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The nano clay influence on mechanical properties of mixed glass fibre polymer composites

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Abstract: This paper presents the influence of nanoclay particles on epoxy/hybrid glass fibre, in combination with woven roving and chopped strand mat reinforced composites. Hand lay-up technique was applied to prepare hybrid glass fibre/epoxy nanocomposites laminates with varying nanoclay content. X-ray diffraction (XRD) was used to characterize the structure of the dispersed nanoclay particles into matrix material. XRD images revealed that the dispersion of nanoclay particles was orderly exfoliated with the epoxy resin. The mechanical properties of hybrid glass fibre/epoxy nanocomposites laminates were investigated. It was observed that the tensile strength, flexural strength and interlaminar shear strength significantly increased, when nanoclay particles were added. In addition, it was also found that small amount of nanoclay (1%) enhances the tensile strength by 14.8%, flexural strength by 9% and interlaminar shear strength by 25%. Fracture surface of nanocomposites specimens were analyzed using the scanning electron microscopy (SEM).
Keywords: Glass fibre; Nanocomposites; Mechanical properties; Scanning electron microscopy.

1. Introduction

Polymer composites materials are widely used in aerospace, aircraft, marine, sports and military industries. The materials provide unique mechanical and tribological properties combined with a low specific weight and a high resistance to degradation in order to ensure safety and economic efficiency[1]. Clay-containing polymeric nanocomposites have several advantages over the conventional polymer composites. Nanoclay is one of the several ideal reinforcements for polymers due to its high modulus and aspect ratio. Manfredi et al.[2] studied the influence of MMT in the matrix of unidirectional glass fibre/epoxy composites. The composites with C10A showed the highest increment in their mechanical properties when compared with the neat epoxy matrix composites. The mechanical and impact properties were improved through hybridization techniques[3,4].

As mentioned above, most of the researchers have investigated on the effect of addition of nanoclay on the mechanical properties of epoxy resin systems. However there is very little literature on the effect of adding nanoclay into epoxy on the mechanical properties of hybrid glass fibre combination of woven roving and chopped strand mat (WRM & CSM).

2. Experimental

2.1. Materials and Preparation of hybrid composites

The matrix material used in this study was diglycidly ether of bisphenol-A (DGEBA) based epoxy resin in the trade name of LY 556 while the hardener was Araldite HY 951. The nanoclay used was organo modified clay called montmorillonite (MMT). The alkyl ammonium based clay commercial available in the trade name Garamite-1958 was procured from southern clay product USA. The glass fibres of continuous and discontinuous mat were woven roving mat (WRM) and Chopped Strand Mat (CSM) of 610 gsm used as reinforcement. A hand lay-up process was used to prepare the nanocomposites laminates. The laminates were prepared using 6 layers of glass fibre/epoxy of varying nanoclay content.

2.2. Materials' Characterizations

2.2.1. X-ray diffraction

X-ray diffraction (XRD) test was performed on X ray diffractometer (X' Pert Philips) for epoxy/nanoclay samples to study the interlayer separation. The prepared composite sample was subjected to XRD 2θ° scanning from 2° to 10° at 0.02° step size for 0.5 s per step.

2.3 Mechanical properties

The tensile tests were carried out in accordance with ASTM D3039 using a minimum of 5 specimens for each hybrid glass fibre/epoxy nanoclay laminate. The tests were performed in a universal testing machine of AG.IS Shimadzu with a constant cross-speed of 5mm\min, at room temperature. The flexural properties of the composites were measured using a three-point bending test according to the ASTM D790 and interlaminar shear strength (ILSS) ASTM D2344 procedure.

3. Results and discussion

3.1. Characterization of nanocomposites

Figure 1 show a typical result obtained from XRD tests on samples of epoxy with dispersion of varying nanoclay content. It was observed that neat epoxy and epoxy nanoclay samples (1% and 3%) did not show any significant diffraction peaks in the XRD pattern (Figure 1).

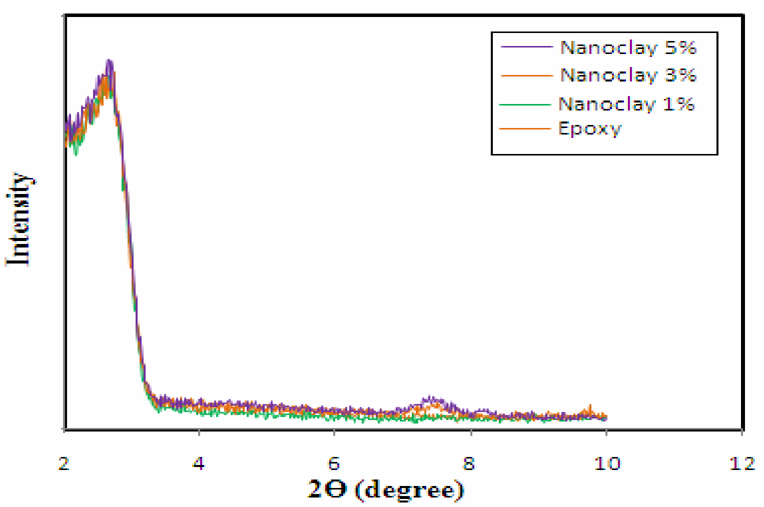

Figure 1: XRD patterns of epoxy-nanoclay composites

3.2. Tensile Properties

The maximum tensile strength was obtained with the inclusion of 3% nanoclay loading. An increase of 22% was achieved over the neat epoxy/hybrid glass fibre composites (Figure 2). A good interfacial bonding between fibre and matrix is the reason for improving the tensile properties.

