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Study the Effect of Mica on Mechanical, Thermal and Morphological Properties of Epoxy/Polyester Blend

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Abstract: Epoxy/unsaturated polyester blend (85/15% w/w) with fillers of mica samples were prepared by cast molding method with filler volume fractions (0, 1, 2 and 3%). Hardness, tensile strength, elongation, DSC, FTIR, UV, atomic force were studied. This experimental investigation is aimed at assessing the performance of polymeric material in high temperatures applications. Shore hardness tests were used to measu the hardness. Fourier Transform Infrared spectroscopy (FTIR) to study the bonds which enhanced the mechanical, thermal properties of polyester material compounded with filler. Polymer composites Exhibits a new UV-visible absorption band which is attributed to interchain interaction. hardness enhanced with filler content increase. The experimental results showed that (3% mica) sample has the minimum value of tensle strength, hardness and elongation. The increase with filler content increase therefore, increase. On the other hand (1% mica) sample give the maximum value of tensile strength, hardness and elongation. The glass transition temperature increase by adding mica. The homogeneous morphologies of UP toughened epoxy were studied using atomic force.

Key words: Mica, polyester, epoxy, blend, DSC, hardness

INTRODUCTION

A polymer composite is made by the combination of a polymer and synthetic or natural inorganic filler. Fillers are employed to improve the desired properties of the polymer or simply reduce the cost (Alamri, 2012). Nano composites are considered as the next industrial revolution materials. What differentiates nano composite materials from classical composites is the degree of control in fabrication, processing and performance that can be achieved nearly down to the atomic scale (Chakradhar *et al*., 2012). The effect of nanoclay in enhancing thermal, mechanical and physical properties of polymer composites has been well studied ever, since, it is lighter in weight, eco-friendly, bio-degradable, cost-effective, performance-oriented as well as suited for diverse applications (Domun *et al*., 2015).

One way of achieving some of the above functionalities is by using organic and natural materials as filler material in different polymer blends (Thind *et al*., 2015). Polymer-polymer blends have gained significant commercial growth as it saves nearly 36% weight of the total polymer consumption without compromising weigh. The polymer blending offers possibility of adjusting the cost-performance balance and tailoring the technology to make products for specific end use applications, enhancing resin's performance, improving specific properties, viz. impact strength, solvent resistance, etc. and provide means for industrial and consumer plastics waste recycling (Utracki, 2002; Chozhan *et al*., 2007).

The epoxy resin commonly used by most researchers. epoxy resins have good dialectical properties such as high adhesion strength, thermal properties and good process ability (Wang, 2005; Misra, 2014). Epoxy matrix is widely used to fabricate advanced composite materials, also is used in coating adhesive, molding compounds. however the use of epoxy material is limited because of low toughness property therefore its blended with toughness, mostly polyester, used as the second phase in the resin system, toughening of epoxy material is essential to improve its impact resistance.

Polyester blended with epoxy to achieve development of inter-cross-linked polymer network of thermoset-thermoset blends the mechanical, thermal, corrosion properties, industrial finishes architectural uses and paints properties enhanced (Viswanath *et al*., 2009). Polyester like elastomers in low viscosity of the resin and from the structure of the resin which contains a relatively polar and aromatic backbone and aliphatic side chains with low polarity (Okpala, 2014; Pinto *et al*., 2001). Nano composite offer good mechanical, thermal and thermal properties therefore it's essential for this application. Nano particles have higher surface area and aspect ratio which could improve adhesion between nanoparticles and polymers and lower the amount of loading to achieve equivalent properties (Harper, 2001; Tian *et al*., 2008).

Mica is a distinguished of low cost mineral, noted for its easy cleavage into thin, highly flexible, resilient plates with outstanding electrical, heat and chemical resistance it has good abrasion and tensile resistance. Micas having

different compositions differ I n their fine structural features and in particular, is amorphous cautions in octahedral and tetrahedral of 2:1 layers, distribute with different degrees of order-disorder. Reconstruction of the caution distribution patterns in terms of short and long-range ordering is one of the main problems in determination of actual mica crystal structures (Wang *et al*., 2002; Harper, 2002; Shahryar, 2011).

Literature review

The aim of the research: The main goal of the work was to investigate the compatibility effect of miscible epoxy/polyester nanocomposite blends on mechanical and thermal properties. For this purpose a blend of epoxy/polyester (85/15% w/w) polymers were prepared as a function of mica nano clay in different weight ratios such as 0, 1, 2 and 3%. The final objective of this study is to identify a suitable nanocomposite which offers low cost, high toughness material, used in high temperature applications which can be applied in making light weight components for automobile parts, transportation systems and friction materials matrix in disk brake.

