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INVESTIGATION ON MECHANICAL PROPERTIES OF UNSATURATED POLYESTER REINFORCED BY NANOCLAY AND DIFFERENT GLASS FIBERS COMPOSITES

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ABSTRACT

This study covers an investigation on the mechanical properties of unsaturated polyester (UPE) reinforced by nanoclay particles and different glass fiber fabrics. Four different composites i.e., chopped glass fiber reinforced UPE without and with 3 % nanoclay (C- GRP and C-GRP/3NC); and woven 0°/90° glass fiber plies toughened UPE without and with 3 % nanoclay (W- GRP and W-GRP/3NC) have been prepared by a conventional hand-lay method. The experimental results of tensile strength, bending strength and impact strength of pure UPE and the composites revealed that the existence of nanoclay particles improved the interfacial adhesion between glass fibers and the matrix, and resulting in a notable increase in all mechanical properties of the composites filled with nanoclay. The composites reinforced by woven fibers and filled by nanoclay had the highest mechanical properties compared to the pure UPE matrix

KEYWORDS: UPE, fiberglass, chopped, 0/90, nanoclay .

INTRODUCTION

Reinforced composite materials with fiber glass became very significant not only in composite material's world in aerospace construction because of its light weight, but also in marines, railways, steel construction, vehicles and more different fields. That is related to its specific strength and specific hardness for materials reinforced by fiber glass [1].

The fiber glass is material used for reinforcing the polymers .These material basically are made of cord glass have diameters ranging from 3-19 µm. the fiber glass give good performance and playing major role in enhancing the materials properties added to them. The reinforced materials can be used in sport equipment and so many leisure facilities. Also it is widely used in all types of pipes and many industrial application .It is considered to be economical comparing to carbon reinforced materials [2].

Polystyrene is one of these materials which can be reinforced by fiber glass for advanced applications in composite materials. That due to it is low cost and easy handling and gives robust anticorrosion and flame retardant product [1].

Tiago, João, Luís, Raul, and Paulo [3], study the effect of fiber glass as reinforced materials for polyester to improve a composite material based of natural fibers for the interior of dividing walls, which it improve the tensil strength and given 12% more flexural stress.

Estabraq [4], the researcher study the effect of chopped and 0/90 fiber glass composted with unsaturated polyester resin on flexure properties which found the reinforced polyester with fiber glass behave differ from pure unsaturated polyester, In all samples the matrix cracking occur in the lower face of the specimen followed by fiber fracture due to the bending stress.

Nano clay material have recently met great intention as materials used for reinforcing the polymers as it supposed to be having high aspect ratio with unique behavior. Adding a small amount of Nano clay the polystyrene (base materials) reveals extraordinary result like reducing gas permeability and enhancing solvent resistance. High mechanical specification and temperature control and enhanced flame retardant can be result in [1].

Kusmono and Zainal ArifinMohd Ishak [2] study the effect of addition of clay on unsaturated polyester reinforced with fiber glass on the mechanical structure properties XRD results showed that the exfoliated structure was found in 2 wt% of clay while the intercalated structure was obtained in 6 wt% of clay. The tensile strength, flexural strength, and flexural modulus of the composites were increased in the presence of clay. The optimum loading of clay in the UP/glass fiber composites was attained at 2wt%, where the improvement in tensile strength, flexural strength, and flexural modulus was approximately 13, 21, and 11%, respectively. On the other hand, the highest values in impact toughness and fracture toughness were observed in the composites with 4wt% of clay.

Shoumya Nandy Shuvo, , Kazi Md. Shorowordi and and Md. Aminul Islam [5] focus on investigate the effect of nanoclay on the mechanical and thermal properties of jute fiber reinforced polyester composite. found that modulus and strength of nanoclay reinforced polyester nanocomposite is higher than that of pure polyester, jute fiber reinforced polyester composite and nanoclay reinforced jute fiber composites.

