MODIFICATION THE CHARACTERIZATION OF EPOXY POLYESTER BLEND BY USING TITANIUM DIOXIDE FILLER

Abeer adnan abd
Polymer Department, College of Engineering Materials, Babylon University, Iraq

ABSTRACT

Epoxy resin blended with Unsaturated polyester resin and filled with TiO₂ filler, ultrasonic mixing process. TiO₂ nanoparticles were used as reinforcement in prepared by cast molding method with filler volume fractions (0%, 1%, 2%, and 3%). The thermal conductivity constant, hardness, compression strength, wear, impact strength and DSC were studied. Compression strength, wear loss, thermal conductivity constant, DSC, FTIR, UV, atomic force were studied. The experimental results showed that the thermal conductivity constant decrease, hardness increase with filler content increase. Titanium dioxide content in epoxy/polyester blend matrix was dispersed and investigated by using ultrasonic technique. Sample four give the maximum value of compression strength. The glass transition temperature, melting point and degree of crystallization decrease by adding titanium dioxide.

Key words: Epoxy unsaturated polyester, TiO₂, nanofiller, Mechanical properties, thermal stability, polymer blend


http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=10&IType=3

1. INTRODUCTION

One of the ways Nano science has advanced Polymer composites industries of high-performance for automotive and aircraft applications serving many properties, such as tensile strength and modulus of elasticity, and thermal stability. With the advent and application of nanotechnology .[1,2]

Epoxy resin are the widely used materials as a matrix, disc brake, high performance adhesive joints, automobile industry, paints manufacturing, heat resistance coating [3]. It displays low reduction as well as its adhesion ability to a variety of substrate materials, high corrosion and chemical resistance [4].

Epoxy cured by adding hardener like ethylene triamine . [5,6]. The research works carried out to develop the thermal and mechanical properties of epoxy resin by blended with polyester and the use nanofillers reinforcement.[7,8] Between the most investigated metal-oxide, the
Titanium dioxide is possibly the most interesting because of the combination of its exceptional properties such as photo catalytic, low cost, non-toxicity and high chemical stability. Titanium dioxide industries such as aerospace, sports, paints due to high hardness and corrosion resistance and thermal stabilities and cosmetics (UV protection in sunscreens).[9,10]

Unsaturated polyester have higher impact resistance than epoxy, low cost, good service properties, thermal stability and weather resistance. Hence these resins are used in number of applications like insulation coatings, fiber reinforced plastics (FRP) products, bulk molding compounds, and frictional material matrix.[11,12,13]

The polymer blending reduce the cost-performance balance and tailoring, modifying resin’s performance, improving specific properties, toughness, solvent resistance.[14-16]

2. THE AIM OF THE WORK:
The main goal of the work was to investigate the blended matrix properties of miscible epoxy/polyester blends by adding TiO2 filler to enhance mechanical and thermal properties. For this purpose a blend of epoxy/polyester (85/15 %w/w) polymers were prepared as a function of nanocomposites in different weight ratios such as 0%, 1%, 2%, and 3%. The final objective of this study is to identify a suitable nanocomposites 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.

3. MATERIALS AND METHODS
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 titanium dioxide nanofiller with average particle size (D50:.507) µm.

4. FABRICATION OF BLENDED NANOCOMPOSITES:
Epoxy/polyester (i.e. 85/15 %w/w ratio) were mixed together by intensive mixer for about one hour 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.

Titanium dioxide was added to the blend at different weight ratios (0,1,2,3,4)% then ultrasonic assisted dispersion of titanium dioxide (TiO2) nanoparticles. The samples prepared by using glass mold. Glass mold covered with nylon adhering film to enable easy removal of the sample. The dimensions according to ASTM standard. Another cylindrical mold used to mold the compression samples. The nanocomposites blend was molded over the glass mold. Brush and roller was used to impregnate the nanocomposites to ensure complete curing the blended nanocomposites samples were post cured at 70°C for one hour.

5. RESULT AND DISCUSSION
Mechanical Properties
Hardness Tests
The hardness increases with Filler content increase as shown in figure (2). The filler (TiO2) has more hardness than polymer blend. The hardness increase because the density increased. Particles shape are irregular including pentagonal, rectangular shape and greater surface area, better aspect ratio , and higher loading therefore the surface area increase.
Wear Tests Results and Discussions

Figure (3) displays the wear lost as a function of the time with (4 N) load of specimen (1). The wear rate increase when the load capacity increase led to increase the temperature of the surface of the sample. When the wear time increased the friction force is increased. That’s led to convert the friction work to heat energy thus the wear lost increase due to fatigue cracks led to remove the thermoset material by brittle fracture. Epoxy materials gets removed in the form of fine wear debris caused by brittle fracture of the resin.
Figure 3 Represent weight loss versus time for sample two.

Figure (4) shows the wear loss of the blend of epoxy and polyester of sample (2). The wear lost increase with time and reach the steady state that is due to increase the ductility of material by adding polyester and the wear debris decrease.

