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EFFECT OF MONTMORILLONITE ON TENSILE PROPERTIES OF FRP COMPOSITES

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ABSTRACT

The field of FRP nanocomposites is stimulating both fundamental and applied research because these nanoscale materials often exhibit Mechanical, physical and chemical properties that are dramatically different from conventional micro composites. A large number of nanoparticles, layered fibers and polymeric whiskers are being used of the preparation of nanocomposites. Polymer nanocomposites containing layered silicates have attracted much attention. These nanocomposites can be exhibit increased modulus, decreased thermal expansion coefficient, increased solvent resistance and enhanced ionic conductivity when compared to the polymer alone. Here we have developed four different combinations of FRP with Montmorillonite and measured Mechanical properties. Measurement showed that tensile strength greatly increased, yield strength increased moderately and young's modules also increased. Lateral strain and linear strains are reduced, so it will give less poisson ratio. A plausible explanation for high increase of mechanical properties has also been discussed.

Keywords: *Nanocomposites, Montmorillonite, FRP*.

1. Introduction

Nanotechnology is the design, characterization, production and application of structures, devices and systems by controlling shape and size at the nanoscale. Eight to the atoms span one nanometer (nm). The human hair is approximately 70,000 to 80,000 nm thick. Nanotechnology has been put to practical use for a wide range of applications, including stain resistant paints. "NT is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications." The dream of a near perfect future will come true with these smart materials. NT is all set to prove that there are no limits for technological developments and is going to make our life easier than before. Though nanotechnology is at its instant stage, the lead time for it maturing into technology can be expected in the next 10-15 years. The scope range and potential applications of this technology could not be defined. NT will find its application in energy, medicine, electronics, computing, security, material sciences etc.

"Building things atom by atom, molecule by molecule" is nanotechnology. Put differently, it is a "bottom-up" manufacturing approach in which machines and mechanisms are built with nanoscale dimensions to build things on a small scales, one has to manipulate atoms individually the real challenge is to place atom precisely where we wish on a structure[1].

Some advantages of using polymers are found in their easy processing and light-weight. During processing, high particle loadings result in end products with much higher weight than that of the pure polymers. Therefore a composite with improved properties at low particle concentration is desired. Nanostructured materials often exhibit combination of physical and mechanical properties that are not superseded by conventional materials. For example, by decreasing the particle size of silica from the micrometer to the nanometer domain, a change in strength, elongation at break, modulus and yield stress was observed in polyurethane and nylon. Polypropylene is one of the fastest growing turnover polymers to date [2].

Polymer/clay nanocomposites are a class of hybrid materials composed of organic polymer matrix in which inorganic particles with nanoscale dimension are embodied. At this scale, the inorganic fillers improve dramatically the properties of polymer even though their amount is small. These nanocomposites exhibit improved modulus, lower thermal expansion coefficient and gas permeability, higher swelling resistance and enhanced ionic conductivity compared to the pristine polymers presumably due to the nanoscale structure of the hybrids and the synergism between the polymer and silicate[3].

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The Montmorillonite inorganic clay consists of stacked silicate sheets, each approximately 200 nm long 1 nm thick. The spacing between each sheet (or gallery) is also of the order of 1 nm, and this quantity is clearly smaller than the average radius of gyration of any conventional polymer. Therefore, entropy generally constitutes a large barrier that prevents the polymer from penetrating these galleries and becoming an intercalated material. Then determine the factors that control the macroscopic phase behavior of the mixture. Finally, the properties of the polymer clay nano composites commonly depend on the structure of the material [4].

Nano particles are presently considered to be high potential filler materials for the improvement of mechanical and physical polymer properties. The nanometer size, leading to huge specific surface areas (SSA) of upto more than 1000 m^2/g and their unique properties have caused intensive research activities in the fields of natural and engineering sciences. Candidates in the collectivity of nanoparticles with a high potential for the enhancement of mechanical and physical properties of polymers are carbon nanotube [5-7].

Their mechanical properties [8-11], a high aspect ratio and a high young's modulus and tensile strength, in combination with an electrical and thermal conductivity make them interesting materials for the use as nano fillers in polymers and open up new perspectives for multi functional materials. E.g. Conductive polymers with improved mechanical performance.

A nano-modification of the epoxy matrix leads to novel FRPs with enhanced matrix dominated mechanical properties and an anisotropic electrical conductivity. In order to efficiently exploit the potential of nano-particles are appropriate dispersion and sufficient amounts of nano modified epoxy are required. Both requirements can be fulfilled by the application of the introduced calendaring method to manufacture the nano tube epoxy suspension.

The nano composites, reinforced with carbon nano tubes, exhibit an improved mechanical performance. Especially an influence of the CNT's on the fracture toughness could be observed [12].