NRR. Anbusagar, and P.K. Giridharan [6] study the effect of nanoclay content on the impact properties of glass fiber reinforced, polyester sandwich composite laminates and showed that the impact strength is greatly increased, over the range of nanoclay loading.

This research focused on reinforced the unsaturated poly-ester with fiberglass and nanclay particles. Using different types of fiberglass and study the diversity effect of different type of fiberglass with and without nanoclay particles on the mechanical properties for unsaturated poly-ester thermosetting polymer type.

MATERIALS AND METHODS

Materials used

In this investigation unsaturated poly-ester (UPE) in liquid form hardened by additives methyl-ethyl-ketone-peroxide (MEKP), 2% harden for each 100gm used at room temperature. Two types of fiberglass (chopped and 0/90) used to reinforce UPE only, and then nanoclay used with fiberglass to reinforce UPE. Aspect ratio for nanoclay loading was 3%W.

(a) ***(b)***

Figure (1): materials used (a) 0/90 fiberglass (b) chopped fiberglass

Sample preparation

Ply wood mold (150*150 mm) and hand lay-up manufacturing techniques (HL) was used to prepare the samples, five layers of fiberglass was used to make the sample The produced composites were then cut into the proper geometry of specimens according to ASTMD638 type I for tensile, ASTMD790 for flexural and ASTMD 5942-96 for un-notched impact standards . These types of samples prepared with thickness of (3 ± 0.2 mm) for the following category depending on type of reinforcement:

1- Pure unsaturated poly-ester with 2% methyl-ethyl-ketone-peroxide (MEKP) as a hardener

2- Unsaturated poly-ester with 2% methyl-ethyl-ketone-peroxide (MEKP) as a hardener reinforced with five layers chopped fiberglass.

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Figure (2): UPE reinforced with chopped fiberglass

3- Unsaturated poly-ester with 2% methyl-ethyl-ketone-peroxide (MEKP) as a hardener reinforced with five layers 0/90 fiberglass.

Figure (3): UPE reinforced with 0/90 fiberglass

4- Unsaturated poly-ester with 2% methyl-ethyl-ketone-peroxide (MEKP) as a hardener reinforced with five layers chopped fiberglass and 3% nanoclay (W- GRP and W-GRP/3NC) mixed with poly-ester before adding the hardener by using electrical mixture

Figure (4): (a) UPE mixed with nanoclay, (b) UPE reinforced with chopped fiberglass and nanoclay

5- Unsaturated poly-ester with 2% methyl-ethyl-ketone-peroxide (MEKP) as a hardener reinforced with five layers 0//90 fiberglass and 3% nanoclay(W- GRP and W-GRP/3NC) mixed with poly-ester before adding the hardener by using electrical mixture

Figure (5): UPE reinforced with 0/90 fiberglass and nanoclay

Tests

Three types of tests were carried out to study the mechanical properties for the five kinds of samples to compare their mechanical properties and the effect of adding nanoclay material to the poly-ester reinforced with two different