Figure 4 Represent weight loss versus time for sample three.

Figure 5 Represent weight loss versus time for sample four.
Modification the Characterization of Epoxy Polyester Blend By Using Titanium Dioxide Filler

Figure 6: Represent weight loss versus time for sample five

Figure (5) shows the wear loss decrease by adding titanium dioxide at ratio (1%) of sample (3) because filler particles harder than matrix material also it was insulated nanoparticles diffuse the heat and decrease it, that’s decreasing the cracks initiate by increasing work temperature by wear (i.e. in brake disk matrix). In some application like disc brake the heat increase during working to reach by repeating car stops to 400°C that’s led to evaporate oxygen to form titanium oxide which dissipate the heat generated during friction. Its behave as lubricant at high temperature and the wear get more stable.

Figure (4) shows the wear loss of sample (4) greater than sample (3) because the agglomeration in nanoparticles. Figure (5) shows the wear loss of sample (5) smaller than sample (4).

Thermal conductivity

When adding the nanoparticle to the blend the thermal conductivity is reduced according to the increasing ratio of nanomaterial and it is concluded that the added nanoparticles have good insulating and thermal stability properties. When the heat increase during service conditions of frictional materials the samples cracks if the matrix brittle material like epoxy therefore titanium dioxide (TiO₂) is suitable insulated filler to dissipate the heat generated during friction.

Impact Test

Figure 7: Represent weight loss versus time for samples
Figure (7) shows the impact strength of the samples increase with filler content increase because titanium dioxide has greater hardness and durability and it has small average particle size (D50: 0.507). Also there is good compatibility between blended matrix and titanium dioxide.

**Compression strength**

The compression strength increase with filler content increase as shown in figure (8) because titanium dioxide represent hard nanofiller fill the space between chains and restrict the movement of chains and increase crosslinks between chains therefore the compression strength increase.

![Figure 8](image)

**Figure 8** Represent thermal conductivity versus filler content for samples

**Atomic force**

Epoxy/polyester blends containing varying concentration of TiO2 as shown in fig. (8). The neat blend sample indicate brittle fracture surface due to miscibility characteristics of epoxy/polyester blend. The brittle fracture become ductile by adding TiO2 filler as shown in fig.8 (1). In figure 9 (c) the brittle fracture disappeared as titanium dioxide content increased. Ductile fractured surface observed 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.

![Figure 9](image)

**Figure 9** Represent atomic force test

Sample a (1%TiO2)         Sample b (2%TiO2)         Sample c (3%TiO2)
Modification the Characterization of Epoxy Polyester Blend By Using Titanium Dioxide Filler

**Figure 9** Represent compression strength versus filler content for samples

*FTIR test*

Figure (10) represent absorbance versus wave number for the samples. FTIR showed that sample (1) figure (9) which contain epoxy without any additives. In sample (1) the bonds (C-H,C-C,O-H,C=C,C-C) stretched. FTIR showed that there is physical interaction between epoxy/polyester blend and titanium dioxide. There is intermolecular H- bonding by single bridge with wave number (3500-3550) cm$^{-1}$ represented by hydroxyl group. The absorbance of the ester group bonds and other bonds increased in the samples which contain TIO$_2$ and increased with filler content increase therefore the bonds be stronger and the insulation properties enhanced and the mechanical properties because there is good filler – matrix interaction and dispersion and the toughness enhanced.

**Figure 10** Represent Intensity Verses Wave Number of the samples
DSC test
The glass transition temperature in sample (1) which contain epoxy pure is 163.96 ºC and there is two TG (162.4ºC) and another (58.9ºC) when adding polyester. The structure be more homogenous by adding TiO₂ because the nanocomposite blend has one TG (135.19ºC). Titanium dioxide (TiO₂) filling the spaces in the structure act as reinforcing filler between chains due to small average particle size (D50 :0.507) and make Vander walls bonds with miscible epoxy/polyester blend. The glass transition temperature increase by adding titanium dioxide as shown in fig. (13,14,15).

Figure 11 Represent DSC test of the sample (1).

Figure 12 Represent DSC test of the sample (2).

Figure 13 Represent DSC test of the sample (3).
6. CONCLUSIONS

In the present study, the mechanical, thermal and morphological properties of epoxy / polyester blend reinforced with titanium dioxide were studied. The following conclusions can be found:

1. Mechanical properties were improved at 1 wt. % titanium dioxide content. When compared with neat blend samples.

2. Differential Scanning Calorimeter (DSC) results showed that the titanium dioxide particles affected the temperature of glass transition (Tg) of the nanocomposites. DSC results also indicate that the blend is miscible.

3. Atomic force revealed that excellent adhesion and interfacing between the matrices and clay is the main reason for optimum improvement of properties. Nanocomposite can be applied in making light weight components as automobile parts, transportation systems and consumer products.
REFERENCES


