TENSILE STRENGTH OF GRAPHENE NANOSHEETS/POLYPROPYLENE COMPOSITE PLATES

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Abstract- In this study, we explored the impact of various proportions of graphene nanosheets on the tensile strength of graphene nanosheets/polypropylene composites plates. Experimental results revealed that when the graphene nanosheets content was 0.2 wt%, the graphene nanosheets/polypropylene composite plates had the optimal best tensile strength of 16.45 MPa. The scanning electron microscope images revealed that the graphene nanosheets effectively enhanced the rigidity of the graphene nanosheets/polypropylene composites plates.

Keywords- Graphene, Polypropylene, Tensile Strength, Elongation

I. INTRODUCTION

Graphene material application in polymer nanocomposites has recently become increasingly researched because of the potential and excellent mechanical properties of graphene material compared with those of neat polymers [1]–[3]. For many polymer-based composites, the most general methods of fabrication are injection molding and hot press molding, which are rapid, stability, and common. Carbon-based materials such as carbon nanotubes, carbon black, and carbon nano fibers have recently become the focus of research in the field of nanocomposites. However, many researchers have used graphene to replace nanomaterials. [1]–[5]. In this study, we were prepared graphene nanosheets (GNS)/polypropylene (PP) pellets composite plates through microencapsulation instead of compounding. Moreover, the varied proportions of the GNS in the GNS/PP composite plates were manufactured by using hot press molding.

II. EXPERIMENTAL

Dispersion solutions were prepared with various concentrations of GNSs (0.1–0.6 wt%). Through microencapsulation, the GNSs were encapsulated within the surface of the PP pellets, forming GNS/PP pellets. The GNS/PP composite plates were fabricated using hot press molding at 210 ^{o}C and 30 kg/m^2 for 10 min with 100 g of pellets. The tensile strength of the GNS/PP composite plates was tested after they cooled to room temperature.

III. RESULTS AND DISCUSSION

A. Mechanical properties of GNS/PP composite plates

Fig. 1 shows the tensile strength of the GNS/PP composite plates. The tensile strength did not increase proportionally with an increase in GNS content. Because the GNSs were dispersed in the composite plates unevenly, weak reinforcement in the horizontal direction resulted. The maximum tensile strength, 16.45 MPa, was achieved when the GNS content was 0.2 wt%, an amount that was 4.91% greater than the neat PP matrix content. Fig. 2 shows the elongation at break of the GNS/PP composite plates. When the GNS content increased, the elongation of the GNS/PP composites plates were all decreased, indicating the tendency of the composite plates to become brittle. Tables 1 list the effects of the GNS content on the GNS/PP composite plates.

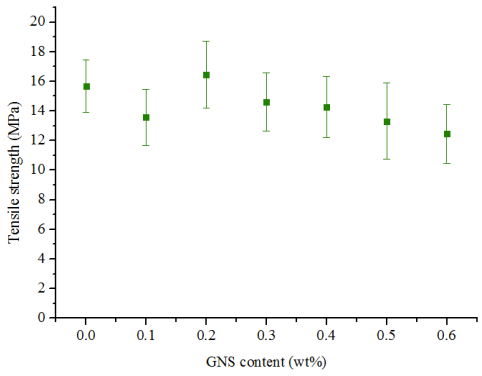


Figure 1 Impact of various amounts of GNS content on the tensile strength of GNS/PP composite plates

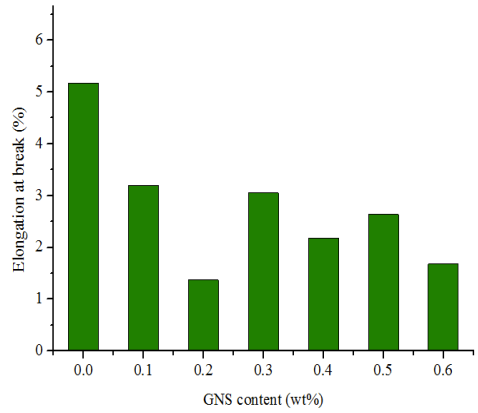


Figure 2 Impact of various amounts of GNS content on the elongation of GNS/PP composite plates

Table 1 Impact of GNS content on the tensile strength and elongation of the GNS/PP composite plates

GNS content (wt%)	Tensile strength (MPa)	Enhanced percentage (%)	Elongation at break (%)	Enhanced percentage (%)
0 wt%	15.68 ± 1.76	---	5.17 ± 0.78	---
0.1 wt%	13.57 ± 1.90	-13.46	3.19 ± 0.23	-38.30
0.2 wt%	16.45 ± 2.27	4.91	1.37 ± 0.44	-73.50
0.3 wt%	14.61 ± 1.95	-6.82	3.05 ± 0.67	-41.00
0.4 wt%	14.26 ± 2.06	-9.06	2.18 ± 0.45	-57.83
0.5 wt%	13.31 ± 2.58	-15.11	2.64 ± 0.17	-48.55
0.6 wt%	12.46 ± 1.99	-20.54	1.68 ± 0.39	-67.50

B. Morphology of GNS/PP composite plates

Figs. 3–8 depicts the scanning electron microscope (SEM) cross-section images of the neat PP matrix and GNS/PP composite plates after the tensile test was conducted. As shown in Figs. 3 and 4, the cross-sections of the neat PP matrix are flat but ductile. Figs. 5 and 6 illustrate the GNS/PP composite plates with 0.2 wt% GNS content. In Figs. 5–8, the dark portions are the GNSs, and the light portions are the PP matrix. The ductility of the cross-sections in the tensile direction was reduced, indicating the tendency of the composite plates to become brittle (Fig. 6). Figs. 7 and 8 depict GNS/PP composite plates with 0.6 wt% GNS content. Most of the area of the cross-section was broken directly (Fig. 7). The cross-sections of the GNS/PP composite plates shown in Figs. 5–8 were flatter than that of the neat PP matrix. However, as shown in Figs. 7 and 8, when the GNS content increased, the GNS/PP composite plates became increasingly brittle.

