MECHANICAL ANALYSIS OF NANO MMT CLAY BASED POLYMER COMPOSITES

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Abstract - *Polymer nanocomposites are attracting considerable interest in polymer science due to their superior properties in comparison to the composites with conventional fillers. In this paper the nanocomposite are prepared by extruding Glass reinforced Polyamide 66 with Montmorillonite clay (organically modified, layered silicate) nano clay in a Twin screw extruder. Specimens are prepared according to ASTM D638 standards by injection moulding and then tested for their mechanical behaviour. Results are interpreted and compared. The tensile test showed that the tensile strength of polymer hybrid nanocomposite increased as the clay concentration increased up to 1% later with the addition of clay the strength is decreased. There was 19.5% increase in tensile strength for 1% sample, 7.83% decrease in tensile strength for 3% sample and 20.52% decrease for 5 % sample with respect to 0% sample. Tensile modulus increased as clay concentration increased up to 1% later with the addition of clay the tensile modulus is decreased. There was 31.44% increase in tensile modulus for 1% sample , 9.43% increase in 3% sample, and 3.68 % increase in 5% sample with respect to 0% sample. Modulus of toughness is increased as the clay concentration increased up to 1% later with the addition of clay the Modulus of toughness is decreased. There was 2.95% increase for 1% sample, 32.69% decrease for 3% sample and 47.48% decrease for 5 % sample with respect to 0% sample. So, nanocomposites with 1% weight ratio provides additional enhancement in properties compared to conventional polymer(0%) and other proportional composites(3%,5%)studies.*

Key Words: *Nano-clay crystal, mechanical properties, organophilic clay, PA66/clay nanocomposites, Marine Structures etc* ---

1. INTRODUCTION

Polymer/clay nanocomposites bring many superior advances in material engineering due to the low filler loadings of clay. These nano composites have been receiving an increasing amount of attention in several areas, such as manufacturing and universities. In recent years, organic-inorganic nanometer composites have attracted great interest from researchers since they frequently exhibit unexpected hybrid properties synergistically derived from two components. One of the most promising composites systems would be hybrids based on organic polymers and inorganic clay minerals consisting of layered structure, which belong to the general family of 2:1 layered silicates. [1] Compared to their micro- and macro counterparts and the pristine polymer matrix, polymer/ clay nanocomposites (PCN) exhibit improved tensile strength and moduli, [2-5] decreased thermal expansion coefficients,[2] decreased gas permeability, [2-5]increased swelling resistance, [6] enhanced ion conductivity, [7-9] flammability[10, 11] and so on. Presumably the enhanced properties of PCN are due to the formed nanoscale structure, the large aspect ratio and large surface area of the layered silicates, and the strong interaction between polymer molecular chains and layered silicate.

PCN have been prepared in three different ways: solution intercalation, in-situ polymerization, or direct melt intercalation. The first two approaches are limited because neither a suitable monomer nor a compatible polymer-silicate solvent system is always available. Moreover, they are not always compatible with current polymer processing techniques. These disadvantages drive the researchers to the direct melt intercalation method. Among all the methods to prepare PCN, the approach based on direct melt intercalation is perhaps the most versatile and environmentally benign.

This paper analyzes how the ordinary MMT clay is converted to nano MMT clay and from the obtained nano clay polyamide66/MMT nanocomposites are prepared via melt intercalaltion and then it is investigated for mechanical properties which plays a prominent role in marine structures.

2. EXPERIMENTAL

MATERIALS

PA66 (glass filled 33%) pallets, organically modified montmorillonite clay (organoclay), toluene gr grade.

Initially mmt clay from river bed is taken and undergone ordinary ball milling operation for about 6hrs. Later seewe the ball milled clay using BS 12 sheet in order to have the clay size around 70 microns. For converting the micro sized clay into nano size, high energy ball milling operation has to be performed in retsh machine for about 30 hrs. later perform xrd test inroder to know the particle size.

CHARACTERISATION OF NANOCOMPOSITES

The mmt nano clay is analyzed by using a Rigaku D/MAX 2200/PC X-ray diffractometer instrument that employed K-α radiation (λ = 1.54060 A°) and performed at 0 to 90°. The scanning rate of the instrument was 2° /minute.