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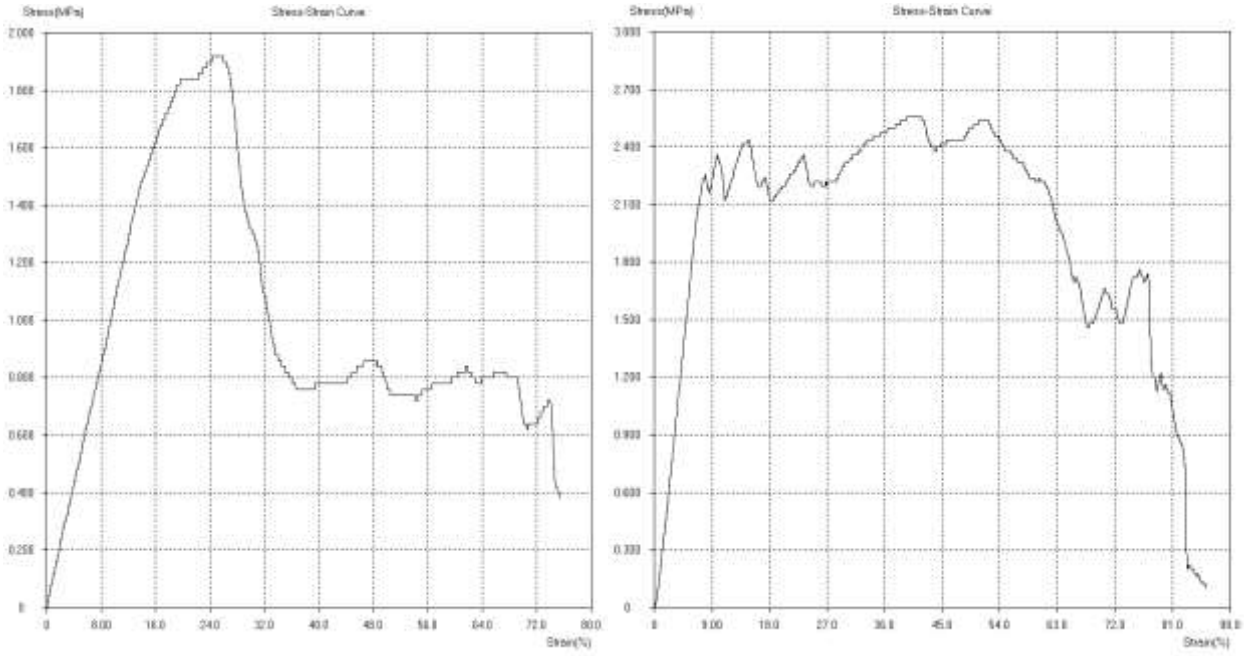
types of fiberglass, these tests were tensile, bending and Izod impact tests.

RESULTS AND DISCUSSION

Tensile strength

Figure (6) shows the tensile test for the UPE reinforced with two types of fiberglass (a) chopped fiberglass and (b) 0/90 fiberglass. It can noticed the improvement in tensile strength when the UPE reinforced with 0/90 fiberglass, this attributed to that mechanical properties depend on direction of anisotropic materials as this composite material. Figure (7) show the tensile strength for the same materials above after adding (3wt%) of nanoclay as a filler .The more enhancement was found in tensile strength for nano clay sample and that was due to silicate particles in nanometer size distributed uniformly in the polymer matrix with high aspect ratio. The high aspect ratio of nanoclay may also increase the tensile strength by increasing the nanofiller contact surface with the polymer matrix. Large numbers of reinforcing nanoclay layers presented in the polymer matrix act as efficient stress transfer agents in the nanocomposites [7]. In addition, the improvement in strength may be attributed to the reinforcing effect of the stiff clay particles. The comparison can be seen obviously in figure (8).



(a) ***(b)***

Figure (6): tensile test curve for unsaturated poly-ester reinforced with (a) chopped fiberglass (b) 0/90 fiberglass.

