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Effect of Nanoclay on the Mechanical properties of Polyester and S-Glass Fiber (Al)

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Abstract

Composite materials play a vital role in many industrial applications. Researchers are working on fabrication of new composite materials worldwide to enhance the applicability of these materials. In view of this, the objective of the present work is to analyze the effect of nanoclay content on the mechanical and morphological behavior of S-glass fiber, reinforced in Polyester with nanoclay as filler. Five different types of composites are fabricated by hand layup technique using 0 wt% nanoclay,1 wt% nanoclay, 3 wt % nanoclay, 5 wt% nanoclay and 7 wt% nanoclay with 40% wt fiber, and polyester. The results of the study show that the incorporation of nanoclay has a significant effect on the mechanical behavior of composites. The optimum loading of clay in the Polyester /glass fiber composites was attained at 3wt%, where the improvement in tensile and bending properties was seen.

Keywords: *Nanoclay , S-Glass fiber (AL), Polyester etc*

1. Introduction

Composites: A composite material is a material made up of two or more materials that are combined in a way that allows the materials to stay distinct and identifiable. Some common composite materials include concrete, fiberglass, mud bricks, and natural composites such as rock and wood. Composites are classified into two types based on a) Matrix Material b) Reinforcing Material.

Glass fiber reinforced composites have become attractive structural materials not only in weight sensitive aerospace industry but also in marine, automobile, railways, civil engineering structures, sport goods etc. This is attributed to high specific strength and specific stiffness of the glass fiber reinforced composites.

Polyester is one of most commonly used polymer matrix with reinforcing fibers for advanced composites applications due to its low cost, easy handling, rigid, flexible, corrosion resistant, weather resistant, and flame retardant.

Nanoclay has received much attention as reinforcing materials for polymer because of its potentially high aspect ratio and unique intercalation characteristics .The small amount addition of Nanoclay into polymer matrix exhibits unexpected properties including reducing gas permeability, improved solvent resistance, being superior in mechanical properties and thermal stability, and enhanced flame retardant properties.

A. B. Inceoglu and U. Yilmazer [1] studied that the tensile strength, tensile modulus, flexural strength, and flexural modulus of neat UP were improved by the presence of clay up to 5wt%. Above 5wt% of clay, tensile and flexural properties were decreased. Many researchers investigated individually Polyetser/glass fiber composites, Polyester/Nanoclay

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and Polyester/E-Glass/Nanoclay no investigation has been carried out on Polyester/S-glass fiber/clay composites. Literature survey indicates that very limited work has been done on tensile behavior of mat S-glass fiber reinforced polyester composite. Therefore, the aim of this work is to fabricate S-glass / polyester /Nanoclay composite of varying wt% using hand layup technique and to study the tensile properties of the composites.

2. Materials

2.1. Materials

Polyester resin of grade ECMALON 4411, methyl ethyl ketone peroxide and cobalt naphthanate were purchased from Ecmass resin (Pvt) Ltd., Hyderabad, India. Nanoclay, which has its surface modified with 25-30wt% methyldihydroxyethyl hydrogenated tallow ammonium is obtained from Sigma aldrich Banglore.

2.2. Fabrication

Firstly, Polyester/Nanoclay composites, with different clay wt% (1, 3, 5, and 7 wt%),were prepared by mixing the desired amount clay with Polyester in a suitable beaker. Then the mixture was placed in a high intensity ultra-sonicator for 30minwith pulse mode (15s on/15s off). Once the process was completed Polyester/Nanoclay/ S-glass fiber composites were prepared by hand layup method. Four plies of glass fiber were cut as per the required dimensions. A layer of Polyester/clay mixture which was mixed and kept was applied on a mold. The first ply was laminated until it became entirely wet by the resin. Additional Polyester/clay mixture was added, and the second ply was laminated until complete wetting. This procedure was repeated until four plies were superimposed. Then, the sample was pressed with a metal roller to find the thickness of approximately 3 mm. The composites samples were cured at room temperature for 24 hours. The cured composites then were cut in a suitable Geometry per ASTM standards.

