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Synthesis and Characterisation of Woven Roving/Epoxy Nanocomposites

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Abstract: Polymer composite materials are used for engineering applications under hard working conditions. The Nano materials have unique wear properties with low specific weight and high resistance to degradation in order to ensure safety and economic efficieny. The matrix material is taken as the epoxy resin and the reinforcement as the woven roving mat (glass fiber). The addition of filler material (nanoclay) improves the wear and tribological behaviour. The laminate were prepared by hand lay-up method with varying %Wt(0 to 4) of nanoclay on epoxy glass fiber. The distribution of nanoclay in epoxycomposites were studied using XRD. The surface morphology of the glass fiber epoxy nanocomposite were analysed by Field Emission Scanning Electrom Microscope (FESEM). The enhancement effect of nanoclay was more significant in the epoxy glass fiber reinforced composite.

Keywords-Glass fibre; Nanocomposites; X-ray diffraction; Field emission Scanning electron microscope; nanoclay.

I. INTRODUCTION

Composite materials have been extensively applied to the areas of aerospace, aircraft, sports, and military industries. Advanced composite materials have progressed from a laboratory curiosity to a production reality. In recent years, polymer has been extensively utilized in structural and tribological components such as cams, brakes, bearings and gears because of their selflubrication properties, lower friction and better wear resistance [1]. Wear is defined as progressive loss of material, due to relative motion between that surface and contacting substance or substances. The five main types of wear are abrasive, adhesive, fretting, erosion and fatigue wear, which are commonly observed in practical situations. More and more polymer composites are now being used as sliding components, which were formerly

composed only of metallic materials^[2]. Polymers without filler materials have been limited only to mechanical properties and for high wear rate. It has been known for a long time that nanoclay (Garamite 1958) are used as fillers in polymer composite to improve wear and tribological properties of the polymer. The particle size, amount and the dispersion homogeneity within the matrix strongly influence the nanocomposite performance. One of the distinct advantages of nanocomposites over microcomposites is that the performance improvement is often acquired at relatively low concentration of the nanoclay.Varley et al. [3] studied the effect of three different nano-modifiers consists of organo-modified layered silicate, Vapor Grown Carbon Fibre (VGCF) and a triblock copolymer (SBM) upon key mechanical properties of carbon fibre reinforced laminates. They indicated that the addition of nanoclay could improve the notch sensitivity under compression.Haque et al. [4] investigated the effect of nanoclay, which were mixed with SC-15 epoxy/ S2-glass fibre by Vacuum Assisted Resin Infusion Molding (VARIM). By adding 1% of nanosilicates. S2-glass/epoxy-clay nanocomposites attributed to almost 44%, 24% and 23 % improvement in interlaminar shear strength, flexural strength and fracture toughness in comparison to conventional S2- glass/epoxy composites.

Nanoparticles reinforced glass fiber composites have attracted more and more attentions. Nanoclayhave the ability in reducing friction and improving the wear resistance of polymers. In many commercial applications and in industries, the clay-nanocomposites have been extensively used.

The present paper focuses on the synthesis and characterisation of glass fiber epoxy nanocomposites filled with different Wt% of nanoclay by hand lay-up techniques. Then the prepared nanocomposites are characterised by using XRD and FESEM.



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II. EXPERIMENTAL PROCEDURE

A. Materials and samples preparation

The matrix material was bisphenol-A, based epoxy resin LY 556 with hardener HY 951 both provided by Huntsman. The glass fiber used was in the form of woven roving Mat (WRM). The nanoclay used in this study was organo modified clay called montmorillonite (MMT) the alkyl ammonium based clay commercial available in the trade name Garamite-1958 bought from southern clay product USA. The primary step of the fabrication process involved indispersion of nanoclay into the epoxy resin. For preparing nanoclay composites, both the resin and filler with desired proportion were carefully mixed using mechanical stirrer for 90 minutes at constant speed before the curing agent was added at a stoichiometric ratio in respect to the epoxy resin. Now the mixture (consisting of epoxy, nanofiller and curing agent) is applied over the reinforcement material(Woven roving mat) which has been cut to a size of (150x150mm). Six layers of mats are used to prepare a sample in that each mat is kept one over the other by applying prepared mixtureby rolling operation using a roller over a moulding board(Fig.1). By the help of screw driver and hammer the samples are removed from moulding board after curing for 48 hours (Fig.2).



