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Polyester nanocomposites: Effect of hydrophilic clay on chemical resistance

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ABSTRACT

Performance of chemical resistance of weave glass fiber reel (WGFR) reinforced clay/polyester nanocomposites were fabricated to assess the influence of modified MMT (i.e. montmorillonite) clay. Research focused on two systems namely (a) polyester filled with clay and (b) reinforced with WGFR/polyester filled with clay are studied at different clay loadings 0, 2, 3, 5, & 12 wt. % respectively. The nanoclay was dispersed by high speed mechanical shearing with the aid of the *in situ* polymerization. A 9 vol. % of weave glass fiber cut in to 20 mm length to prepare composites by hand lay-up method. All the samples were pre-weighed and dipped in the chemicals about 24 hrs and again weighed to find out change in %age of loss/gain of the samples. Nanocomposites exhibited good resistance to attack of all chemicals except sodium carbonate. © 2011 Trade Science Inc. - INDIA

KEYWORDS

Clay;
Polyester;
Weave glass fiber reel;
Nanocomposites;
Chemical resistance.

INTRODUCTION

Polymer nanocomposites have been an area of intense industrial and academic research for the past 20 years. What differentiates nanocomposite materials from classical composites is the degree of control of fabrication, processing and performance that can be achieved nearly down to the atomic scale. Improved properties as compared to the pure polymer or conventional particulate composites are reported for polymer nanocomposites containing substantially less filler

typically (1-5 vol. %) and thus greater retention of the inherent processability of resin^[1,2]. Permeability of water, oxygen and other gases of the nanoclay composites also decreased making these composites ideal for building advanced composite fuel tanks for tomorrow's reusable launch vehicles. Timmerman et al.^[3] clearly demonstrated that number of transverse cracking of carbon fiber/epoxy laminates as a response to cryogenic cycling was significantly reduced when nanofillers were used. Epoxy is a high performance which can be promised to be improving mechanical and thermal properties

for making high performance nanocomposites which need three main factors are to be considered namely aspect ratio of filler, bonding between fiber and matrix and wettability of fibers^[4]. Very little reports were documented on chemical resistance of nanocomposites than composites^[5-10].

In this study, we produced nanocomposites that are resistance to attack with the chemicals to use in chemical industries, aerospace and marine applications. In this research reinforced WGFR/ polyester/ nanocomposites are cut based on the ASTM standards pre-weighed with electrical balancing machine and dipped in to the chemicals about 24hrs and again removed and cleaned with tissue paper weighed again in order to study behavior of nanocomposite subjected to chemicals.

MATERIALS AND METHODS

Materials

Montmorillonite clay (Product No: 682659; Brand: Aldrich, Product name: Nanoclay, hydrophilic bentonite; Formula: $H_2Al_2O_6Si$; Molecular weight: 180.1g/mol; Appearance (Color): Conforms to Requirements Light Tan to Brown; Appearance (Form): Powder; Loss on drying: =18.0%; Density: 600-1100kg/m³; Bulk density: Avg. particle size: =25micron) supplied by Sigma-Aldrich Chemicals Pvt. Limited, Bangalore, India Commercially available polyester/catalyst/accelerator supplied by HUNTSMAN Ciba-Geigy India Ltd Company. Weave Glass fiber reel was (density: 300g/m²) obtained from Saint Gobain Industries Ltd., Bangalore.

Nanocomposite manufacturing

A glass mould with required dimensions was used for making sample on par with ASTM standards and it was coated with mould releasing agent enabling to easy removal of the sample. A 9 vol. % of weave glass fiber reel was dismantled and cut with sharp scissors into 20 mm length were used to prepare composites. The resin/catalyst/accelerator are taken in the ratio of 10:2:2 parts by weight respectively. Clay is mixed with stipulated quantity of resin based on the aforementioned ratio is mixed thoroughly with mechanical shear mixing for about 1hr at ambient temperature conditions. Then pre-calculated amount of catalyst and accelerator were mixed and stirred

for 20 min before pouring in to the mould. Hand-lay up technique was used to impregnate the composite structures. In this technique a glass fiber were wetted by a thin layer of clay/polyester suspension in a mould. Stacking of glass fiber was arranged by side by side all over the mould^[6]. Stacking of glass fiber carefully arranged after pouring some amount of resin against the mould to keep the poor impregnation at bay. Rest of the quantity of mixture was poured over the glass fiber. Brush and roller were used to impregnate fiber. The closed mold was

TABLE 1 : Effect of chemicals on weight of neat polyester matrix and nanocomposites at % change in weight after dipping for 24hr.

Chemical	Neat polyester	WGFR/polyester/clay/nanocomposite
Hydrochloric acid	+1.217	+0.873
Acetic acid	+1.282	+0.241
Nitric acid	+2.459	+1.678
Sodium hydroxide	+1.123	+0.568
Sodium Carbonate	-0.235	-0.245
Ammonium Hydroxide	+0.919	+0.767
Benzene	+2.380	+10.426
Toluene	+2.479	+4.810
Carbon tetrachloride	+2.941	+2.145
Distilled water	+1.630	+1.023

kept under pressure for 24 hrs at room temperature. To ensure complete curing the composite samples were post cured at 70°C for 1 hr and the test specimens of the required size were cut out from the sheet.

Chemical resistance test

To study the chemical resistance of the nanocomposites, the test method ASTM D 543-87^[9] was employed. Three acids, three alkalis and four solvents were used for this purpose. Acetic acid, nitric acid, hydrochloric acid, ammonium hydroxide, aqueous sodium carbonate, aqueous sodium hydroxide, carbon tetrachloride, benzene, toluene, and distilled water were used after purification. In each case, the samples (5mm x 5mm x 3 mm) were pre-weighed in a precision electrical balance and dipped in the respective chemical reagents for 24 hrs. They were then removed and immediately washed in distilled water and dried by pressing them on both sides with a filter paper at room temperature as described elsewhere^[7]. The treated

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samples were then re-weighed and the percentage loss/gain was determined using the equation:

$$\frac{\% \text{ weight loss or gain of the sample}}{\text{gain of the sample}} = \frac{\text{Original weight} - \text{Final weight}}{\text{Original weight}} \times 100$$

CONCLUSIONS

Reinforced with WGFR/polyester/clay/nanocomposites were developed to measure chemical resistance of samples using ASTM D 543-87 method^[9]. TABLE 1 witness nanocomposites respond well in the presence of chemicals gains less weight in contrast with pure epoxy matrix. In each case, ten pre-weighed samples are dipped in the chemicals under study for 24hr, removed and washed thoroughly in distilled and dried immediately by pressing between filter papers. It is evident that weight is increased for matrix after immersion. This is understandable as the matrix is well cross linked and as a result swelling takes place instead of dissolution. These nanocomposites proved to be good resistance to attack on chemicals except sodium carbonate.

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