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Thermal Properties of Modified Epoxy Nano Composite

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***Abstract*— A study on evaluating the effect of nano particles on thermal properties of epoxy resin cast was performed by thermo gravimetric analyzer (TGA), dynamic mechanical analyzer (DMA), and Burnoff tests. It is revealed that epoxy resin cast filled with nano particles represents higher thermal stability. The improvement of thermal properties is attributed to the surface modification of nano particles. The storage modulus of nanocomposites was characterized by DMA, which increases with the addition of nano particles in the glassy stage.**

Keywords*— *Nanotube, Epoxy, Thermal properties.

I. INTRODUCTION

Epoxies are widely used nowadays in a variety of engineering applications due to their unique characteristics of high adhesive strength, relatively high strength, stiffness and hardness, and excellent chemical and heat resistance. However, most cured epoxy systems show low fracture toughness, poor resistance to crack initiation and propagation, and inferior impact strength. For example, delamination and poor impact resistance of fibre-reinforced epoxy composites are often attributed to the low fracture toughness of the epoxy matrix. Many attempts have been made in the past decades to improve the fracture toughness of epoxies by modifying epoxy resins with additives such as rubber, thermoplastics, and organic and inorganic particles. In the current study, an attempt is made to characterize the fracture behaviour of epoxies modified by halloysite nanoparticles, mostly nanotubes, to investigate the toughening mechanisms of such epoxy nanocomposites [1]. the addition of the nanoclay significantly improve the elastic modulus and fracture toughness of diethyltoluene diamine epoxy resin, but they tend to reduce the failure strength and strain significantly with an increase of clay content level [2]. There are a number of studies that show the significant improvements in stiffness and strength of pure polymer for an addition of a small amount of nanosize clay particles improves the thermal stability is comparable with silica modified epoxy system [3] In contrast with other nano-sized inorganic fillers, naturally occurring halloysite nanotubes are readily obtainable and are much cheaper than other nanoparticles such as CNTs. More importantly, the unique crystal structure of halloysite nanotubes resembles that of CNTs. Therefore, halloysite particles may have the potential to provide cheap alternatives to the expensive CNTs because of their tubular structure in nano-scale and also due to their similarity to the other layered clay minerals such as MMTs, having the possibility to be further intercalated chemically or physically [4]. In the current study, an attempt is made to characterize the fracture behaviour of epoxies modified by halloysite nanoparticles, mostly nanotubes, to investigate the toughening mechanisms of such epoxy nanocomposites.

II. EXPERIMENTAL WORK

A. Materials

The epoxy resin used in this study was LY556 with an epoxide equivalent weight OF 185-192 g/ equiv. the curing agent was TETA HY 951. The nanotube particles was used in 200g/m^2 were applied as the major reinforcement.

B. Fabrication of Composite Laminates

The EP/NT/ hybrid composites were manufactured using NT-filled epoxy by followed by casting and epoxy resin with TETA at a 100/10 weight ratio. Nanotube was first dispersed in acetone and mechanically stirred for 30 min at room temperature. The mixture was then introduced into the epoxy resin and stirred for 2h at 75 ^{0} C. HY 951 was added with gentile mixing for 20 min. then filled into the mould and cured into 3mm plate. The nanotube contents varied

between 1 and 5 wt% based on the nanocomposite matrix.

C. Thermal resistance determination

- *Differential Scanning Calorimetry (DSC)*

DSC analysis was conducted on the samples using a TA instrument Q10 model DSC under nitrogen atmosphere at a flow rate of 50 mL/min in order to investigate the effect of clay loading on the glass transition temperature (Tg). To conduct DSC analysis, 5–6 mg of each specimen was weighed in an aluminum pan and placed in the instrument. The dynamic measurements were made at a constant heating rate of 10°C/min from 25 to 580°C. T_g of laminates manufactured with epoxy matrix containing a various concentrations of nanotube particles were calculated by the midpoint method of the epoxy composites.

- *Thermogravimetric Analysis (TGA)*

TGA was carried out in a TA Instrument Hi-Res TGA 2950 that was fitted to a nitrogen purge gas. The sample was heated ambient temperature to 600°C at 25°C/min. degradation temperatures of nanomaterial and their composites were determined using this technique

III. RESULT AND DISCUSSION

A. Thermal Stability of Epoxy Resin Cast

TGA was carried out to analyze the thermal stability and thermal degradation of pure epoxy resin caste and nano epoxy caste fig.1 is the TGA curves of modified nano cast. In this study considered the temperature of the maximum rate of degradation as the decomposition temperature (Tmax) which is show in table 1, In addition initial decomposition temperature (IDT), the mid point of degradation process at which 50% weight loss °C

Table 3.6.1Thermal degradation behaviour of the nanocomposites.

Samples Amount	**% of HNT**	**IDT (°C)**	**Temperatures at 50% weight loss °C**	**Temperature at weight loss °C(Tmax)**
N2	2%	350.70	371.69	399.40
N3	3%	352.13	372.90	404.89
N4	4%	349.11	375.31	399.34

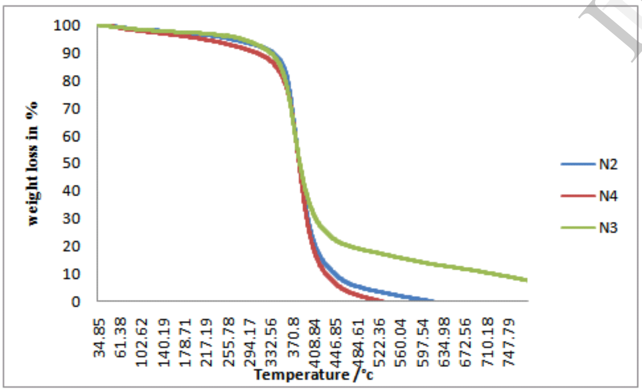

Fig. 1 TGA curves of modified nanotube /epoxy cast.

B. Differential Scanning Calorimetry (DSC) Analysis

The Tg of fabric reinforced nano /epoxy nanocomposites were also measured from DSC analysis and the effect of nano content on the T_g of epoxy cast are illustrated in fig. 2. Addition of NT particles to epoxy matrix as almost effect on T_g value , T_g of the cast were increased by 5% upto 4% wt of NT condent .

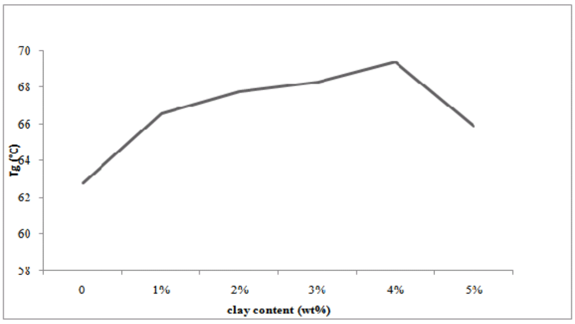

Fig. 2 Tg of the nano composites obtained by Dsc analysis

IV. CONCLUSION

Using nanotubes as the reinforcing fillers, a series of EP/NT composites with high performance have been prepared. It can be conclude that even small(2-6wt%) of nano in the epoxy can be increase the thermal stability of epoxy cast. The reason is that well dispersion of nano particles minimized the defects between fillers and polymer interface, thereby increase the thermal stability of the composite also enhanced.

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