Fig.1.Fabrication of nanocomposites



Fig.2.Finished Samples after curing (0 to 4 %)

B. Characterisation Techniques

X-ray diffraction (XRD)test was performed on X ray diffractometer (X' Pert Philips) for epoxy/nanoclay samples to study the interlayer separation (fig.3). The prepared composite sample was subjected to XRD 2 θ scanning from 2° to 10° at 0.02° step size for 0.5 s per step. The test was then carried out with CuK α radiation source (1.541A°) operating under a current of 30 mA, and a voltage of 40 kV.

1) Nanoclay 1%

Epoxy resin = 85.47gNanoclay= 1% of epoxy resin= 0.85gHardener = 8.59gFiber= 150x150mmFiber (1) = 12.74gFiber (6) = 85.43gRatio = epoxy resin/ hardener=10%Ratio = epoxy resin/ fiber (6)= approx. 1:1



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Fig.3 X-Ray Diffraction

The prepared nanocomposites samples were examined using Field emission scanning electron microscopes (FESEM). FESEM was carried out using Supra-55 Field emission scanning electron microscopes operating at an acceleration voltage of 20 kV (Fig.4). The surfaces were then coated with a thin gold film to increase their conductance for SEM observation. The SUPRATM 55 offers the highest resolution availabletoday, comparable with "In-lens instruments", combined with a superb large fully eucentric 5" stage and a large multi-functional specimen chamber. The SUPRA[™] 55 has been designed for the mostdemanding applications in nanotechnology withsub-nm resolution readily attainable.



Fig.4 Field Emission Scanning Electron Microscope

III. Results and Discussion

X-Ray Diffraction (XRD)

X-ray diffraction experiments were performed to determine the structural characteristics of the

(Fig.5). So the absence of peak reflection in the nanocomposites suggests good intercalation of the clay particles in the epoxy matrix. - Nano 3 wt%



Fig.5. XRD pattern of 3% Nanoclay

Field EmissionScanning Electron Microscopy(FESEM)

Field Emission Scanning electron microscope (FESEM) is a straight forward technique to visualize the dispersion of nanoparticles within matrix and to study the structure of nanocomposites (intercalation/exfoliation).FESEM pictures of Epoxy/ nanoclay are displayed (Fig.6 and 7). A homogeneous dispersion of nanoparticles is clearly visible, although some small agglomerates present in the matrix medium. Fig. 6 shows that the dispersion of nanoclay in the matrix is random and uniformly dispersed throughout the matrix. Epoxy with 3% nanoclay at lower magnification shows agglomerated structure and the dispersion of the agglomerated particles throughout the matrix(Fig.7). This agglomerated structure shows that at higher concentration the nanoclay dispersion is difficult in the matrix medium.



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Fig.6 Nanoclay 1 % distribution



Fig.7 Nanoclay 3 % distribution

In 1% nanoclay specimen, nanoclay particles are in fewer amounts and hence they are randomly distributed over the epoxy. But in 3 % nanoclay specimen, the concentration becomes high. The randomness becomes less and hence they are clustered together. The nanoclay introduced inside the epoxy act as grid lines of a net like a network chain.

IV. CONCLUSION

The nanocomposite are successfully prepared by varying % of 0,1,2,3,4.

The XRD results clearly show that the particles are uniformly dispersed and obtained intercalation structure.

The 1 % nanoclay sample shows the random distribution of nanoclay over epoxy.

The 3 % nanoclay sample shows good interfacial bonding with fiber.

In future we are going to investigate the wear behaviour of the nanocomposite.

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