FABRICATION OF PA66/CLAY NANOCOMPOSITES (PA66CN)

Commercially available pure PA66 pellets and organically modified montmorillonite clay (organoclay) were dried in an oven for 6 h at 80°C, and was melt compounded in a co-rotating twin screw extruder with L/D ratio of 48. Four types of nanocomposites PA66 with 0% organoclay by weight (PA66), 1% organoclay by weight (PA66CN1), 3% organoclay by weight (PA66CN3) and 5% organoclay by weight (PA66CN5) were prepared. The extruder was operated at a screw speed of 150 rpm and temperature set for six heating zones of screw extruder from hopper to die were 260, 265, 270, 275, 280 and 285°C, respectively. After extrusion, the pellets were dried in a vacuum oven for 6 h at 80°C. The dried pellets were injection molded into standard tensile specimens (ASTM D638, Type V). The pressure and temperature used for injection molding were 12.5 MPa and 280°C, respectively.

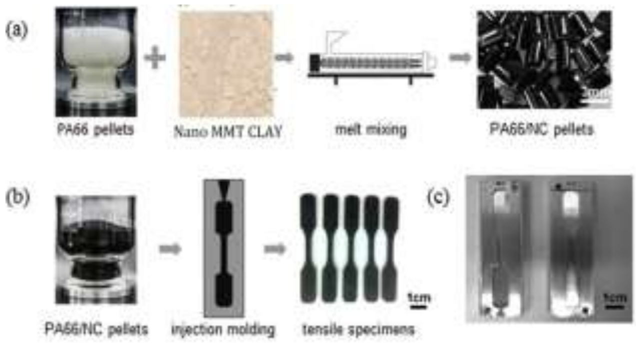

Fig2.1: Polymer Nanocomposites Processing Layout

3. RESULTS AND DISCUSSION

CHARACTERIZATION OF THE NANO MMT CLAY

The ordinary ball milled MMT clay is undergone high energy ball milling operation by varying its operational hours such as 5hrs, 10hrs, 15hrs, 20hrs. After finishing high energy ball milling in order to know the particle size perform XRD test.

Sample1: High ball milled clay for 5hrs

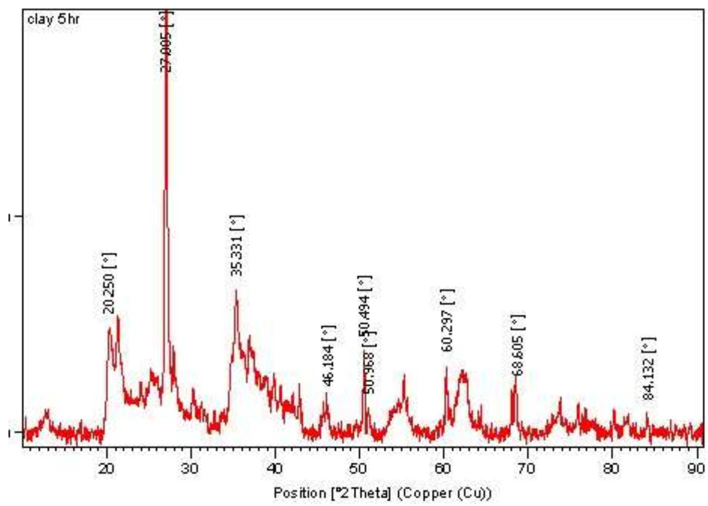

Fig3.1: xrd analysis for 5hrs high ball milled clay sample

Figure3.1 shows the XRD pattern for mmt clay that has been undergone high energy bill operation for about 5hrs.with the help of scherrer formula the particle size is found and it is around 32.4524nm.