MATERIALS AND METHODS

The used type of epoxy and Amine hardener is HY-951 The resins used in this study were Epoxy with the resin-hardener ratio as 100:10 and unsaturated polyester with 2% cobalt naphthanate as accelerator, 2% Methyl Ethyl Ketone Peroxide (MEKP) as catalyst in 10% aniline solution as promoter in the ratio of the resin/accelerator/ catalyst/ promoter:100/2/2/2. In addition mica nano clay with average particle size 5-40 μm.

Fabrication of blended nanocomposites: In the first stage mica was dried in an oven at a temperature of 80°C for 24 h. Then recalculated amount of clay and epoxy/polyester (i.e., 85/15 %w/w ratio) were mixed together by intensive mixer for about 1.5 hours at ambient temperature conditions then hardener/accelerator/ catalyst/promoter (100:10/2/2/2) parts by weight was added to the modified epoxy/polyester mixture. The samples prepared by using glass mold. Glass mold covered with adhesive nylon to enable easy removal of the square sample. The samples were cut into par to the required dimensions according to ASTM standard. The nanocomposite mixture was poured over the glass mold. Brush and roller was used to impregnate the nanocomposite. To ensure complete curing the blended nanocomposite samples were post cured at 70°C for 1 h.

RESULTS AND DISCUSSION

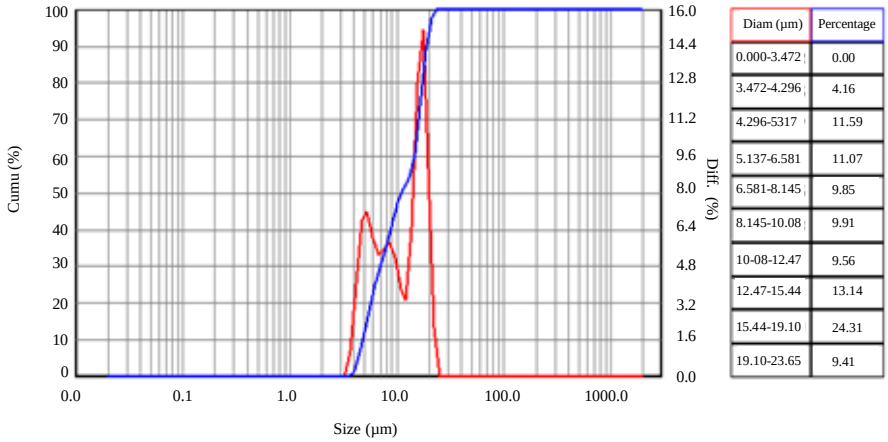
Mechanical properties: Tensile testing samples were cut in dumbbell shapes with dimensions as per ASTM D 638 standards. Nanocomposite blended to withstand the applied mechanical forces. Figure 1 and 2 show that the tensile strength increase with filler content 1% then decrease because the filler material carry the loads applied, transferred it to the matrix and prevent crack growth. mica have 5-20 μ in average particle size therefore, it is filling the spaces in the structure due to that small size and mica particles act as subtitutional filler which filled the spaces between chains due to small average particle size and make Vander walls bonds with miscible epoxy/polyester blend. The tensile strength decrease with filler content increase more than 1% due to filler agglomeration.

The elongation increase with filler content increase from 800-1000 as shown in Fig. 3, that is due to the reasonable filler content which let the blend molecules slipped above each other, after adding more filler the material be stiffer and harder due to that the filler particles hinder the chains movement and the filler particles grouped and the material be less homogenous so the elongation decreased.

The hardness increase because the density increased. Mica particles are platy shape and higher surface area, greater aspect ratio (mean diameter of the plate face to the thickness of the plate) and higher loading (the latter two effectively increasing the surface area exposed to the polymer). Then the hardness decreased due to filler segregation which increase the distance between the molecules chains, reduce crosslinks and act as plasticizer or polymer modifier.

FTIR analysis: Figure 4 represent transparence versus wave number for the samples. FTIR showed that there is physical interaction between polyester and mica. There is intermolecular H-bonding by single bridge with wave number 3500-3550 cm^{-1} represented by hydroxyl group. The intensity of the ester group bonds and other bonds decreased in the samples which contain mica and decreased with filler content increase therefore the bonds be stronger and the insulation properties enhanced and the mechanical properties because the appearance of Vander walls bonds between filler and polymer matrix.