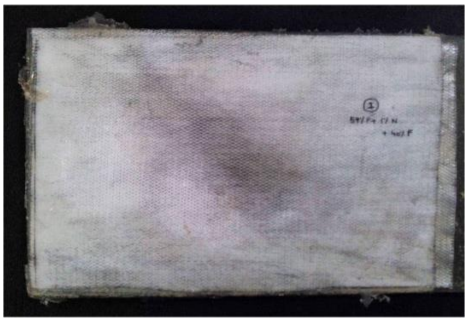

Figure 2.2.1. Cured Composite

Figure 2.2.2. Samples after Cutting

2.3. Mechanical Testing of Composites

A 2 ton capacity - Electronic tensometer, its capacity can be changed by load cells of 20Kg, 200Kg & 2000 Kg. A load cell of 2000 Kg is used for testing composites. A digital micrometer is used to measure the thickness and width of composites. The tensometer is fitted with a fixed self aligned quick grip chuck and other movable self aligned quick grip chuck. The movable chuck is adjusted to accommodate 25 mm wide and 3mm thick specimen. The specimen was held in fixed grip and the movable grip is manually moved until the specimen is held firmly without slackness. The power supply is switched on.

3. Results and Discussion

3.1. Tensile Strength and Tensile Modulus Values

Table 3.1.1. Tensile Streng

Wt% of Nanoclay	Tensile Strength(Mpa)
Polyester	19.76
0%N	77.9
1%N	84.36
3%N	88.54
5%N	74.002
7%N	68.26

Table 3.1.2. Tensile Modulus

Wt% of nanoclay	Tensile modulus(mpa)
Polyester	236.26
0%n	1139.49
1%n	1195.82
3%n	1449.31
5%n	1130.5
7%n	1078.2

3.2. Bending Strength, Bending Modulus and Bending Moment Values

Table 3.2.1. Bending Strength

Wt% of nanoclay	Bending strength(mpa)
Polyester	35.3
0%n	59.6
1%	64.2
3%	76.6
5%n	56.25
7%n	47.88

Table 3.2.2. Bending Modulus

Wt% of nanoclay	Bending Modulus (mpa)
Polyester	881.4
0%n	1747.8
1%n	1892.8
3%n	2192.7
5%n	1833.9
7%n	1592.7

Table 3.2.3. Bending Moment

Wt% of nanoclay	Bending Moment (N-M)
Polyester	1.3
0%n	2.235
1%n	2.40
3%n	2.87
5%n	2.10
7%n	1.79

3.3. Results and Discussions

(Tensile Results) From Figure 3.3.1 the maximum load carrying capacity is observed for 3wt% Nanoclay and the maximum load obtained is 352 Kg.

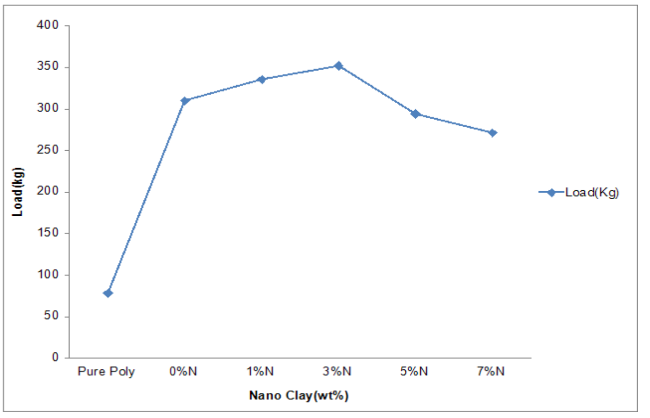

Figure 3.3.1. Tensile Load Variations for Different wt% of Nanoclay

From Figure 3.3.2 The maximum elongation that is observed for pure polyester and the maximum elongation obtained is 4.6.

