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The Studies on Properties of Epoxy-Graphene Nano Composites

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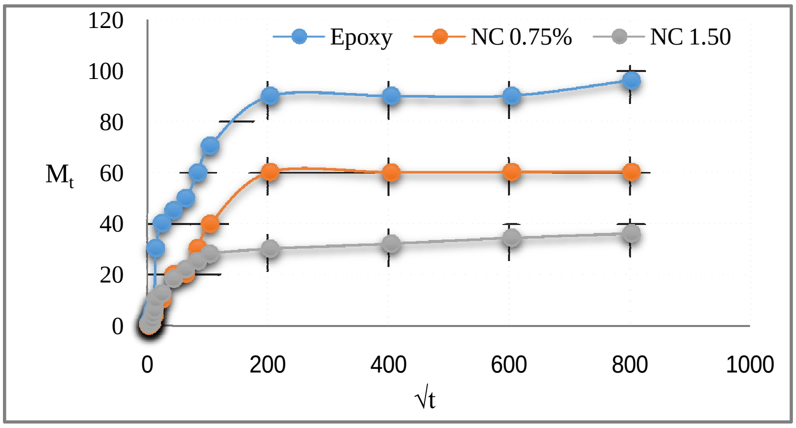
ABSTRACT

The water sorption and diffusion in (reduced) graphene epoxy nanocomposites of various compositions (0.75 and 1.5g) is analyzed. Water sorption of epoxy membrane can be significantly reduced by the inclusion of graphene oxide sheets due to the formation of an extensive hydrogen bonding network between oxygenated groups. Crosslinking of epoxy groups with divalent metal ions and the presence of reduced graphene oxide can further improve the swelling resistance due to the strong interactions between metal ions, epoxy group, and filler sheets. Depending on conditions and composition, the overall water barrier properties of epoxy graphene nano composites improve upon (reduced) graphene oxide filling, making them attractive for moisture barrier coating applications. Water sorption kinetics in all epoxy composites indicates a non-Fiskian diffusion process. In addition, the water barrier properties of epoxy-graphene oxide composites can be adequately predicted using permeation coefficients calculated from sorption and diffusion coefficients.

Graphical Abstract:



Sorption kinetics of epoxy specimens for moisture absorption for the epoxy and the epoxy filled with 0.75wt and 1.5 wt. % of nanoparticles in an atmosphere with 91% during moisture absorption.

Keywords: Epoxy-graphene nano composites, Overall water barrier properties of epoxy graphene nano composites, Kinetics, Diffusion properties.

INTRODUCTION

The change in the concentration and morphology of nano particles had great effect on the final properties of traditional polymer resins. The development of novel nano composites as advanced polymer with graphene nano particles have unique mechanical properties their stiffness and strength value which have limited indoor applications due to relative sensitivity to environmental conditions such as moisture and temperature. The decrease in the diffusion coefficient of moisture in epoxy field with graphene (0.75 and 1.50%) was found to increase with temperature from 20 to 40 degree centigrade this was mainly due to reduction in revalue, high cross link density and lower segmental mobility in the nano composites. The greater plasticization effect which leads to similar glass transition temperature both epoxy and nano composites show decrees in equilibrium moisture content with addition of graphene nano particles. The dispersion and chemical functionalization of graphene nano particles in to epoxy improve the maximum barrier characteristics and stability against environmental factors [1-11].

MATERIALS AND METHODS

All the epoxy and epoxy graphene nanocomposites were conditioned in a desiccator with silica gel at relative humidity of around 24% to remove the adhered moisture before starting the moisture sorption test till there is a constant mass with each specimen.

The test samples are then placed in desiccators at relative humidity of 47% 73% and 91% which is achieved by using saturated solution KCNS, KCL and Na_2 So_4 respectively after all the samples reached the equilibrium moisture content the moisture sorption experiment were performed at temperature at temperature 20 to 40 degree respectively the specimens were periodically removed from desiccator and weighed by using METTLER TOLEDO balance with precision of 0.05 mg.

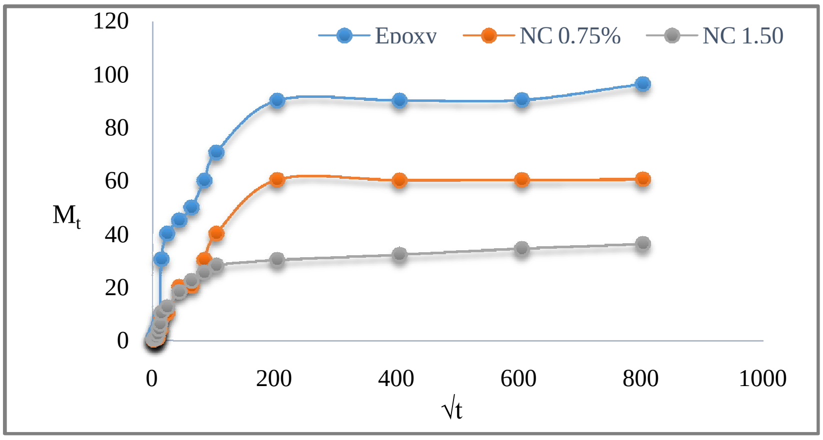


Figure 1. sorption kinetics of epoxy specimens for moisture absorption for the epoxy and the epoxy filled with 0.75 wt and 1.5 wt % of nanoparticles in an atmosphere with 91% during moisture absorption.