UV spectra: It is shown in Fig. 4, that the adding of the filler to the polymer lead to increase the intensity of peak. Critical analysis of UV-Vis spectra of composites shows that the highest shift in absorption in all the wave length of the curve which indicate good physical attraction between polymer chains and mica.



Diam (µm)	Percentage
0.000-3.472	0.00
3.472-4.296	4.16
4.296-5317	11.59
5.137-6.581	11.07
6.581-8.145	9.85
8.145-10.08	9.91
10-08-12.47	9.56
12.47-15.44	13.14
15.44-19.10	24.31
19.10-23.65	9.41

Fig. 1: LBZA chart of particle size analysis of mica

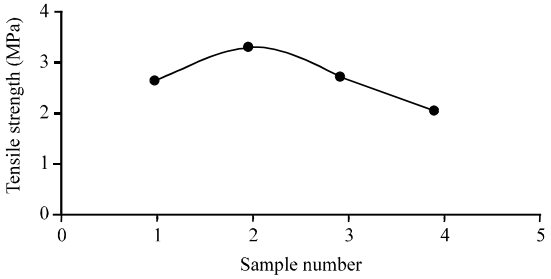


Fig. 2: Tensile strength versus sample number

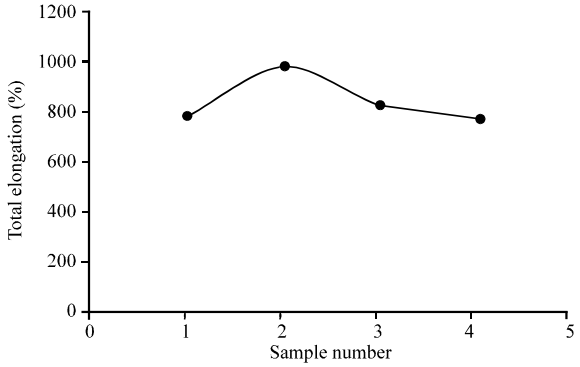


Fig. 3: Total elongation versus sample number

The shift in the absorption edge from UV to visible region could be attributed to an increase in conjugation length, there are shifting in (1-4) absorptions. The absorption of light energy by polymeric materials in UV and visible regions involves transition of electrons in n to *π orbital from ground state to higher energy states. This is because the absorption peaks for these transitions fall in an experimentally convenient region of the spectrum (330-800).

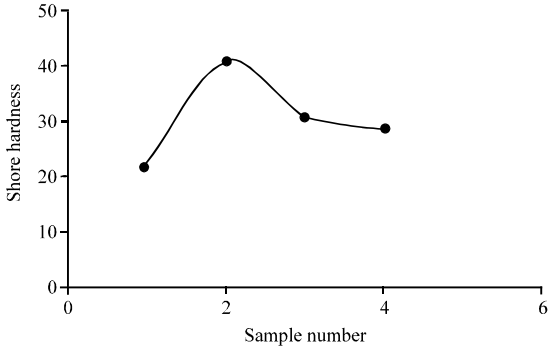


Fig. 4: hardness versus sample number

DSC: The amorphous structure decrease by adding mica because it is filling the spaces in the structure act as subtitutional filler between chains due to small average particle size and make Vander walls bonds with miscible epoxy/polyester blend. The glass transition temperature decrease by adding mica 339.88-464°C as shown in Fig. 5 and 6 when filler content 1% then decreased to 295.8°C due to amorphous structure increase by filler agglomeration.

Atomic force: Epoxy /polyester blends containing varying concentration of mica as shown in Fig. 8. The neat blend sample indicate brittle fracture surface due to miscibility characteristics of epoxy/polyester blend as shown in Fig. 8a. The brittle fracture become ductile by adding micas filler as shown in Fig. 8b. In Fig. 8c, the battle fracture disappeared as mica content increased. Ductile fractured surface observed h give indication about good adhesion and dispersion of nanoparticles that improved the mechanical properties. The samples have good roughness properties which make it suitable for frictional material product and automotive applications.