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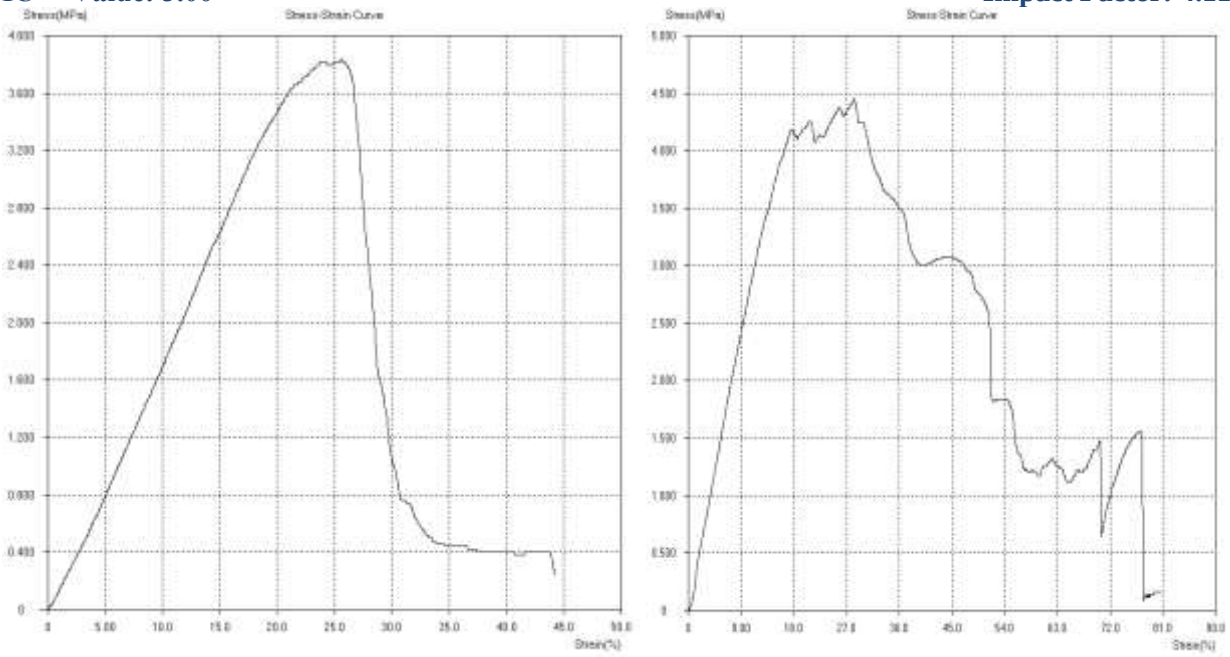

(a) *(b)*

Figure (7): tensile test curve for unsaturated poly-ester reinforced with (a) chopped fiberglass (b) 0/90 fiberglass and 3% of nanoclay.

