Mechanical Properties of Graphene Nanocomposite at Cryogenic Temperature

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Abstract

Graphene sheets has been a great nanoscale additive in a composite to enhance its mechanical properties such as Young's modulus and fracture toughness at room temperature [1]. It has also showed a great potential in application at low or cryogenic temperature [2]. Multifunctional high performance functionalized graphene sheets (FGSs) based epoxy nanocomposites have been investigated to understand changes of its mechanical properties and possibly to test its feasibility in applications at room temperature and cryogenic temperature.

In this study, we report; (1) The FGSs are successfully synthesized from graphite flakes through preparing graphite oxides by oxidizing graphite flakes first and next, thermally exfoliating the formed graphite oxides. (2) These high performance FGSs are next incorporated into epoxy matrix resin system to generate the uniformly dispersed FGSs reinforced epoxy nanocomposites. The resultant FGSs-epoxy nanocomposites significantly enhanced resin strength about 30–80% at room and low temperatures of -130C, respectively. Figure 1 shows reduced the coefficient of thermal expansion (CTE) of polymer resin at both below and above Tg about 25% at loading of 1.6 wt% FGSs, and increased Tg of polymer resin about 8C at low loading of 0.4 wt% FGSs without deteriorating their good processability. We found that these significantly improved properties of FGSs-reinforced epoxy nanocomposite were closely associated with high surface area and wrinkled structure of the FGSs. (3) Several carbon fiber composite plates are manufactured with varying concentrations of graphene and tested under both room and cryogenic conditions to characterize graphene's effect on the composite. Results from tensile and fracture testing indicate that the ideal concentration of graphene in our carbon fiber reinforced polymer (CFRP) composites for cryogenic applications is 0.08% mass graphene as shown in Figure 2.

References

[1] M. A. Rafiee, J. Rafiee, Z. Wang, H. Song, Z. Yu, and N. Koratkar, ACSNANO, Vol.3, No.12(2009), pages 3884-3890
[2] J. Lee, S. Song, and B. Kim, Polymer Composites, Vol. 33, Issue 8(2012), pages 1263-1273

Figures

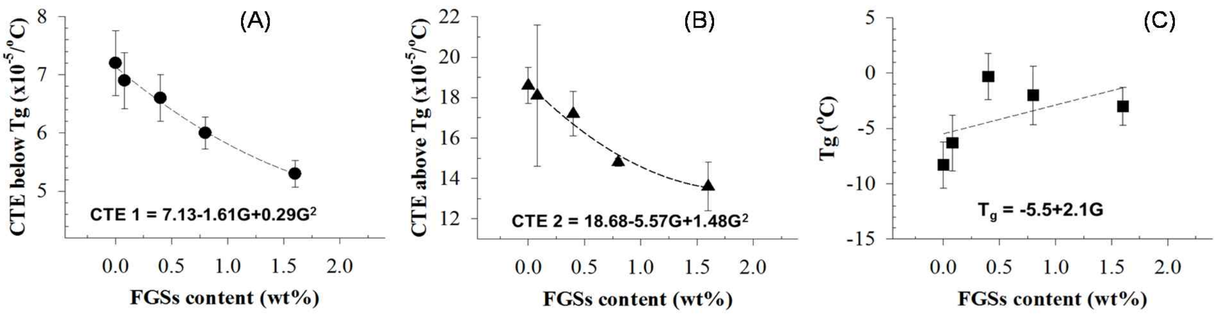

Figure 1 CTE behaviors (a) below and (b) above Tg and (c) Tgs of FGS-Epoxy nanocomposites as a function of FGS content comparing with pristine epoxy

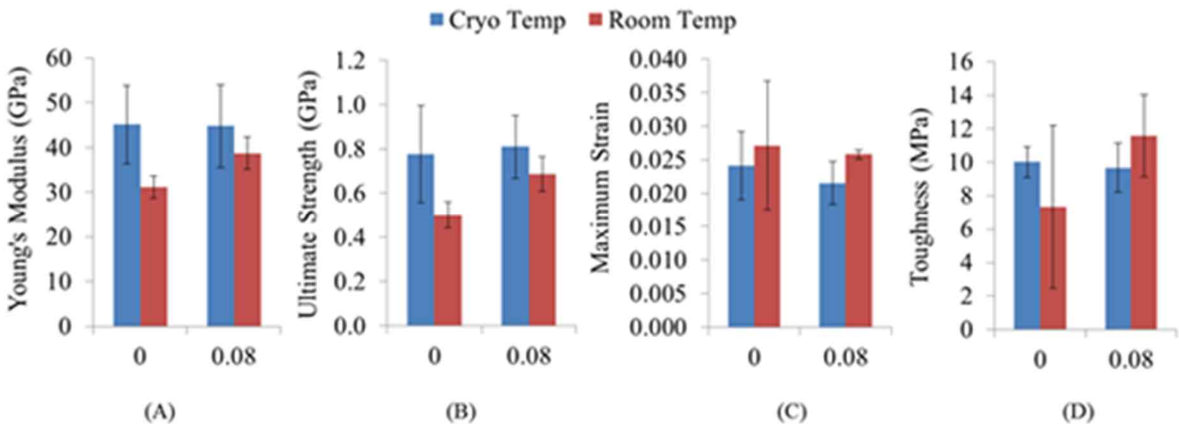

Figure 2 Comparison of 0% and 0.08% mass graphene CFRP tensile samples at room and cryogenic temperatures including (a) Young's Modulus, (b) ultimate strength, (c) maximum strain, and (d) work of fracture/toughness