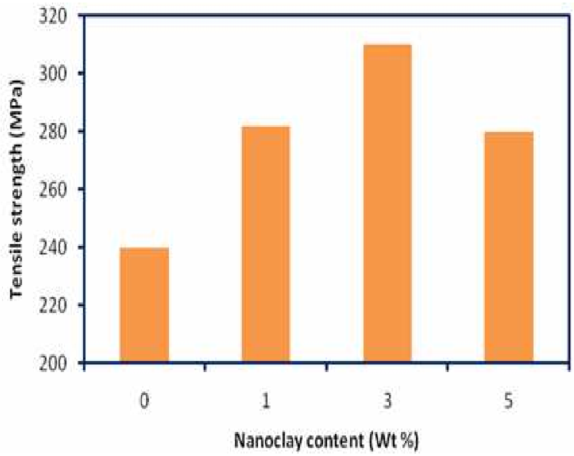

Figure 2: Tensile strength of nanocomposites

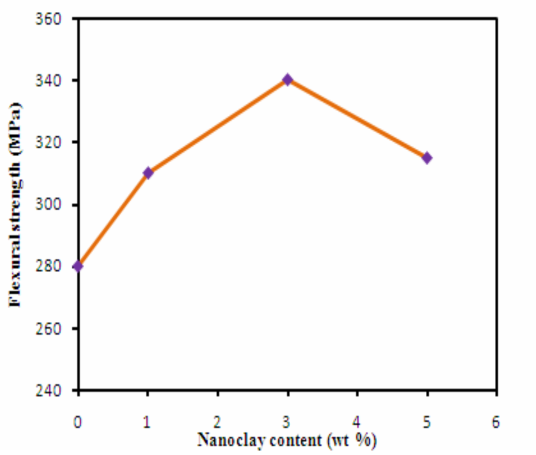

Figure 3: Flexural strength of nanocomposites

3.3. Flexural properties of hybrid glass epoxy /nano composites

Figure 3 shows the flexural strength of the hybrid glass epoxy nano composites. The addition of nanoclay concentration upto 3% loading brought about a significant improvement of 17% in flexural strength. At 5% nanoclay loading the flexural strength is decreased[5]. The fractured surfaces of flexural specimens were examined in order to study the fracture behaviors of the neat glass fibre/ epoxy composites and nanocomposites as shown in Figure.4. The modes of failure for neat glass fiber/epoxy are fibre pullout and fibre breakage. In the case of 1% and 3% nanocomposites specimens the fibres completely adhere with the matrix material. Figure 4 (b) and (c) shows that there is good interfacial bonding between glass fibre and matrix with the presence of nanoclay.

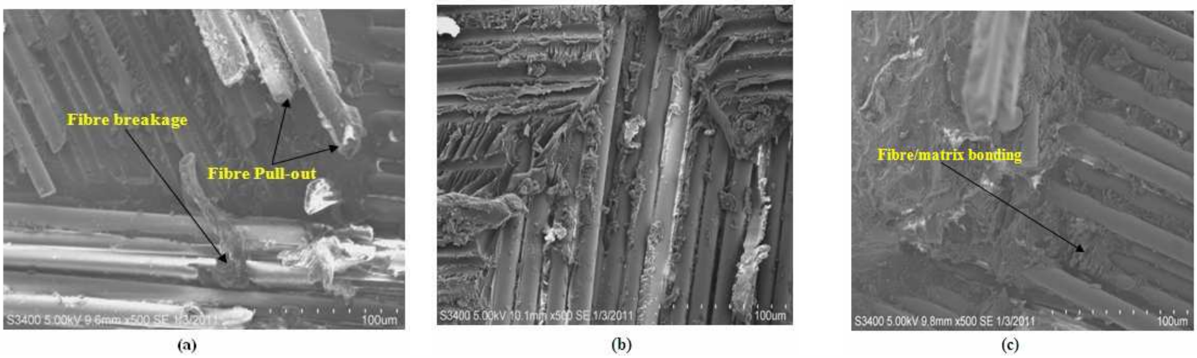

Figure 4: SEM micrographs of the fracture surfaces for (a) neat epoxy (b) 1% and (c) 3% nanoclay

The interlaminar shear strength in nanocomposites increases slightly with the filler content up to 3% which showing the reinforcing capability and well adhered nanoclay particles.

4. Conclusions

The XRD pattern of nanocomposites exhibited fully intercalation or orderly exfoliation structure, which ensures that the nanoclay particles are uniformly dispersed into epoxy resin. Incorporation of nanoclay up to 3% in the epoxy/ hybrid glass fibre results in enhancement of tensile strength, flexural strength and interlaminar shear strength compared to conventional composites laminates. The improvement in mechanical properties of glass fiber/epoxy composite is attributed to the presence of nanoclay which acts as an interface material between fibre and matrix.

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