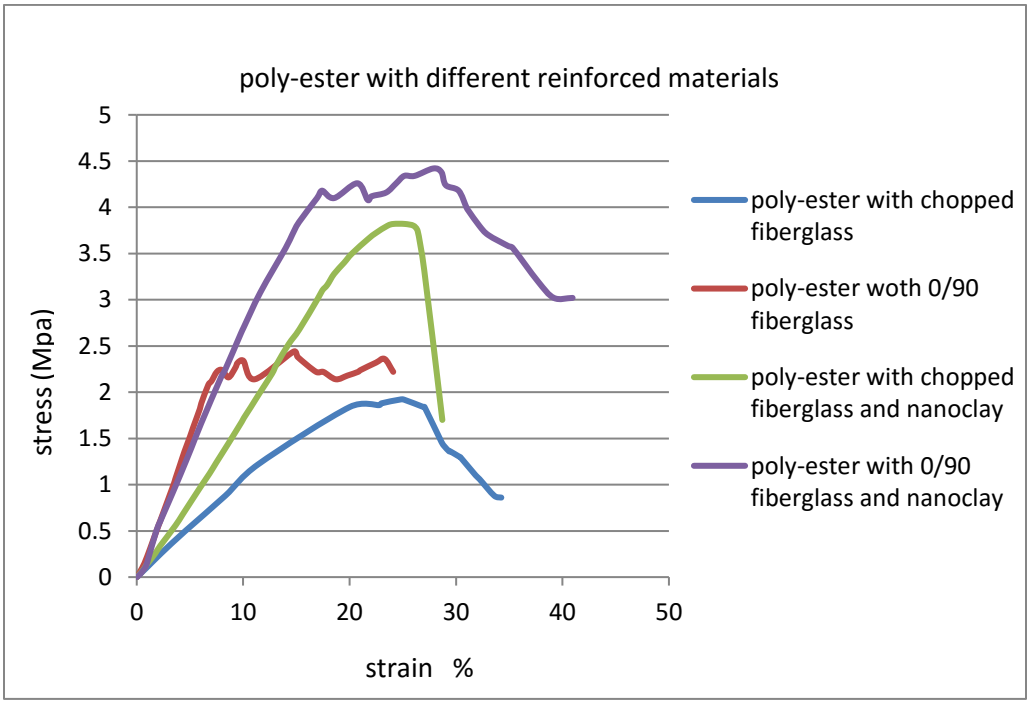

Figure (8): tensile test results

Bending strength

For the same reasons above the bending strength improved with 0/90 reinforced fiberglass as show in figure (10), while the bending strength is very weak for UPE without any type of reinforced as show in figure (9), and The high

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aspect ratio of nanoclay may also increase the bending strength by increasing the Nano filler contact surface with the polymer matrix, as show in figure (11). The comprising can be seen obviously in figure (12).

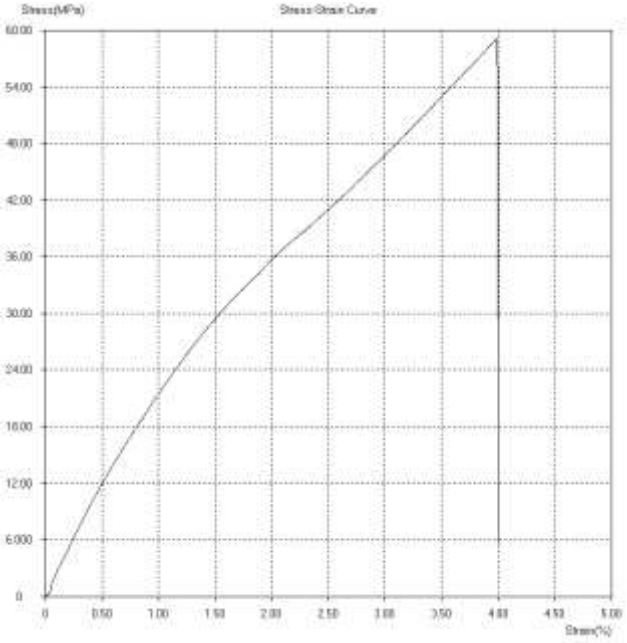
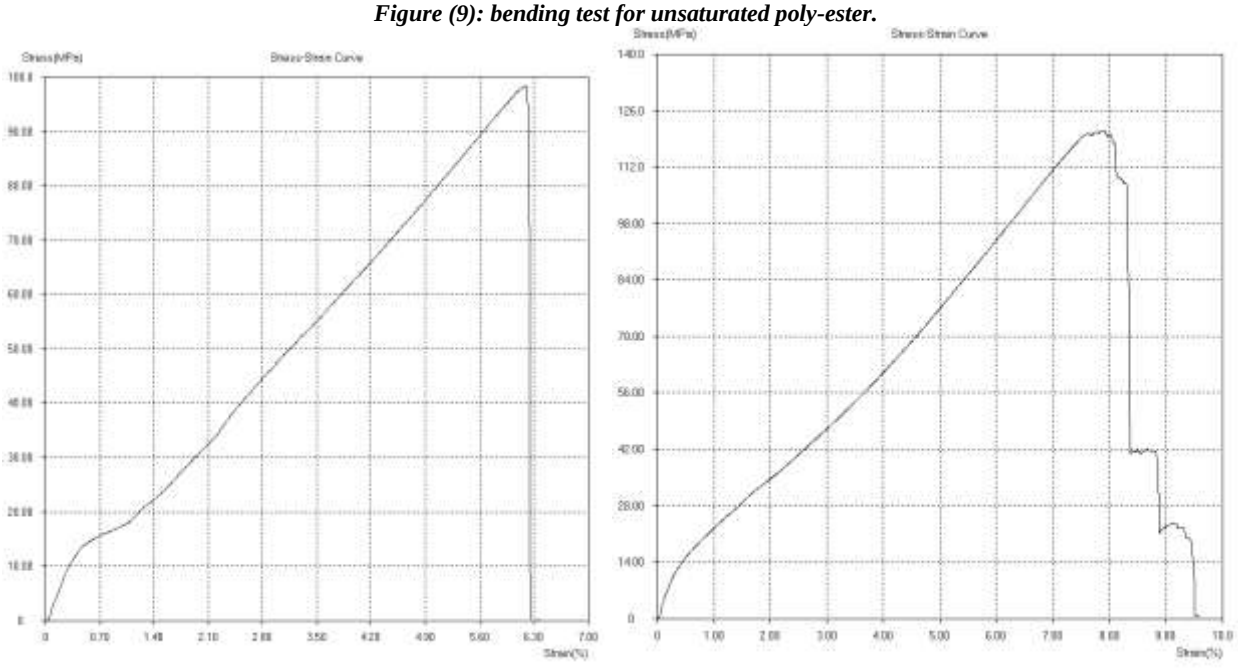