Sample2: High ball milled clay for 10hrs

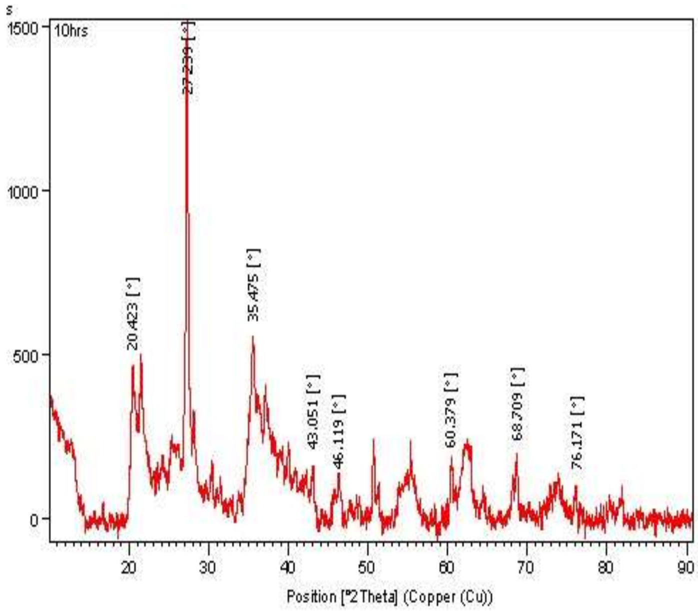

Fig3.2: xrd analysis for 10hrs high ball milled clay sample

Figure3.2 shows the XRD pattern for mmt clay that has been undergone high energy bill operation for about 10hrs.with the help of scherrer formula the particle size is found and it is around 24.33nm.

Sample3: High Ball Milled Clay For 15hrs

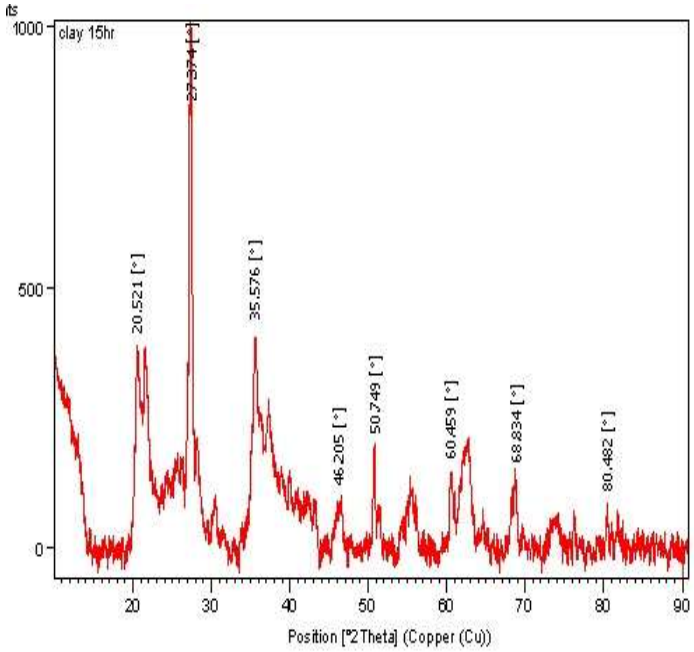

Fig3.3: xrd analysis for 15hrs high ball milled clay sample

Figure3.3 shows the XRD pattern for mmt clay that has been undergone high energy bill operation for about 15hrs.with the help of scherrer formula the particle size is found and it is around 17.70nm.

Sample4: High ball milled clay for 20hrs

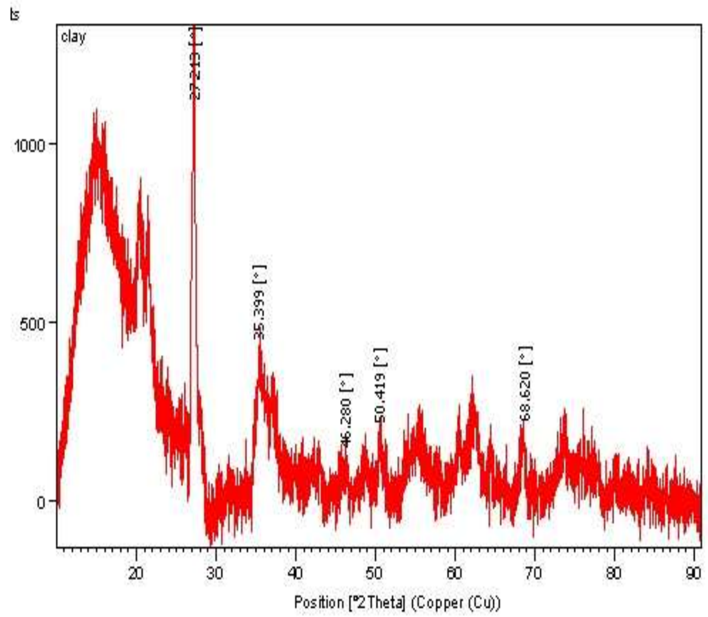

Fig3.4: xrd analysis for 20hrs high ball milled clay sample

Figure3.4 shows the XRD pattern for mmt clay that has been undergone high energy bill operation for about 20hrs.with the help of scherrer formula the particle size is found and it is around 16.22nm.