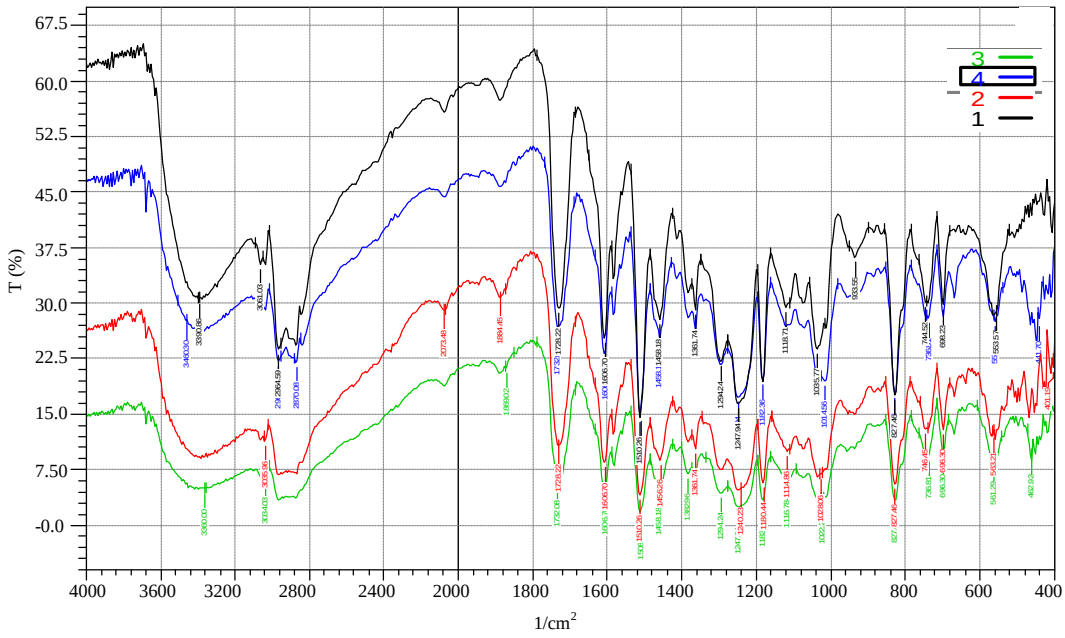


Fig. 5: Intensity verses wave number of the samples

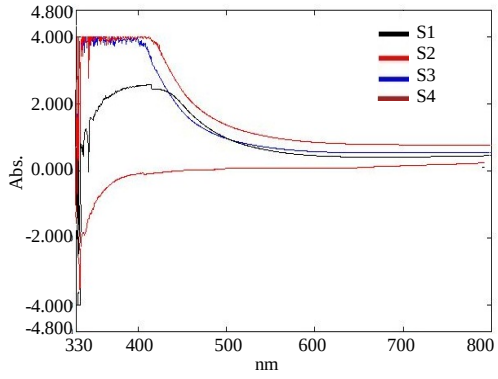


Fig. 6: UV absorption versus wave length

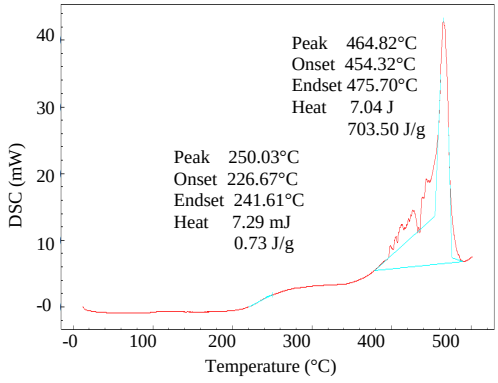


Fig. 8: DSC curve shows the test sample (1) where 1% mica

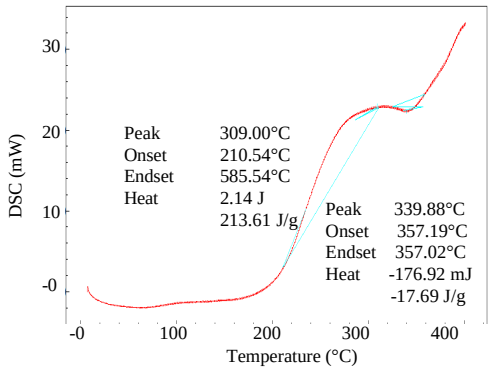


Fig. 7: DSC curve shows the test sample (1) where 0% mica

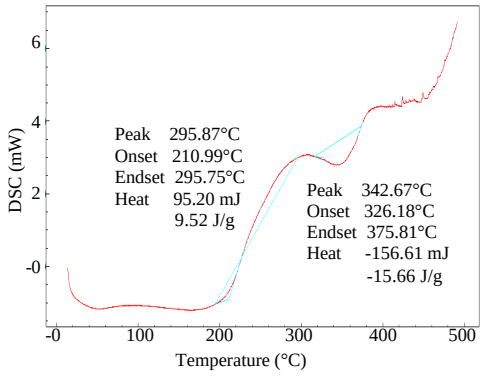


Fig. 9: DSC curve shows the test sample (1) where 2% mica

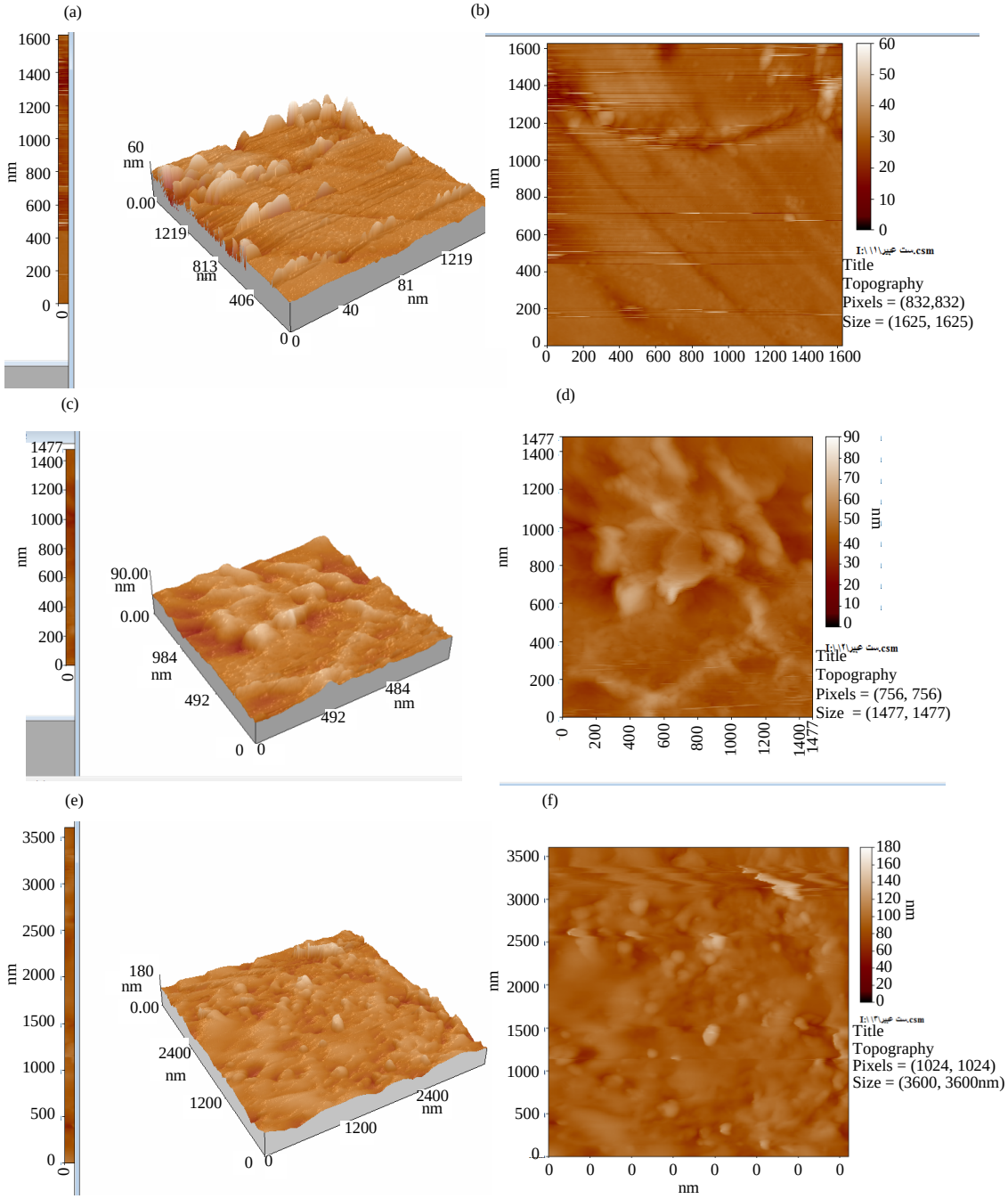


Fig. 10: a, b) Sample 1; c, d) Sample 2 and e, f) Sample 3

CONCLUSION

In this study, the mechanical, thermal and morphological properties of epoxy/polyester blend reinforced with mica clay were studied. The following conclusions can be drawn:

Mechanical properties were optimized at 1 wt.% clay content. When compared with neat blend samples, 2. Differential Scanning Calorimetry (DSC) results showed that the clay particles affected the glass transition Temperature (Tg) of the nanocomposites. DSC results also indicate that the blend is miscible.

Atomic force revealed that excellent adhesion and interfacing between the matrices and clay is the main reason for optimum improvement of properties. This

nanocomposite can be applied in making light weight components as automobile parts, transportation systems and consumer products.

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