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PHYSICO-CHEMICAL PERFORMANCE OF EPOXY RESIN/MODIFIED BENTONITE COMPOSITE

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ABSTRACT:

Physico-chemical performance of the prepared composite were tested to investigate Chemical resistance property, Water absorption property, and Flammability property test of the modified bentonite composite, the result of the study revealed that, the composite were resistant to most of the chemicals tested, with exception of chloroform, water absorption test revealed that, the composite absorbed 2.8% of the distilled water in 7 days due to the composite material had an exfoliated structure in which the modified layers of bentonite clay were completely separated and highly dispersed into the polymer matrix, while Flammability test reveal that the composite fell into the classification defined by the UL 94 HB showing much lower burning rate than the neat epoxy. Hence, the time required for burning the sample is drastically increased by the incorporation of modified

bentonite in the matrix may be due to an increased in the molecular interaction and compactness due to the organo-bentonite filled inside the matrix and higher rigidity there by making it harder and tougher to catch fire. Hence the composite were found to be good fire retardant.

KEYWORDS: *Physico-chemical*, *Chemical resistance property*, *Water absorption property*, *Flammability property*.

INTRODUCTION:

A Composite material is a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties. The two constituents are a reinforcement and a matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. The reinforcing phase provides the strength and stiffness. In most cases, the reinforcement is harder, stronger, and stiffer than the matrix. The reinforcement is usually a fibre or a particulate. Particulate composites are usually much less expensive and usually contain less reinforcement (up to 40 to 50 volume percent) due to processing difficulties and brittleness. Poly epoxides, are a class of reactive pre-polymers and polymers which contain epoxide groups. The epoxy resin is made of bisphenol (and there is more than one type) and epichlorohydrin. The most common type of bisphenol is a combination of acetone and phenol known as bisphenol A [1]. Epoxy resins may be cross-linked either with themselves through catalytic homopolymerisation, or with wide range of co-reactants including polyfunctional amines, acids (and acid anhydrides), phenols, alcohols, and thiols (usually called mercaptans). These co-reactants are often referred to as hardeners or curatives and the cross linking reaction is commonly referred as curing [2].

METHODS:

Purification of raw bentonite clay

This was carried out according to the method reported by [3], 20g of the powdered raw bentonite was weighed and dispersed into 60ml of de-ionized water. 0.2g of sodium hexametaphosphate ($Na(PO_3)_6$) was weighed and dispersed inside the bentonite solution and stirred magnetically for 2hrs. The dispersion was separated by centrifugation at 4500 rpm for 2 min followed by drying the solid at 60 ^oC in an oven. Then the FT-IR of the purified bentonite was conducted.

Modification of purified bentonite clay

This was carried out according to the method reported by [4], 20g of the purified bentonite was weighed and dispersed into 60ml of distilled water and stirred magnetically at a temperature of 60 ^{o}C for 30 min. 0.05g of tetra phenyl phosphonium bromide (TPPB) surfactant was weighed and mixed with 15ml of 0.05M hydrochloride acid (HCl) solution and then poured into the hot bentonite–water mixture and stirred at a temperature of 60 ^{o}C for 60 min. The mixture was then filtered and washed with distilled water until no bromide was detected using a drop by drop of 1.0M silver nitrate ($AgNO_3$) solution. Then the organo-bentonite was obtained after drying it at 60 ^{o}C in a vacuum oven for 60 min. Then the FT-IR analysis and the scanning electron microscopy (SEM) analysis of the modified organo-bentonite was conducted.

Preparation of epoxy resin/modified bentonite composite

This was carried out according to the method reported by [5], 100ml of DGEBA epoxy resin (1.15 gcm^{-1} density) was mixed with 8.2g of the modified bentonite Clay (organophilic clay). The organo-bentonite was dispersed uniformly into the epoxy matrix at 50 ^{o}C and 200rpm for 1 hour. Then 50ml of the amine curing agent (triethylene tetramine hardener of 0.98gcm^{-1} density) was added to the epoxy /modified bentonite hybrid system and mixed thoroughly by stirring. The mixture was then poured to the hand lay-up mold cavity and placed in an oven at 110 ^{o}C, maintained for a period of 7 hours, and post cured at 160 ^{o}C for 2hours.