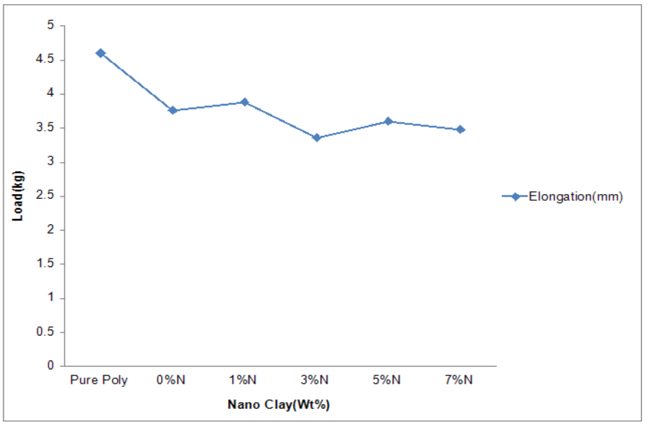

Figure 3.3.2. Tensile Elongation Variations for Different wt% of Nanoclay

From Figure 3.3.3 The maximum value of tensile strength obtained is 88.54Mpa at 3wt% Nanoclay.

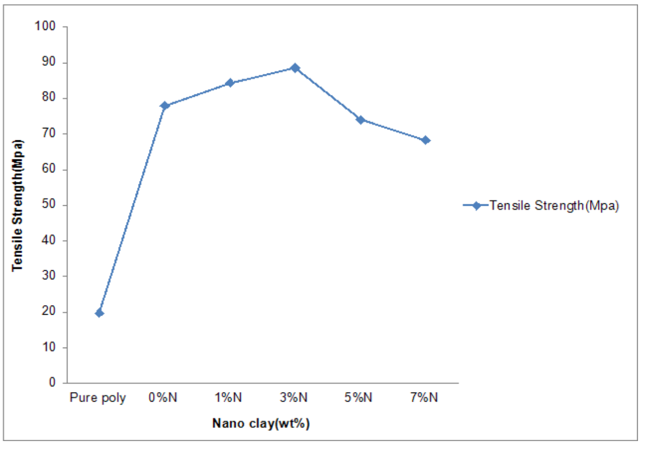

Figure 3.3.3. Tensile Strength Variations for Different wt% of Nanoclay

From Figure 3.3.4 The maximum value of tensile modulus obtained is 1449.3Mpa at 3wt% Nanoclay.

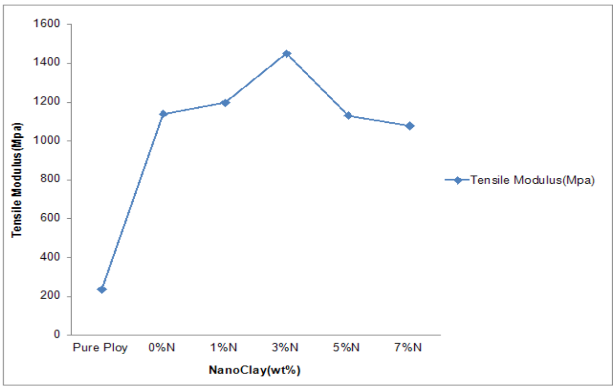

Figure 3.3.3. Tensile Modulus Variations for Different wt% of Nanoclay

(Bending Results) From Figure 3.3.4 The maximum load carrying capacity is observed for 3wt% Nanoclay and the maximum load obtained is 18.32 Kg.

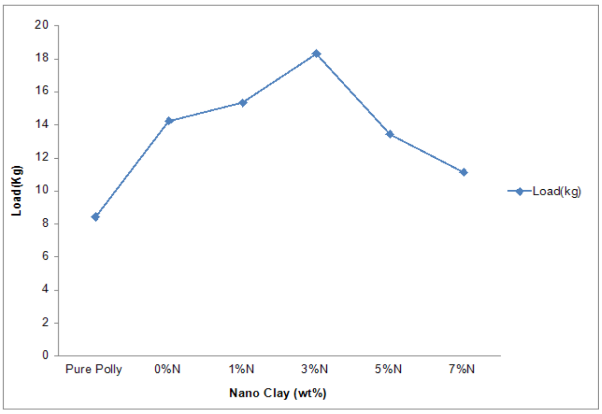

Figure 3.3.4. Bending Load Variations for Different wt% of Nanoclay

From Figure 3.3.5 maximum elongation that is observed for pure polyester and the maximum elongation obtained is 9.12

