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Short beam Shear strength measurements of Glass fibre reinforced Epoxy Nanocomposites modified with Graphene Oxide interfaces

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Abstract: The effect of graphene oxides on the interlaminar shear strength characteristics of glass fibre reinforced epoxy composites has been studied. Graphite was oxidized through modified Hummer's method to form graphite oxide and then to exfoliated graphene oxide (EGO) followed by reduction in the presence of hydrazine hydrate to produce reduced graphene oxide (RGO). As-synthesized nanoparticles were characterized for morphological studies, chemical composition, spectroscopic and diffraction studies using SEM, Raman spectroscopy and FTIR respectively. At different concentrations of EGO & RGO, glass fibre reinforced epoxy composites have been prepared through simple hand layup method ensuring no air bubbles. According to ASTM standards, Baseline and modified composite test specimens were characterized for interlaminar shear strength measurements. It was observed that reduced graphene oxide has shown significant enhancements in properties and a good fibre-matrix interface bonding. Fractured surfaces of composites were examined under SEM which revealed uniform distribution of nanofillers in the matrix.
Key words: fibre reinforced composites; epoxy; graphene oxide; short beam shear strength.

1. Introduction and Experimental

Fibre reinforced composites (FRC) with favourable strength to weight ratio and stiffness to weight ratio can replace their metal counterparts in a variety of high performance structural applications. However, the performance of FRC's to a large extent is controlled by the properties of fibre matrix interface, which is the critical link that provides structural integrity for these materials. Major design characteristics of laminated composites are their interlaminar shear strength (ILSS). Since the conventional manufacturing techniques fails to produce reinforcing fibres oriented in thickness direction to sustain transverse loads, matrix modification using micro or nano structured fillers demands prior importance [1-2].

In the current work, we report the effect of graphene derivatives on the short beam strengths of glass fibre reinforced epoxy composites which are fabricated through a simple hand layup method ensuring with no air bubbles trapped. Initially, graphite oxide was prepared from graphite through modified Hummer's method [3-4]. It was then followed by thermal exfoliation at 450 °C in an oven at 5 °C/min; typically, 5 g of graphite oxide was used to produce 1 g of exfoliated graphene oxide (EGO). Then, EGO was chemically treated with reducing agent hydrazine hydrate under a water cooled condenser maintained at 100 °C for 24 h to produce reduced graphene oxide (RGO). Dispersion of graphene derivatives in epoxy resin was obtained by solvent assisted method where tetrahydrofuran (THF) was used as organic solvent which in later stages removed. At different concentrations of EGO and RGO, neat and modified glass fibre reinforced epoxy composites were fabricated through a simple hand layup method without any air bubbles. Short beam test specimens of neat and modified composites were prepared, and characterized under universal testing machine (Tinus Olesan, 10 KN) as per the ASTM D2344 [5]. Finally, fractured surfaces of test specimens were studied under scanning electron microscopy for morphological studies.

2. Results and Discussion

Figure 2.1 shows Raman spectra of reduced graphene oxide, exfoliated graphite oxide and graphite oxide. For GO and EGO the broadening of peak at 1580 cm^{-1}(G) and intense peak at 1350 cm^{-1} (D) are visible. Raman analysis indicated an intense D band and significant broadening of both D and G bands indicating a high degree of disorder. In the inset, SEM images of reduced graphene oxide, exfoliated graphene oxide and graphite oxide were given. The changes in size were evident as it reduced from graphite to reduced graphene oxides.

Figure 2.2 shows the FTIR spectra of graphite oxide, exfoliated graphite oxide and reduced graphene oxides. It was studied to confirm the functional groups present on the surfaces which exhibits a peak at 3405 cm^{-1} which attributes to stretching vibration of -OH groups. The other characteristic absorption peaks at 1729 cm^{-1} and 1227 cm^{-1} are observed in the spectrum which are due to the stretching vibrations of C=O and C-O, respectively. These results confirm that the graphite oxide contains oxygen based functional groups.

Figure 2.3 shows the interlaminar shear strength measurements (ILSS) of neat and modified epoxy composites against concentration of nanofillers. It was observed that increase in ILSS properties was evident as the concentration of nanofillers increasing. The highest shear strength was noticed at 1 wt. % concentration of EGO. In the case of RGO, at 1 wt. % concentration, composites resulted in a dramatic increment of about 50% enhancements in interlaminar shear strength properties. This kind of behaviour can be understood when characteristics of nanofillers were considered. It was expected that the higher specific surface area, high aspect ratio, and two dimensional sheet geometry of graphene derivatives have brought an efficient fibre matrix interface which in turn resulted in dramatic increments in the shear strength measurements. It was confirmed from the SEM images of fractured surfaces that interfaces of fibre and matrix were stronger in modified composites. There is no indication of nanoparticle pullout from the epoxy matrix, suggesting a strong interface.