Chemical resistance property test

The chemical resistance of the composites samples was studied using the ASTM D543-87. The effects of two polar solvents, i.e. ethanol and acetone, and two non-polar solvents, i.e. chloroform and n-Hexane, the effect of dil. hydrochloric acid (1M) and the effect of dil. sodium hydroxide (1M) were studied on the prepared composite. In each case, pre-weighed samples were immersed in the respective chemical reagents for 7 days. They were then removed and immediately washed with distilled water and dried by pressing their both sides with filter paper at 25 ^{o}C. The samples were then weighed, and the loss/gain was determined using equation (ii).

$$\text{Chemical resistance (\%)} = \frac{W_i - W_o}{W_o} \times 100 \quad \text{.....(ii)}$$

where, W_i is the weight of composites samples after immersion and W_o is the weight of composites samples before immersion [6].

Tensile strength test

The tensile strength of the epoxy resin/modified bentonite composites as well as that of the cured neat epoxy resin was determined with a Shimadzu standard universal testing machine with

a cross head speed of 20mm/min (MODEL AG-1) with 100kN capacity at strain rate of $1.6 \times 10^{-2}s^{-1}$ and the span-to-depth ratio of 9 at Mechanical Engineering Department Bayero University Kano Nigeria, in accordance with an ASTM D-638-91 standard. This test method covers the determination of the tensile properties of reinforced plastics in the form of standard dumb bell-shaped test specimen with 125x21mm sized dimension and thickness of 6.4, tested under defined conditions of pretreatment, temperature, humidity and testing machine speed. The Tensile strength was calculated using equation (iii).

$$\frac{L \times 10^{3}N}{Area} \quad \text{.....(iii)}$$

where, L is the average calculated Force and Deformation at Break from the machine, N is Newton, Area is breadth x thickness of the specimen (Thind *et al*., 2015)

RESULT S:

Chemical resistance property test

The results of chemical resistance property tests carried out on the composite samples using various chemicals was shown in Table 1.

Table 1: Chemical resistance property test

Chemical	Mass (g)		Thickness (cm)		Length (cm)		% Chemical absorption	% chemical resistance
	Before test	After test	Before test	After test	Before test	After test		
Dil.HCl (1M)	1.70	1.80	0.70	0.70	1.60	1.60	5.50	94.50
Dil.NaOH (1M)	1.70	1.80	0.70	0.70	1.60	1.60	5.50	94.50
Chloroform	2.00	1.90	0.70	-	1.90	-	94.50	5.50
n-Hexane	1.30	1.30	0.50	0.50	2.00	2.00	0.00	100
Ethanol	1.20	1.30	0.60	0.60	1.70	1.70	5.50	94.50
Acetone	1.60	1.70	0.60	0.60	2.80	2.90	5.50	94.50

Water absorption property test

Mass (g)		Thickness (cm)		Length (cm)		% water absorbed
Before test	After test	Before test	After test	Before test	After test	
2.30	2.40	0.50	0.60	2.80	2.90	2.80

Flammability property test

The results of flammability tests carried out in horizontal (UL 94 HB) mode is shown in Table 2.

Table 2. Flammability property test

Burning mass (g)			Maximum time taken (s)		Maximum length of composite burnt (mm)	Rating
Before	After	Loss	Before it catches with fire	To stop catching with fire		
5.90	5.60	0.30	4	6	5	HB

DISCUSSION:

The results of chemical resistance property tests carried out on the composite samples using various chemicals was shown in Table 1. The results revealed that, the composite is resistant to most of the chemicals tested but, with exception of chloroform where it became disintegrated due to the fact that, the cross-linked polymers are easily attracted by chlorinated hydrocarbons indicating that the composites were swollen with the gel formation rather than dissolving in chemical reagents. Finally, it can be suggested that these composites have resistance to all chemicals used. This is due to the addition of the modified bentonite clay which increases the inter-facial adhesion with the polymer matrix. This results agreed with the findings of Hossen *et al* (2016) on effect of clay content on the morphological , thermo-mechanical and chemical resistance properties of propionic anhydride treated jute fibre/polyethylene/clay composites where they reported that, the effect of solvents (benzene, toluene, chloroform) ; acids (hydrochloric acid, nitric acid, and acetic acid) and alkalis (sodium hydroxide, sodium carbonate

and ammonium hydroxide) on raw and treated jute with and without clay were studied and revealed that, the percentage of weight gain/loss for the manufactured composites immersed in solvents, acids, and alkalis. It was clearly observed that weight gain was observed for almost all the chemical reagents except carbon tetrachloride. It has been reported that the composites have weight loss in carbon tetrachloride, because the cross-linked polymers are easily attracted by chlorinated hydrocarbons. The positive values indicate that the composites were swollen with the gel formation rather than dissolving in chemical reagents. Finally, it can be suggested that these composites have resistance to all chemicals used. This is due to the addition of clay increases the inter-facial adhesion between treated fibre and the polymer matrix.

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