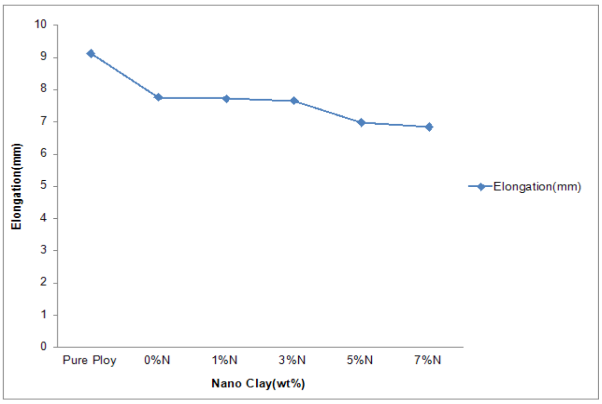

Figure 3.3.5. Bending Elongation Variations for Different wt% of Nanoclay

From Figure 3.3.6 maximum value of bending strength obtained is 76.6Mpa at 3wt% Nanoclay.

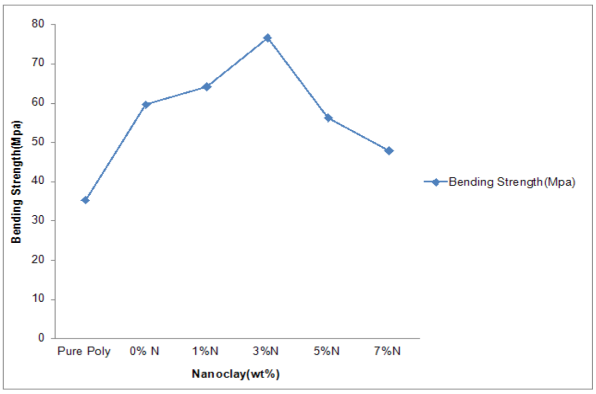

Figure 3.3.6. Tensile Strength Variations for Different wt% of Nanoclay

From Figure 3.3.7 maximum value of bending modulus obtained is 2192.7Mpa at 3wt% Nanoclay.

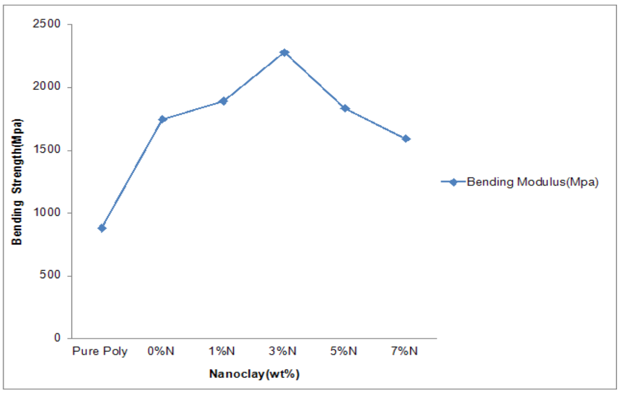

Figure 3.3.7.Bending Modulus Variations for Different wt% of Nanoclay

From Figure 3.3.8 maximum value of bending moment obtained is 2.87Mpa at 3wt% Nanoclay.

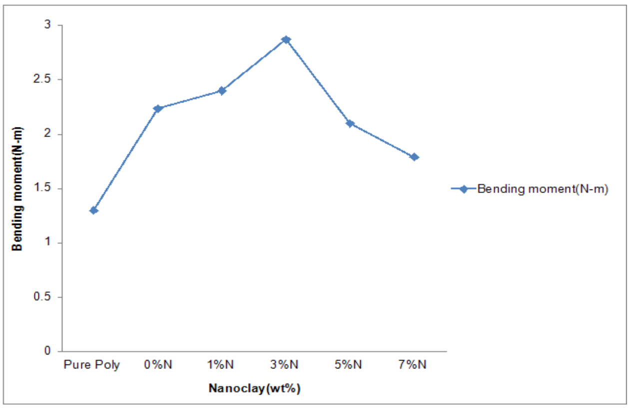

Figure 3.3.7. Bending Moment Variations for Different wt% of Nanoclay

From the tensile and bending test results, as the weight percentage of nanoclay increased, the tensile and bending strengths of the samples also increased. 3 wt% samples showed the maximum tensile strength,tensile modulus, bending strength, bending modulus,bending moment. But it was not the case for 5 wt% and 7 wt%, instead they tended to break apart before the peak, which meant they were brittle. It was because when the nanoclay weight percentage increased, the mixture itself became too viscous, sluggish and more void formations in the samples of high wt%.The more the nanoclay added the more viscous of the clay–resin mixture. This is the reason for which the higher wt% samples failed.Another reason for failure of higher clay loading is low aspect ratio of clay particles and low contact surface area resulting in weak adhesion between polymer matrix and clay. This subsequently lowers their tensile strength. In addition, at high clay loading this behavior was probably attributed to the filler-filler interaction which resulted in agglomerates, induced local stress concentration, and finally reduced mechanical properties of the nanocomposites.