From the above xrd results 20 hrs clay sample has least particle size so, it is used for fabrication of polymer nanocomposites.

MECHANICAL ANALYSIS

Figure3.5 shows the engineering stress vs strains curve for pa66.

PA66CN0%

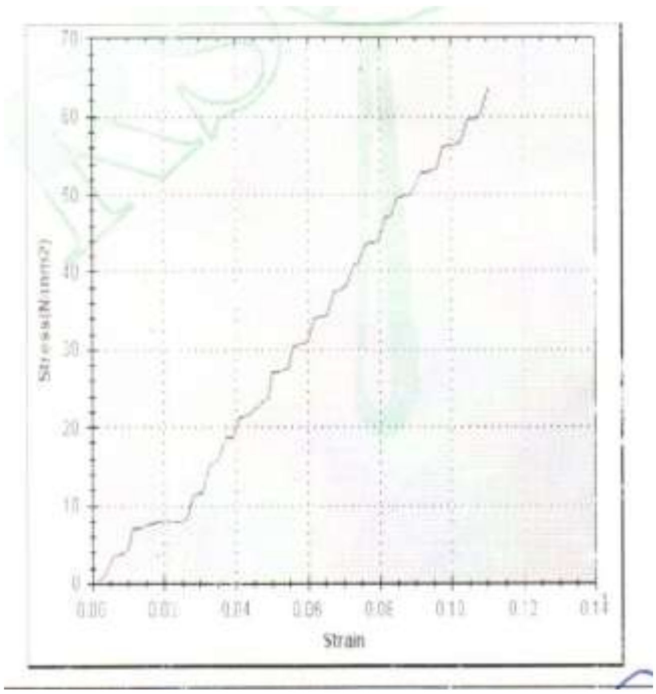

Fig 3.5 stress vs strain for PA66CN0%

THE TENSILE STRENGTH

Figure3.6 shows that the tensile strength of polymer hybrid nanocomposite increased as the clay concentration increased up to 1% later with the addition of clay the strength is decreased. There was 19.5% increase in tensile strength for 1% sample, 7.83% decrease in tensile strength for 3% sample and 20.52% decrease for 5 % sample with respect to 0% sample.