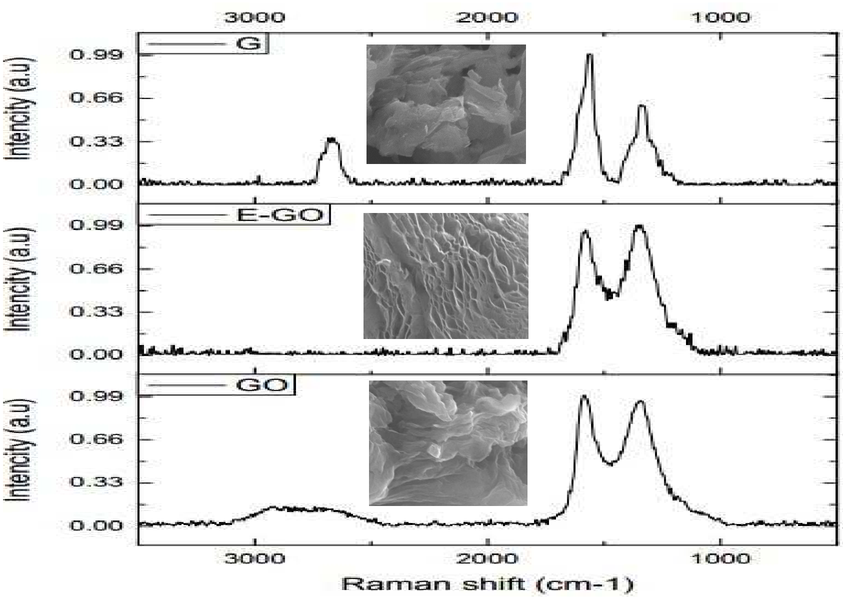

Fig. 2.1. Raman spectra of graphene (reduced graphene oxide), exfoliated graphene oxide and graphite oxide, corresponding SEM images in inset.

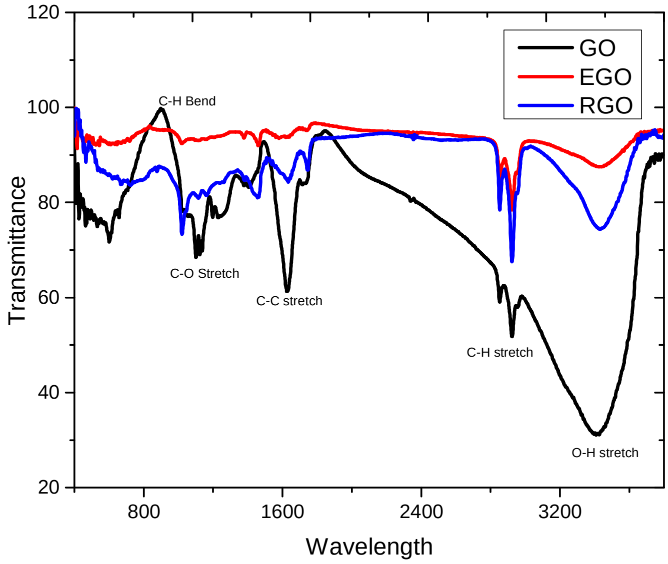

Fig. 2.2. FTIR spectra of graphite oxide, exfoliated graphene oxide and reduced graphene oxides.

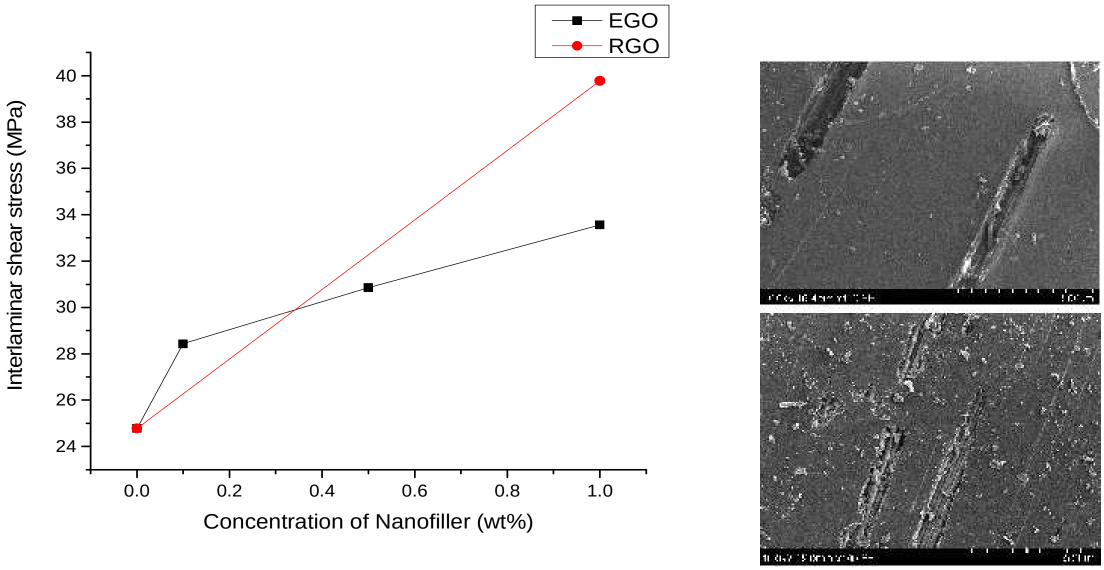

Fig. 2.3. A graph showing interlaminar shear strength measurements of EGO and RGO filled composites, corresponding SEM images of fractured surfaces of plane (top) and 1% RGO added (bottom) composites on the right

3. References

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