Synthesis and characterization of inorganic-organic hybrid materials have received more and more considerable alteration. Inorganic-organic hybrid materials can combine remarkable properties of inorganic phase and organic polymer. Epoxy resins are widely used in a large scale as packaging materials, laminates and adhesives in the field of electric and electronic industries owing to exceptional combination of properties such as toughness, adhesion and chemical resistance. However waterproof, thermal and mechanical properties are not sufficient to meet requirement of advanced electronics. Many efforts have been made to improve properties of epoxy resins. They had been modified with CTBN (Carboxyl Terminated acrylonitrile-buta diene), ATBN (Amine-Terminated butadiene acrylonitrite), functionally terminated acrylates, poly and alkylene oxides to improve their mechanical properties and with silicone to improve thermal properties. Nano Tio_2, nano-Zno, nano-Sio_2 were dispersed in epoxy resin to improve both mechanical and thermal properties for their large specific surface area.

Modification of nano Sio_2 in epoxy resin based composite was more effective than that of standard Sio_2 for tensile properties and impact properties due to large specific surface area and active groups on surfaces of nano-Sio_2 particles. Similar behavior has been shown for the toughness of epoxy resin based composite with nano-Sio_2 and standard Sio_2 in SEM images [13].

2. Experimental Procedure

2.1 Preparation of material

Specimen was prepared by Layer Manufacturing Techniques. Prepare moulding box with the required size and use wax polish and poly vinyl alcohol which act as a releasing agent. Apply the mixture of Nanopowder and polyester resin over the Emulsion E-Glass Fiber mat of 300 micron thickness.

2.2 Test procedure

Tensile testes measure the force required to break a specimen and the extent to which the specimen stretches or elongates to that breaking point. Tensile tests produce a stress-Displacement diagram and load-Displacement diagram, which is used to determine tensile modulus. The data is often used to specify a material, to design parts to withstand application force and as a quality control check of materials.

ASTM D 638 specimens are placed in the grips of the UTM at a specified grip separation and pulled until failed at test speed of 50mm/min for measuring strength and elongation.

2.3 Results and discussion

Table 1 shows various combinations of polyester resin, fiber and nanopowder (Montmorillonite) in wt%. Specimens A and B were prepared in the combination of PR and FR only. Specimens C and D were prepared by optimizing the PR and change the wt % of fiber and nanopowder.

These moulded specimens were prepared as per ASTM D 638 is shown in figure 1 and tested in computerized universal testing machine in 50 mm/min at room temperature.

Table 1: Combination of Specimens

Specimen	Combinations	%	Weight (gm)
A	PR	75	1125
	FR	25	375
B	PR	70	1050
	FR	30	450
C	PR	70	1050
	FR	25	375
	NP	5	75
D	PR	70	1050
	FR	20	300
	NP	10	150

PR – Polyester resin; FR – Fiber; NP –Nanopowder

Fig. 1 Tensile Specimens before Testing

Fig. 2 Tensile Specimens after Testing

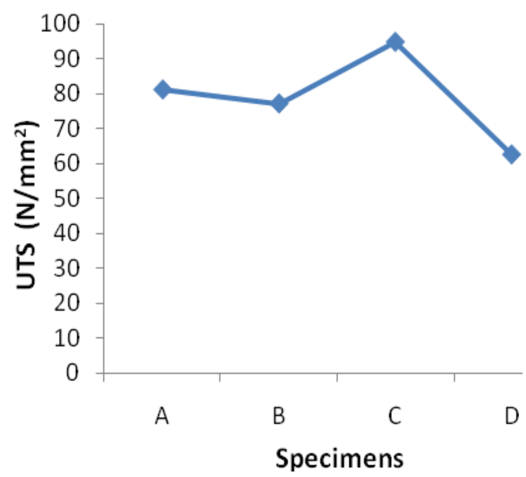

Fig. 3 UTS versus Specimens

Figure 3 illustrates the plots of Ultimate Tensile Strength (UTS) in N/mm^2 versus specimens of various combinations. It can be seen that the specimen A yielded 81 N/mm^2 for 5wt% increment of FR, B yielded UTS in 77 N/mm^2 in addition of 5 wt% of FR, almost it reduced 5% of UTS for the increment of 5% in fiber due to improper bonding strength between FR and PR. Specimen C yielded 95 N/mm^2 for the 5 wt% increment of Montmorillonite. Almost 17% UTS increased due to better bonding strength between FR, PR and NP. Specimen D yielded 62 N/mm^2 for the 10 wt% increment of Montmorillonite, it can be reduced 35% of UTS from C.