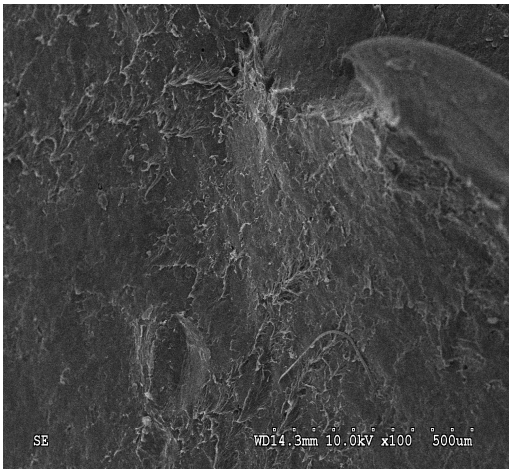


Figure 3 SEM image of depicting the cross-section of neat PP matrix after a tensile test (100 times magnification)

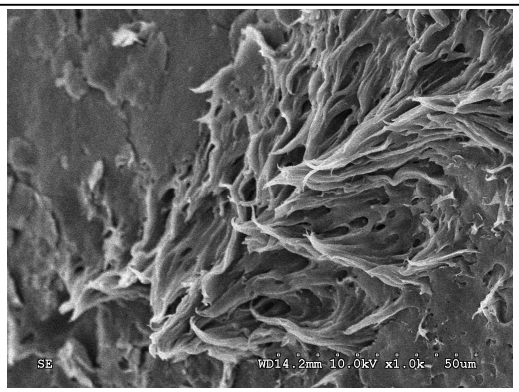


Figure 4 SEM image of depicting the cross-section of neat PP matrix after a tensile test (1000 times magnification)

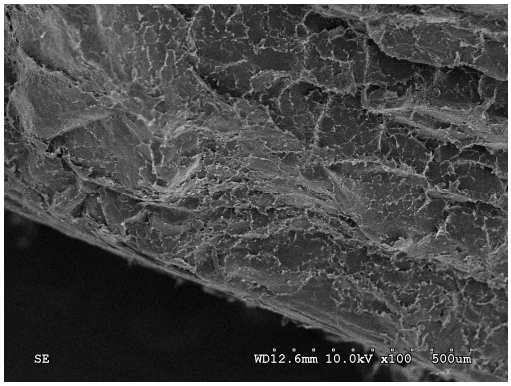


Figure 5 SEM image of depicting the cross-section of the GNS/PP composite plates with a 0.2 wt% GNS solid content after a tensile test (100 times magnification)

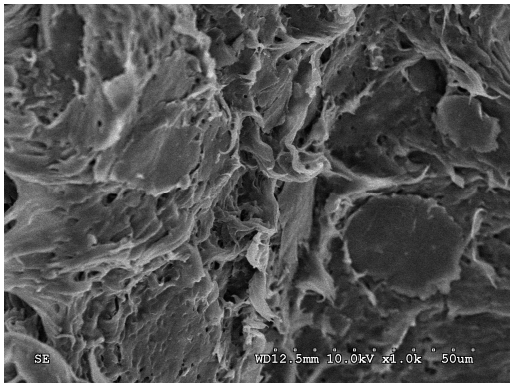


Figure 6 SEM image of depicting the cross-section of the GNS/PP composite plates with a 0.2 wt% GNS solid content after a tensile test (1000 times magnification)

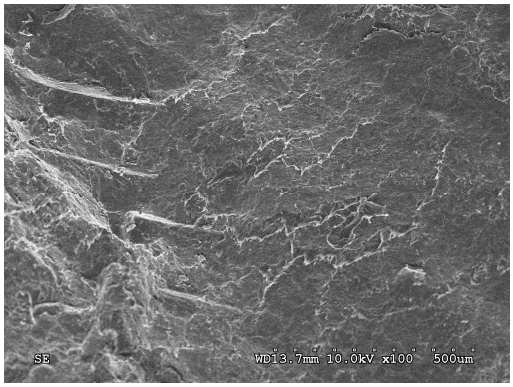


Figure 7 SEM image of depicting the cross-section of the GNS/PP composite plates with a 0.6 wt% GNS solid content after a tensile test (100 times magnification)

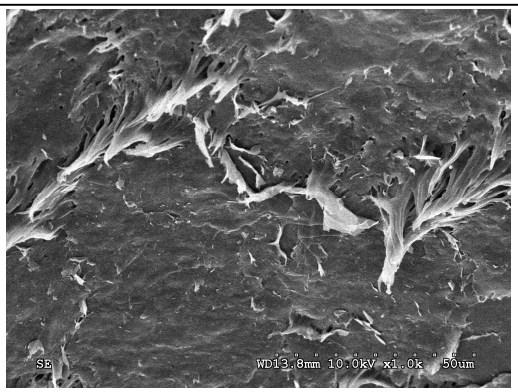


Figure 8 SEM image of depicting the cross-section of the GNS/PP composite plates with a 0.6 wt% GNS solid content after a tensile test (1000 times magnification)

CONCLUSION

In this study, the GNS content yielding the optimal tensile strength of GNS/PP composite plates was 0.2 wt%. The addition of GNS improved the rigidity of the PP composite plates; however, it reduced the tensile elongation. When the GNS content increased, the ductility of the PP composite plates decreased. Future studies we will encapsulate GNS on other polymer pellets surface, such as polycarbonate, polystyrene, etc.

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