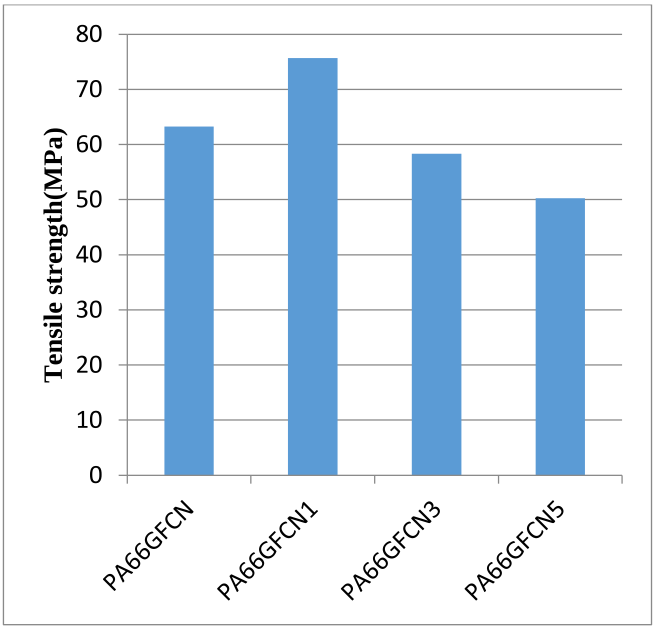

FIG3.6 Tensile strength of polymer nanocomposites

TENSILE MODULUS

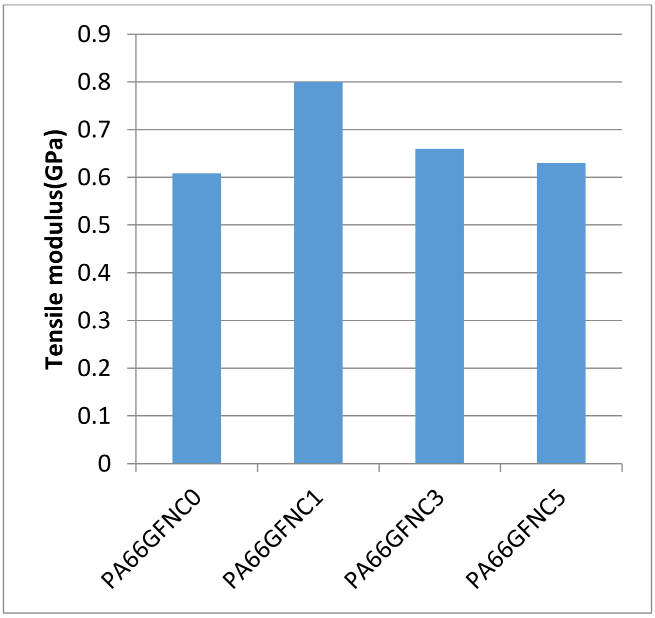

Fig3.7: Tensile modulus of polymer nanocomposites

Figure3.7 shows that Tensile modulus increased as clay concentration increased up to 1% later with the addition of clay the tensile modulus is decreased. There was 31.44% increase in tensile modulus for 1% sample, 9.43% increase in 3% sample, and 3.68 % increase in 5% sample with respect to 0% sample.

IMPACT STRENGTH

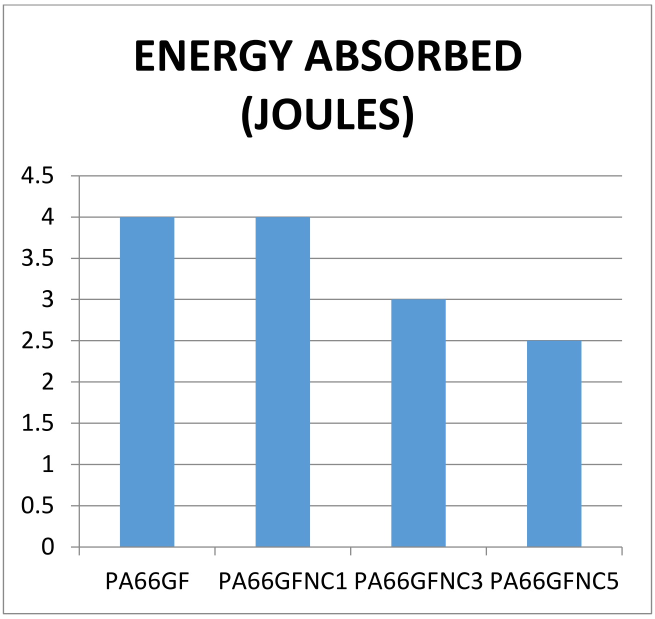

Fig3.8 Energy absorbed by the polymer nanocomposites

Figure3.8 shows that energy absorbed by conventional polymer pa66 and pa66cn1 are nearly equal. Whereas there is 25% decrease in energy absorbed for pa66cn3 and 37.5% decrease in energy absorbed for pa66cn5 with respect to pa66.

4. CONCLUSIONS

The polymer hybrid nanocomposites (PA66GF with Montmorillonite nanoclay) are prepared in a twin screw extruder. Four batches of 0%, 1%, 3%, 5 % nanoclay by weight were prepared. Specimens for tensile test were prepared acccording to ASTM D638 standards by injection moulding.

The tensile test showed that the tensile strength of polymer hybrid nanocomposite increased as the clay concentration increased up to 1% later with the addition of clay the strength is decreased. There was 19.5% increase in tensile strength for 1% sample, 7.83% decrease in tensile strength for 3% sample and 20.52% decrease for 5 % sample with respect to 0% sample.

Tensile modulus increased as clay concentration increased up to 1% later with the addition of clay the tensile modulus is decreased. There was 31.44% increase in tensile modulus for 1% sample, 9.43% increase in 3% sample, and 3.68 % increase in 5% sample with respect to 0% sample.

Impact strength remains nearly equal as clay concentration increased up to 1% later with the addition of clay the Impact strength is decreased. There was 25% decrease Impact strength for 3% sample, 37.5% increase in 5% sample with respect to 0% sample.

From the above it is observed that the polymer nanocomposites with 1% weight ratio provides additional enhancement in mechanical properties compared to conventional polymer(0%) and other proportional composites(3%,5%).

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