Studies on Spectral, Thermal, Morphological and Tribological Behaviour of Bentonite/Montmorillonite Based Polyester Nanocomposites

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Abstract: **Polymer/clay composites have received much attention worldwide. General purpose unsaturated polyester/clay (Montmorillonite, Bentonite) composites were prepared with clay distribution of 5, 10, 20, 30, 40 wt%. Casting technique was adopted to fabricate the composites. 1 ml of 1 wt% of Cobalt Napthanate (accelerator) and 1 ml of 1 wt% of Methyl ethyl ketone peroxide (MEKP) catalyst were added during fabrication of sheets. 30 wt% of clay distribution into polymer matrix exhibits improved hardness and the same produces higher electrical resistivity compare to neat and other compositions. Non- destructive tests (NDT) were also carried out for various samples. The result of NDT reveals smooth distribution of the clay in the polyester matrix. The coefficient of friction and wear loss increases the specific wear rate of polyester was 2.495 x 10-4 mm3/Nm. The specific wear rate of composites decreases by the addition of clay. Further, it decreases to 2.0496 x 10-4 mm3/Nm and 0.080 x 10-4 mm3/Nm for clay content of 20wt% and 10wt% respectively.**

Keywords: Casting; Wear rate; Coefficient of friction- tribological properties

I.   INTRODUCTION

Nanotechnology is a field of applied science and technology covering a broad range of topics. The main unifying theme is the control of matter on a scale smaller than 100 nanometers, as well as the fabrication of devices on this same length scale. It is a highly multidisciplinary field, drawing from fields such as colloidal science, device physics, and supramolecular chemistry. Much speculation exists as to what new science and technology might result from these lines of research. Some view nanotechnology as a marketing term that describes pre-existing lines of research applied to the sub-micron size scale.[1]. In solution blending, a solvent or solvent mixture is use to disperse the nanoparticles and dissolved the polymer matrix. depending on the interaction of the solvent and nanoparticles, the nanoparticle aggregates can be disintegrated in a good solvent due to the weak van der Waals force that stacks the layers together polymer chains can then absorbed on to the nanoparticle . However, upon solvent removal, the nanoparticles tend to re-agglomerate. Few exfoliated nanocomposites were prepared via this method. Another disadvantage of this method is the large amount of solvent needed, resulting in a high product cost. The types of polymers that can be used to synthesis nanocomposites ultimately depend on the selection of proper solvent, limiting the applicability of this method [2]. Nevertheless, this is an attractive route to prepare nanocomposites based on water soluble polymer and layered silicate nanocomposites because most water soluble polymers are polar and hydrophilic enough interact with the silicate surface without the need of cation exchange modification the silicate surface. It is well known that inorganic layered silicates are able to exfoliate in water and form colloidal particles [3]. For most thermoset polymer, in situ polymerization it is the only viable method to prepare nanocomposites. By tailoring the interactions between the monomer, surfactant, and on the clay surface, exfoliated nanocomposites (e.g., nylon6, poly (e-caprolactone), epoxy and polycarbonate) have been successfully synthesized via the ring-opening polymerization [4-5]. The functional group in the organic cation can catalyze the intralayer polymerization and facilitate layer separation. Based on the careful analysis of literature, the present investigation aimed to compare the tribological behavior of bentonite or MMT/ polyester nano composite.

II.   Experimental

a.   Preparation of polyester sheets:

The cleaning of the mold at every trail was necessary so as to remove any present polyvinyl alcohol (PVA) coating and atmospheric impurities from the previous trial. The cleaning involved washing with acetone

followed by washing with water, scraping any existing PVA coating or polyester left behind and finally rinsing with water again and then allowing the inner surfaces to dry. The preparation of the PVA coating involved the boiling of 100 ml of water to 1000c and adding 3 grams of the polyvinyl powder to it while continuously stirring the mixture. The solution is then allowed to cool to room temperature. On cooling a sticky viscous liquid is obtained which is uniformly applied to the inner iron surfaces. This PVA coating acts as a film separating the iron surface from the polyester dispersant. The PVA coating is allowed to dry completely before the mold is tightly sealed shut. The polymer solution prepared is then poured in to the mold slowly so as to avoid any spillage .The solution is then allowed to cure in the mold for 24 hours .After the stipulated curing time the mold is taken apart and the polyester sheet is carefully removed from the mid-section. At every trial of the process 210 ml of polyester was optimally required to fill the mold to its capacity. In addition to this 2 ml of cobalt napthanate and 2 ml of methyl ethyl ketone peroxide were used as hardener and accelerating agent respectively. To the 210 ml of polyester the 2 ml of cobalt napthanate was added initially and stirred until the purple colour of the hardener was completely dispersed in the polyester solution. At such time the 2 ml of methyl ethyl ketone peroxide was added and stirred thoroughly following which the solution was immediately poured in to the mold. Similar procedure was adopted with calculated quantity of bentonite or MMT with polyester based nano composite sheets (Table. 1). Four trials were carried to optimize the polyester sheet fabrication until a uniform, homogenous sheet was obtained.

