to the performance. But the specific gravity increased by 20%, flexural strength is increased by more than 50%.

3.3 Thermal Property

At thermal equilibrium, the Fourier heat flow equation applied to the composite sample becomes

$$R_s = [T_u\text{-}T_m]/Q] - R_{int} \qquad (1)$$

Where R_s = thermal resistance of the test sample
T_u = upper plate surface temperature
T_m = lower plate surface temperature
Q = heat flux through the test sample
R_{int} = total interface resistance btn sample and surface plates

The thermal resistance of the composite sample is defined as

$$R_s = d/\lambda \qquad (2)$$

Where d = sample thickness
λ = thermal conductivity

Table. 1 Thermal conductivities of polymers & fillers (at 25℃ (W/mK)).

	Material	Thermal Conductivity
Matrix	PA-6	0.25
	PA-6.6	0.26
	PPS	0.30
Filler	Graphite	100～400
	Boron Nitride	250～300

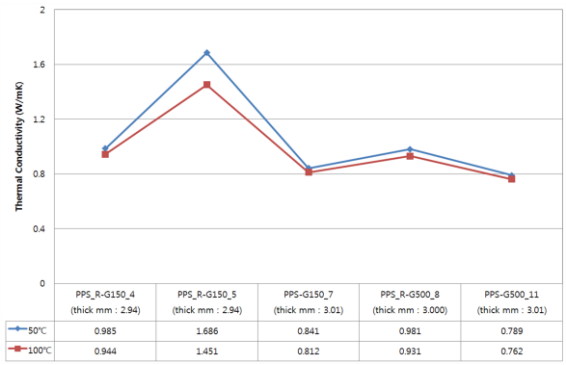


Fig. 3 Thermal conductivities of composite (W/mK).

Table. 2 Thermal conductivities of composite (W/mK).

	Weight %	@ 50℃	@ 100℃
PA-BN	70:30	0.5	0.501
	60:40	0.647	0.618
PPS(GF30) -G150	80:20	0.985	0.944
	70:30	1.686	1.451
PPS(GF30) -G500	80:20	0.981	0.931
PPS-G150	70:30	0.841	0.812
PPS-G500	70:30	0.789	0.762

4. Conclusion

- Fillers of different sizes than the same size were more advantageous in term of networking structure.
- Graphite filler of 180 ㎛ than 900 ㎛ is more likely to represent an excellent thermal conductivity.
- Rather than the pure resin matrix reinforced grades utilizing conductive filler to fill in terms of performance is excellent.

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Acknowledgements

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