Figure (9): bending test for unsaturated poly-ester.



(a) (b)

Figure (10): bending test curve for unsaturated poly-ester reinforced with (a) chopped fiberglass (b) 0/90 fiberglass.

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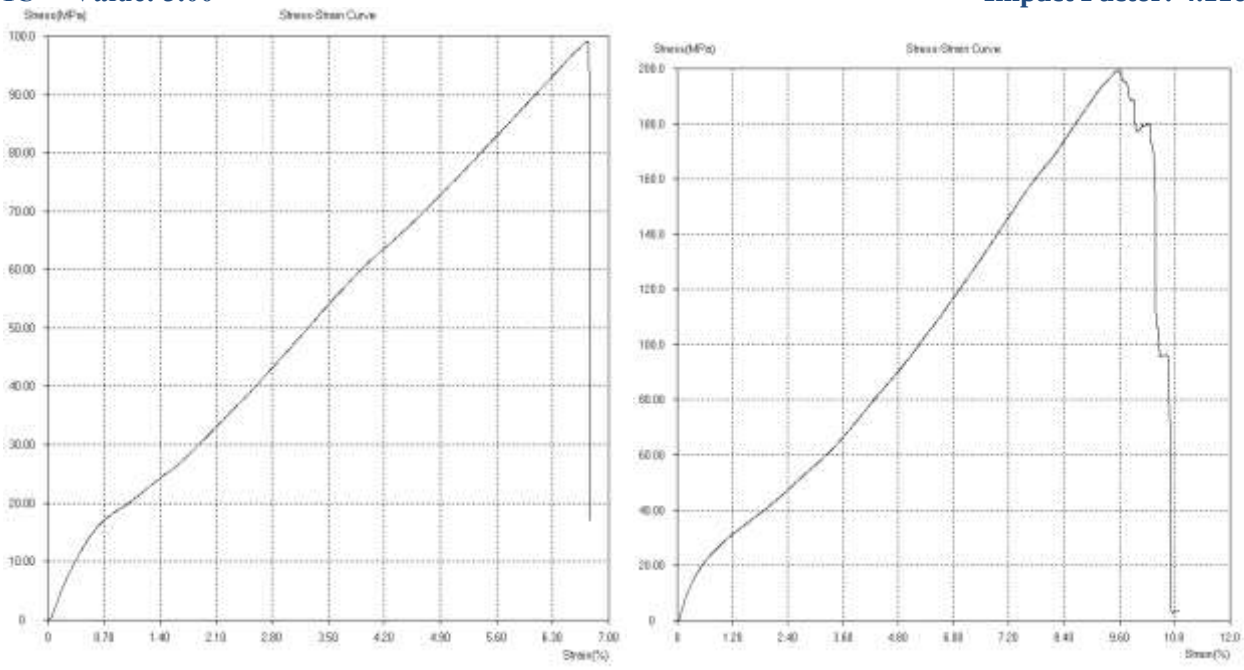

(a) (b)

Figure (11): bending test curve for unsaturated poly-ester reinforced with (a) chopped fiberglass (b) 0/90 fiberglass and 3wt% of nanoclay.

