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Comparative Study of Moisture Diffusion Behavior of Textile Structured Nano Composite with Varying Nano Clay Composition

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Abstract: *Moisture absorption behavior of any fibre reinforced composite structure is one of the major concern towards it applicability because it affects the mechanical properties of the composite. The diffusion phenomenon of any composite materials is followed Fick's second law of diffusion. The purpose of this study is to understand the diffusion behavior of this nanocomposite structure prepared through woven E-glass/Epoxy reinforced with nanoclay (cloisite-Na). This composite material produced through varying concentration of nanoclay such as 2%,3%,4%,5%,6%,7%.Once the composite is produced all the samples were tested towards its moisture diffusion behavior.In addition to that the loss of tensile structure were also studied due to moisture diffusion of composite materials. The moisture diffusivity of nanocomposites decreased with increasing clay content up to 6% after that there won't be any significant changes in its diffusion behaviou .*
Keywords*: Nanoclay, woven glass fibre mat, moisture diffusion*

I. Introduction

Due to the increasing demand in the field of material science,researchers are working on to find the polymeric composite structure with the intervention of nano- particles. These nano-particle exhibit improvements in physical and mechanical properties of the composite structure as compared with the conventional one.As reported by Alexandreetal (2000) the properties such as high moduli,increased strength,increased thermal stability and decreased flammability. Nanocomposites are a composite in which atleast any one of its component material's material dimension. Presently, the main application of composite structures is as construction materials(Springer, S. G,1997) , such as decking and railing products. However, Most of the composite structures have an undesirable property, namely, hygroscopicity due to its chemical constituents. The moisture absorption by composites creates adverse effects on their physical properties and thus affects their long-term performance. For example, increased moisture decreases their mechanical properties(Schultheisz, R.C ,1997).Many attempts have been made to address this issue. Coupling agents, compatibilizers or other chemical modifications are used to improve the moisture resistance of composites(Pomies, F et al,1995).However, moisture absorption of composites is still one a major concern especially for their outdoor application.It was reported that the water diffusivity decreased with increasing the clay component As reported by Okada(1990) the intervention of 1% of wt% of clay with vinylester resin based composite the diffusion coefficient reduced half of its time.However ,the equilibrium moisture content increased with increasing clay content for all samples. It is further reported by Messermith(1990) 80% of decrease in water absorption with the intervention of nanoclay composition towards in the nylon based composite materials.

II. Effects of Moisture on composite properties

Most of the literatures proved that when water molecules diffuse into the network of composites,which affects the mechanical properties of the composite materials. Marom (1989) reported that the short-term effect of water diffusion increases the fracture toughness, while in the long run the toughness deteriorates. Shen and Springer (1977) reported that for 90 degree laminates the ultimate tensile strength and elastic moduli decreased by 50% -60% with increasing moisture content. When moisture diffuses intocomposites, it degrades the fiber-matrix interfacial bonding (Schultheisz, R.C et al,1997), lowers the glasstransition temperature (Brinson, H.F ,et al ,1987), swells, plasticizes and sometimes microcracks the matrix(Schutte, L.C,1994)]. The uptake of moisture usually is measured by weight gain and the mechanism of water diffusion is characterized by Fick's law . In 1975, Shen and Springer (1977) studied based on Fick's law about absorption and desorption of water in composite materials and derived expressions for the moisture distribution and moisture content as a function of time for one-dimensional composite materials.Many research data supportedthis expression and which has beenwidely accepted to describe the water diffusion behavior in composites.Water absorption behavior for some composites, however, is far from fittingthe Fickian model. In this research work Moisture diffusion study was conducted through nanoclay reinforced glass/Epoxy composite with varying percentage of clay component from the range of 3% to 7%at room temperature.

III. Fick's law of Moisture diffusion

Moisture diffusion into the composite resin can lead to a reduction in glass transition temperature(Tg) and softening, which result in the degradation of stiffness and strength. This degradation further can be aggravated and involve the interface under more severeconditioning. Some composites and neat resins have simple water absorption behaviour which fits Fick's second law

Fick's second law states that

$$\frac{\partial M}{\partial t} = D \cdot \frac{\partial^2 M}{\partial Z^2}$$

where

D: diffusion coefficient

M: moisture content

t: conditioning time

z: the length in the thickness direction

IV. Materials and methods

The raw materials used in this study was Plain Woven E-glass matt, Diglycidyl ether of bisphenol A(Epoxy) resin and 1,3 –phenylenediamine(curing agent) were supplied by GVR enterprises,Maduri. Nano clay (cloisite-Na) were supplied by ACME fibresltd,Chennai.