RESULTS AND DISCUSSION

The classical Fick's model use usually applied to describe the moisture absorption curves of epoxy and epoxy graphene nano composites.

In 3D mode the moisture content absorbed for each specimen w(t) in the specimen is expressed as

$$w(t) = (w_\infty - w_0)\frac{8}{\pi^2}\ \sum_{k=1}^{\infty}\sum_{n=1}^{\infty}\sum_{m=1}^{\infty}\frac{[1-(-1)^k]^2[1-(-1)^n]^2[1-(-1)^m]^2}{k^2n^2m^2}\exp\left(-\lambda_{kmn}^2\ D_t\right)\ ...(1)$$

W_t and w_∞ are the initial and equilibrium moisture content basically, in Equation (1), there are two independent parameters: the diffusion coefficient D and the equilibrium moisture content w_∞.

The maximal moisture content over sorption test at equilibrium and the time varying moisture content (in %) is obtained by time dependent diffusion expression (Table 1).

$$D_t = D_{0\_}\exp(-yt)\ ...(2)$$

Sorption kinetics of epoxy specimens for moisture absorption for the epoxy and the epoxy filled with 0.75 wt and 1.5 wt % of nano-particles in an atmosphere with 91% during moisture absorption (Figure 1).

Table 1. Values of Diffusion coefficient

Amount of Graphene	Temperature	D-Values from Fick's equation		
0.00	20	2.30	1.10	0.64
0.75	30	3.10	4.00	0.72
1.50	40	4.30	2.20	0.33
0.00	20	1.30	1.60	2.10
0.75	30	0.90	1.10	1.60
1.50	40	0.41	0.65	0.92

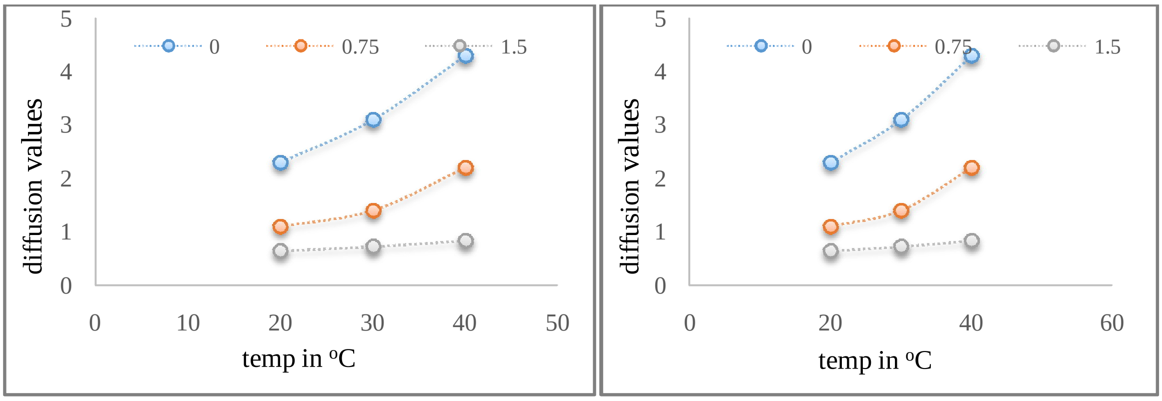


Figure 2. Variation of D with temperature.

In the current study the purpose was to evaluate the Fick's model correlates well with the experimental data also for the case of moisture absorption (Figure 2).

To improve the description of experimental data for moisture absorption both Fick's model and the model with time-variable diffusion coefficient were applied. Obviously, the applications of the model with time-variable diffusion coefficient provided better description of the experimental data than the Fick's model and were used for further analysis of the sorption characteristics during the absorption.

It is seen that all sorption processes were characterized by similar trends with a considerably higher sorption rate in the early stages and a progressively slower water uptake as the equilibrium plateau was approached.

It is observed that the diffusion coefficients both Fick's model and the model with time-variable diffusion of epoxy graphene nano composites are lower when compared to neat epoxy resins similarly permeation coefficients calculated from product of sorption and diffusion coefficients.

Showed similar variation for epoxy graphene nano composites which accounts for the improved barrier properties for epoxy graphene nano composites.

APPLICATION

The main application of this work is epoxy graphene nano composite coating can be used for proective purposes especially in corrosion etc. The significant increase in the electrical thermal and mechanical properties of nanocomposites have also used in the preparation of electrothermal materials.

CONCLUSION

The rate of diffusion and the highest equilibrium moisture content in both epoxy and nano composites had the intermediate effect when compare to the moisture absorption. During the absorption of moisture the structural changes and swelling rate is considerably reduced.

In all sorption tests the diffusion coefficients and equilibrium moisture content are decreased for epoxy filed with nano particles when compare to neat epoxy which may be due to reduced mobility of polymer chain and decreased free volume allowing the water molecules to defuse through the nano composites**.**

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