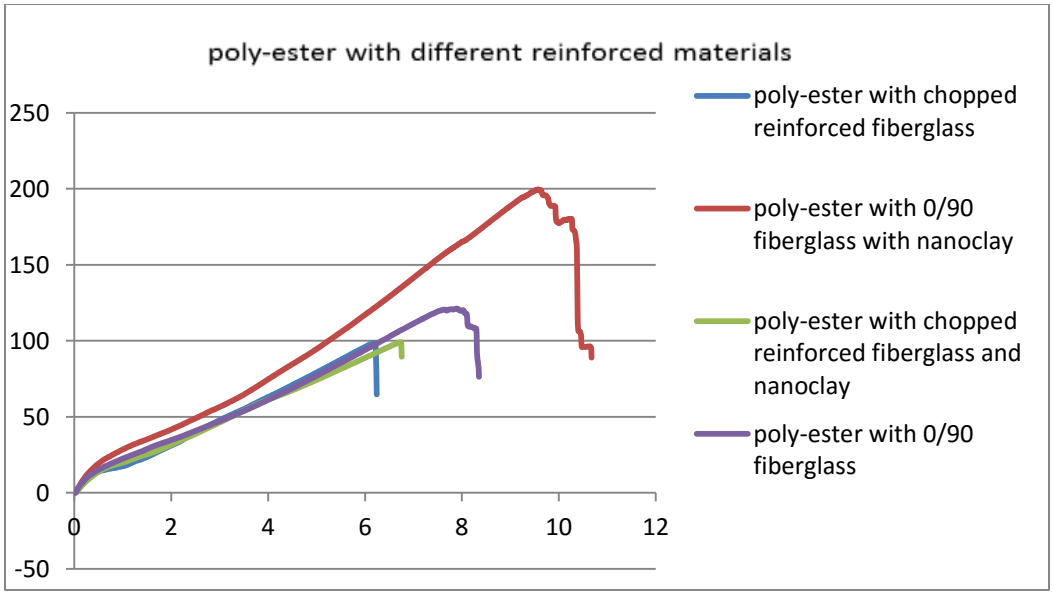

Figure (12): bending test results

Impact test

Table (1) shows the hardness results for all samples. The table shows that the adding of .0.03 of clay weight increases the toughness of UP/glass fiber composites considerably. The improvement after nanoclay adding related to the intercalated structure in the UP/glass fiber composite with 3wt% of clay. In addition, in the intercalated structure, clay particles may form a tortuous fracture path [8] and the growth of microcrack is stopped by clay platelets [9, 10]

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Table (1): Results of Izod Impact strength test

Sample number	Poly-ester	Energy absorbed (J)
1	Without any reinforcement	0.25
2	With chopped fiberglass	1.25
3	With 0/90 fiberglass	2.15
4	With chopped fiberglass and 3wt% nanoclay	2.6
5	With 0/90 fiberglass and 3wt% nanoclay	3

CONCLUSION

UPE reinforced with two types of fiberglass (chopped, 0/90) were prepared by hand layup method and then UPE with fiberglass and 3wt% nanoclay, to study the mechanical properties at room temperature. The results can summarize as follow,

1. Generally, the mechanical properties were enhanced recognizably in reinforced UP/fiberglass rather than unreinforced pure UP.
2. The reinforced UP with 0/90 fiberglass revealed better mechanical properties comparing to UP with chopped fiberglass.
3. Adding nanoclay as additional reinforcement materials to UP/fiberglass gives better mechanical performance generally.
4. The reinforced UP with 0/90 fiberglass and nanoclay revealed better mechanical properties comparing to all UP samples.

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