V. Preparation of composite

Composite was prepared through hand layup method. The first step of this process was preparation of mould with the measurement of 250mm*250mm*10mm. The inside surface of the mould was coated with fine amount of PVA which helps to remove the moulded composite. The necessary amount of epoxy was drawn in to the beaker ,which was heated to 75 o C to lower the resin viscosity ,The required amount of clay (2%,3%,4%,5%,6%,7%) were added in to the resin . The entire mixture were taken for the sonication process using ultrasonicator(Ultrasonic processor XL2020) for about 12 h.The next step to mix the resin with 10% hardener.Then the mould is allowed to cure in the room temperature .The moisture diffusion study was conducted on the prepared samples.The Mositure diffusion study was conducted as per model of Fick's law of diffusion .Subsequently the nano clay dispersion on the composite were also studied.

VI. Characterization of Water Absorption

The nanocomposite materials were removed from the mould .The specimen was cut with the dimensions of 100mmX100mmX10mm. This test was conducted as per the standard of ASTM 5229 .Before commencing the study all the test specimens were polished to ensure that the surfaces were flat and parallel each other, followed by drying in a vacuum oven at 90 o C for 4 days(Akay M,1995).Specimens were then soaked in distilled water at the temperature of 50°C. During the conditioning time, the specimens were periodically removed from the environment, dried by using towel and weighed using an electrical balance accurate to 0.0001g. The weight and conditioning time were recorded to calculate the moisture content. The moisture content was plotted as the weight gain against square root of conditioning time.

VII. Results and Discussion

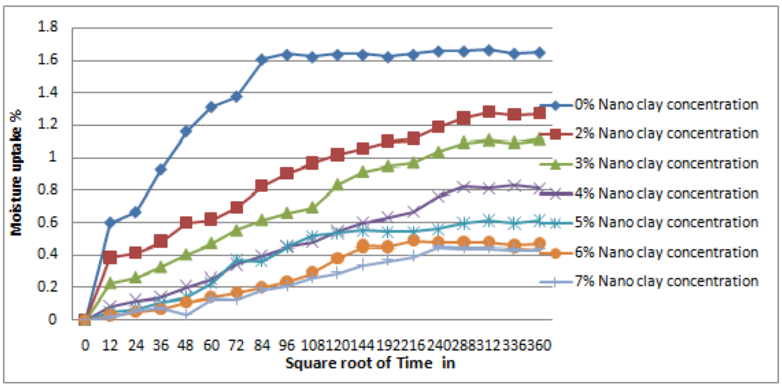

Figure 1.1 Moisture uptake with varying nanoclay percentage

In figure 1.1, indicated the moisture uptake curve of various samples of nano composite with varying concentration of nanoclay such as 0% ,2%,3%,4%,5%,6%7%. More over all the other parameter such as woven glass matt,Epoxy resin type were kept unchanged. It is understood that all the samples moisture diffusion behavior follows fick's second law. It is obvious that, the two kinds Fickianbehavior are: (1) the absorption curve should be linear initially and (2) the moisture content should reach a saturation level at large values of time. The moisture content and time to reach moisture saturation may be calculated from two parameters: the maximum moisture content *Mm*, which can be read directly from the weight gain curve, and the one dimensional diffusivity *D*, which can be calculated by Shen and Springer's(1997) method .It is noted that 0% nano-clay concentrated composite took higher moisture intake as compared with other samples.

The time to take the saturated moisture update for the o% nanoclay concentrated composite was 84 hrs. whereas in the case of 6% of 7% nano clay concentrated composite was attained around 240 hrs.The time of saturation difference was 156 hrs .This is due to restricted molecular chain movement between the resin structure. In addition to this advantage the overall % moisture diffusion for the o% nano clay composite was 1.649, where as in the case of 7% nano clay concentrated composite it was 0.44 . The difference in diffusion between this two cases was 27%. This changes is the remarkable advantage of nanoclay reinforcement. This is due to the blocking of micro cracks by the nanoclay component..

Paired Samples Correlations

		N	Correlation	PValue (Sig.)
Pair 1	6% nanoclay concentrated composite & 7% nanoclay concentrated composite	18	.980	.000

As per the above table Paired sample "T"Test was conducted to find the statically difference between the 6% nanoclay concentrated composite to 7% nanoclay concentrated composite. Since the P Value is less than 0.05,so it was concluded that difference is statically insignificant.It is further understood that further improvement in nanoclay composition will not influence much on moisture diffusion behavior of the composite. Moreover there is chance of increasing the moisture diffusion due to lack of sufficient bonding between the polymers.

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