3.4. Scanning Electron Microscope(SEM)

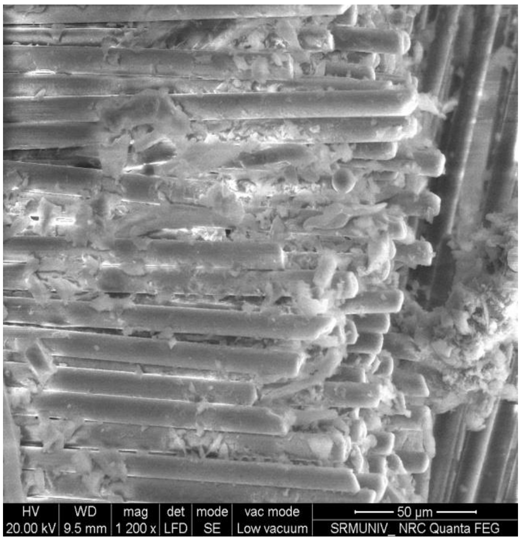

Figure 3.4.1. SEM Image Polyester/S-Glass Fiber

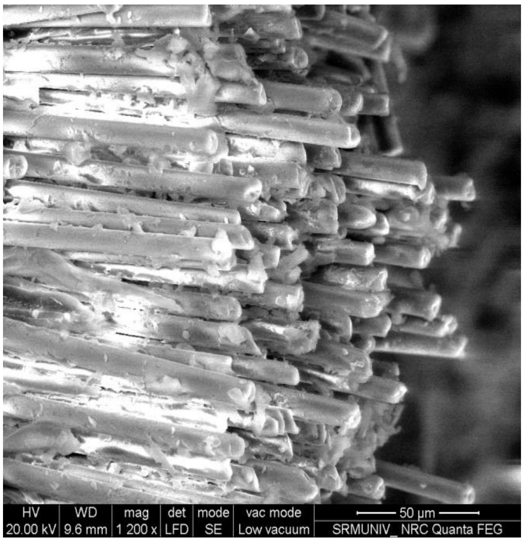

Figure 3.4.2. SEM Image Polyester /S-Glass Fiber with 3wt% of Nanoclay

The scanning electron micro-graphs of the specimens with 0and 3wt% nanoclay are shown above. It is often not possible to see individual nanoclay particles mixed in polymer matrix using SEM. However, the surface properties observed in specimens is an indication of the uniformity of the nanoclay dispersion.From Figure 3.4.1it can be seen that the Polyester/glass fiber composites exhibited as smooth fracture surface especially on the Polyester matrix compared to the Polyester/glass fiber composite, the fracture surface of the Polyester/glass fiber/nanoclay composites showed much rougher fracture surface (as shown in Figure 3.4.2. The rough fracture surface is due to the presence of clay particles.When comparing SEM images with the mechanical results the addition of nanoclay made the Polyester/Glass fiber brittle upon high addition of nanoclay this is why after 3wt% of nanoclay we have seen reduced mechanical properties.

4. Conclusion

S-glass / Polyester composite of nanoclay is prepared with five different wt% of nanoclay, i.e: 0wt%, 1wt%, 3wt%, 5wt%, 7wt%. From the study, following observations were made. Mechanical properties at 3wt% nanoclay composite are more compared to other clay loading. The optimal clay loading obtained is 3wt%.The maximum tensile strength obtained is 88.54Mpa at 3wt% and the maximum tensile modulus obtained is 1449.3Mpa. Maximum Bending Strength obtained is 76.6Mpa, Bending modulus is 2192.7Mpa and bending moment is 28.7N-m.

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