III. Results and Discussion

a.   XRD Analysis of Clays

XRD pattern of the both BEN & MMT are shown in the Figure 1 & 2. The strong and sharp peaks of samples indicate that it has good crystalline state. The broadening of peaks predominantly attributes to the decrease in the crystalline size. The calculated mean crystallite sizes were in the range of 40-65nm and 80-98nm for BEN and MMT respectively (Figure 1 & 2).
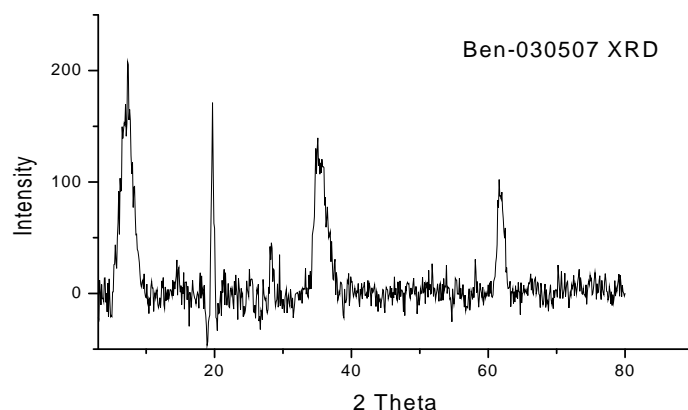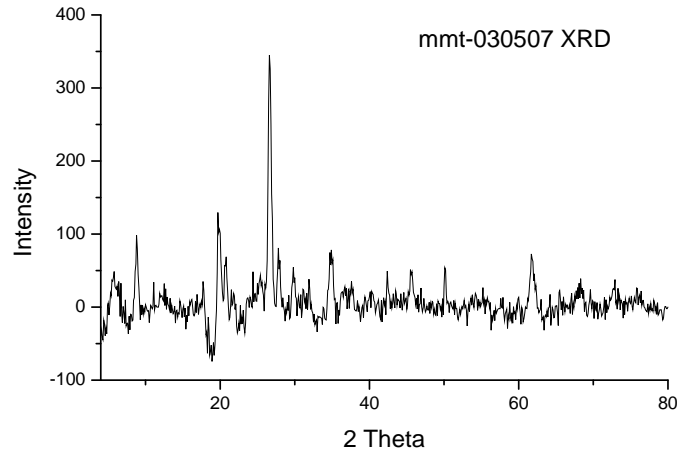

Figure 1 XRD pattern for BEN Clay

Figure 2 XRD pattern for MMT Clay

b. FT-IR Studies

FT-IR analysis was performed on Nicolet Avatar 330 Spectrometer with KBr pellets for solid specimens FT-IR spectra of 100% polyester, which exhibits characteristic strong absorption peaks at 2925 cm^{-1}, 1728 cm^{-1} 3435 cm^{-1} due to aliphatic C-H, C=O and O-H Stretching's respectively. FT-IR spectra of 5, 10, 20, 30 and 40 wt% of BEN and MMT clay filled composites and it shows peak such as terminal O-H group, aliphatic C-H and Carbonyl group around 3430, 2925, 1728 cm^{-1} respectively. The peak at 465-470cm^{-1} corresponds to Si-O-Si peaks revealed that clay was dispersed in polymer matrix.

c. *Tribological properties*

The wear rate of the GPR/BEN clay composites was decreased due to addition of nano sized clay. The specific wear rate was low for BEN clay content of 10 wt. % (0.080 x 10^{-4} mm^3/Nm) remaining values were given in Table 2. Where, the specific wear rate maximum is 2.495 x 10^{-4} mm^3/Nm for neat polyester sheet. The co-efficient of friction of nanocomposites was studied with respect to clay content. Co-efficient of friction (COF) for GPR/BEN (10 wt. %) clay filled composites was 0.4435 where as 100% GPR composite is 0.565. COF increases on the addition of bentonite clay were shown in Table. 3.

Table 1 Compositions of polyester/clay composites

S.No	GPR %	Clay %	
		BEN	**MMT**
1	100	0	0
2	95	5	5
3	90	10	10
4	80	20	20
5	70	30	30
6	60	40	40

Table 2 Mechanical properties – Polyester/BEN clay nanocomposites

S.No	Composition	Percentage	Hardness (R scale)	Tribological Property	
				Wear rate (10^{-4} mm^3/Nm	**Coefficient of Friction**
1	GPR	100	10.6	2.4952	0.5651
2	GPR : BEN	95 : 5	14.0	0.5346	0.4435

3	GPR : BEN	90 : 10	19.8	0.0801	0.7292
4	GPR : BEN	80 : 20	94.0	2.0496	0.7380
5	GPR : BEN	70 : 30	95.1	0.8832	0.7515
6	GPR : BEN	60 : 40	81.0	1.3367	0.6005

Table 3 Mechanical properties – Polyester/ MMT clay nanocomposites

S.No	Composition	Percentage	Hardness (R scale)	Tribological Property	
				Wear rate (10^{-4} mm^3/Nm)	Coefficient of Friction
1	GPR	100	10.6	2.4952	0.5651
2	GPR : MMT	95 : 5	20.6	0.5346	0.3703
3	GPR : MMT	90 : 10	30.0	0.3564	0.8384
4	GPR : MMT	80 : 20	13.6	1.1585	0.2698
5	GPR : MMT	70 : 30	96.3	0.2673	0.6568
6	GPR : MMT	60 : 40	91.0	1.1585	0.8606

IV. Conclusions

- General purpose unsaturated polyester/clay (Montmorillonite, Bentonite) nanocomposites were prepared with clay distribution of 5, 10, 20, 30, 40 wt%.

- GPR/Bentonite nanocomposites of 30 wt% of clay distribution into polymer matrix exhibits improved hardness 95.1 (R scale), Wear Rate (0.8832 x 10^{-4} mm^3/Nm), Coefficient of Friction (0.7515) and the same produces higher electrical resistivity compare to neat and other compositions.

- GPR/ MMT nanocomposites of 30 wt% of clay distribution into polymer matrix exhibits improved hardness 96.3 (R scale), Wear Rate (0.2673 x 10^{-4} mm^3/Nm), Coefficient of Friction (0.6568) and the same produces higher electrical resistivity compare to neat and other compositions.

- Comparison between GPR/BEN ad GPR/MMT nanocomposites, GPR/MMT nanocomposites are best in overall characterization.

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