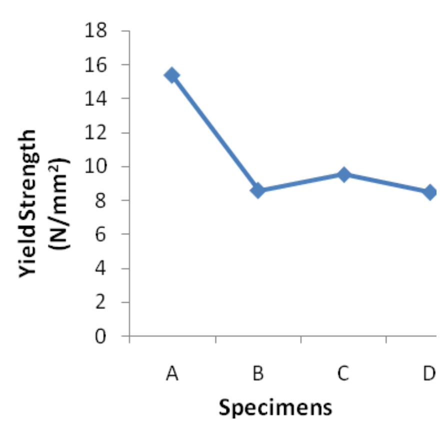

Fig. 4 Yield Strength versus Specimens

Figure 4 illustrates the plots of yield strength in N/mm^2 versus different specimens. For 5 wt% increment of FR, specimen A yielded 15.38 N/mm^2 and B yielded 8.58 N/mm^2. For the addition of 5 wt% of

Montmorillonite, specimen C yielded 9.54 N/mm^2 and specimen D yielded 8.47 N/mm^2. It shows that addition of Montmorillonite will increase the yield strength.

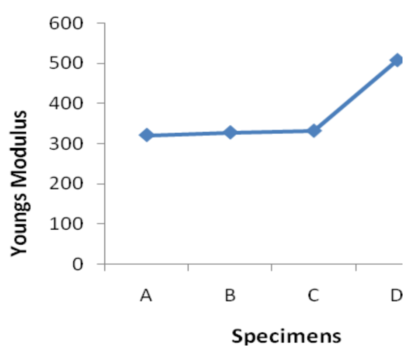

Fig. 5 Young's Modulus versus Specimens

Figure 5 shows the plots of young's modulus in N/mm^2 versus different specimens. For 5wt% increment of FR, Specimen A yielded 320.727 N/mm^2 and B yielded 327.33 N/mm^2. For the addition of 5 wt% of Montmorillonite, specimen C yielded 331.43 N/mm^2 and Specimen D yielded 508.37 N/mm^2. It shows that addition of Montmorillonite will greatly increase the young's modulus.

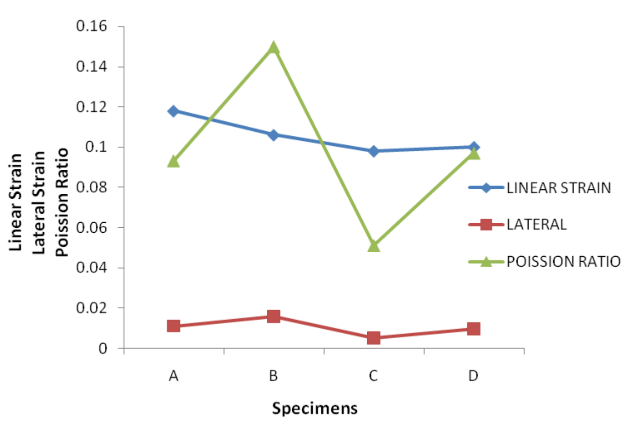

Fig. 6 Poisson Ratio versus Specimens

Figure 6 illustrates the plots of linear strain, lateral strain and Poisson ratio versus different specimens. By addition of 5 wt% of FR, specimen A has 0.118 linear strain and 0.011 in lateral strain. In specimen B, the linear strain is reduced into 0.106 and lateral strain into 0.015. Addition of 5 wt% of Montmorillonite in specimen C can reduce the linear strain to 0.098 lateral strain into 0.005. In specimen D slightly increased to 0.1 in linear strain and 0.0097 in lateral strain. This result shows a least value of linear strain and lateral strain for specimen C.

Specimen A has 0.093 Poisson ratio. In addition of 5 wt% of FR in specimen B, the Poisson ratio is increased into 0.15. Addition of 5 wt% of Montmorillonite in specimen C can reduce the Poisson ratio to 0.051 and in specimen D to 0.097. This result shows a least value of Poisson ratio for specimen C.

Addition of 5 wt% of Montmorillonite gives the lesser value of linear strain, lateral strain and Poisson ratio due to proper bonding between Montmorillonite, polymer and fiber.

3. Conclusions

In this study, the tensile behavior of an experimentally produced FRP with Montmorillonite in various combinations was investigated at room temperature in 0.833 strain rates. The results are summarized as follows.

i. The FRP with Montmorillonite has sufficiently high ultimate tensile strength and 17% improvement of UTS at 5wt% increment of Montmorillonite.

ii. Yield strength increases into 9.54 N/mm^2 with an addition of 5% of Montmorillonite.

iii. Compare with specimen A and B young's modulus increases into 333.43 N/mm^2 in C with an addition of 5 wt% of Montmorillonite.

iv. Reduction in linear strain, lateral strain and Poisson ratio has been observed in specimen C with an addition of Montmorillonite 5 wt%

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