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Mechanical, Physical, Morphology and Properties of Multi-Functional Natural fiber and nano SiO_2 Reinforced Epoxy Hybrid Composite

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Natural fibers are being used to balance the environment. Comparatively low costs as well as low energy consumption add to their benefits. The emphasis is on enhancing the properties of the composite with the use of nano- filler materials with natural fiber. The purpose of this work is to develop a high-quality hybrid composite by mixing nano silica with natural bamboo fiber. The composite was made by hand–layup technique. The epoxy, hardener, bi-directional bamboo mat and nano SiO_2have been used as the filler material. After making the Hybrid Composite (HC) we gave it nine different names because we have taken bamboo layer with nano silica in 3 different patterns. Nano SiO_2Filler Material (NSFM) with three different wt. % were used. NSFM is used with 0,2 and 4 wt. %. The name of composite is HC1, HC2, HC3, HC4, HC5, HC6, HC7, HC8 and HC9. The various tests like tensile test, flexural test, hardness test and impact test of all nine-hybrid composites were conducted. Based on the obtained mechanical properties Water Absorption (WA), Thickness Swelling Test (TST) was also conducted as per ASTM standard. Field Emission Scanning Electron Microscope (FESEM), X-ray Diffraction (XRD), and Heat Deflection Temperature (HDT) test of six composites (HC4, HC5, HC6, HC7, HC8 and HC9) were performed. Fourier Transform Infrared (FTIR) and FESEM of nano silica particle was also performed. During the water absorption test, we found that HC4 sample has shown the least water absorption and the HC9 shown the highest value. From the HDT test, it was found that the HC9 has better heat resistance properties than other composite samples. The amorphous peak located at $20.8^{o}(2\theta)$ in the XRD pattern. The primary nano silica particle was 20-40 nm in size and they aggregated/cluster in bigger particle. The FESEM image we can see that for HC9 silica nano particle forms clusters. In the natural composite mixture, as the use of filler material increased, the properties shown an increase upto certain limit followed by the decrease in properties with further increase of the filler material. The addition of nano particles beyond 3 wt.% has shown reduction in tensile strength, flexural strength, impact strength and hardness strength properties at 4 wt. % silica (SiO_2).

Keywords: Polymer Composite, Hybrid Composite, Heat Distortion Temperature (HDT), FESEM, Water Absorption (WA), Thickness Swelling Test (TST), Fourier Transform Infrared spectroscopy (FTIR), XRD

1 Introduction

Due to environmental pollution and energy shortage, scientists and researchers have sought alternatives to biomass composites and natural fibers. Natural fiber research mainly includes jute, kenaf, sisal and bamboo fiber. Natural fibre has many attractive features such as low cost, low density, low energy requirements, renewable, high strength to weight ratio, high strength, elasticity modulus, thus Glass and other synthetic fibres are showing great potential for replacements by the natural fibres[1]. According to Prasad et al., The bamboo fibres have a relatively high tensile strength compared to fibres of most plants such as sorghum and sisal[2]. At least two or more materials with dissimilar properties were combined to form a new material with enhanced properties . Mixing the materials further enhances the strength of the material matrix composites . The use of natural fibers is continuously increasing as reinforcement with the different polymers. Manufacture of natural fiber and their use is increasing on the basis of their exciting properties. Natural fiber has several beneficial characteristics, such as their cost, ease of manufacture, lightweight, environment friendly and superior in strength to the conventional materials. At present, the use of plastic has been discouraged in many countries. As results, the use of vulcanized fibers has been increased. The dependence of industries on traditional materials has decreased. These of different types of natural fibers, mainly jute fiber, bamboo fiber, sisal fiber, have increased .

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The bamboo fiber is mostly composed of light lingo cellulosic biomass, high moisture and absorption capacity. Synthetic fibers gain strength through the use of synthetic fibers with different types of weaving. If we talk about making a good matrix for a composite, then nano particle, should be used as filler material, which can increase the properties of the composite. Most researchers have clearly revealed that the polymer used in the composite should be of good quality. The specialty of the work being done on the previous composite and the present composite is very different. An attempt has been made to enhance the properties of the composite made through chemical reaction. The use of nano silica improves the wear properties of the composite[3]. The use of nano silica has increased the performance of the composite, its use can increase the hardness and flexural strength of the composite[4].

The material matrix composite has good mechanical, thermal and tribological properties. The properties and characteristics of a composite material compared to other materials are excellent. Water absorption (WA) increased as the amount of nano silica particles increased. Due to its use, the toughness and strength of the substance became stronger. Addition of nano silica enhance the properties of composite, improves tribological and mechanical properties[5].Water absorption properties of the natural fiber reinforced composites are important the composites. The lignin content of natural fiber is responsible for thermal stability and lower water absorption, shows the hydrophobic nature[6]. The thermal conductivity of polymer composite materials has been studied, through which the thermal conductivity of composite material has been compared[7.]Diffusion of water molecules get into the polymer chain through the micro gap. Water molecules enter at the interface between the fiber and matrix through the crack due to the capillary action. The capillary transportation of water molecules gets into the natural fiber and developed fiber swelling[8]. Fiber have been continuously explored under positional conditions but the thermal behaviors of hybrid composite has been poorly analyzed .

Research and studies revealed that the properties exhibited by composite materials depend on various factors including the composition of the material. Proper selection of components to make composite materials provided effective conductivity. As the orientation of the fiber affects the thermal properties, the mutual mixing of materials can increase the thermal conductivity. Researchers can determine the possible appearance of chemical interaction in a variety of film-making processes using FTIR (Fourier-transform infrared spectroscopy). The characteristics of bio-nano composites are determined by these chemical interactions[33]. Research has been done on the vibration spectra of silica glass[9] and infrared (IR) spectroscopy has been used to monitor changes in amorphous SiO_2 during heating to 1150 °C[10] of sol-gels. IR spectroscopy is used to investigate the various phases during manufacture of silica. Increasing the alkali concentration softens the hemp fibres as can be seen from their SEM images. The NaOH treatment raised the crystallinity index (CI%) and peak or maximum intensity, according to XRD results on alpha fibres[11].

In this work hand lay-up technique was used to make the composites. Water absorption ,heat defection test and mechanical tests were done to know the effect of SiO_2 in composites. FESEM test was carried out to know the absolute dispersion of SiO_2. FTIR test was done to identify the compound present in silica[12]. This work aims to the development of the multi-component materials with desirable properties.

2 Materials and Methods

2.1 Composite Preparation

Composite materials are made up o more than two materials. The properties of the composites are significantly different from each of the elements being mixed. In this work the composites were made through hand lay-up methods the epoxy hardener and bi directional woven bamboo mat was purchased from Go-Green Products Ltd., India. Bi-directional natural fiber bamboo mat, epoxy LY556 and hardener HY951 were used to make the composite. Electric ovens, electronic weighing machine, magnetic stirrer and compression molding machine were used for the manufacture of composite. The plate die of the size 15cm*14cm was used to prepare a composite plate. First of all, cut the bamboo mat according to 15cm*14cm size and place it in an electric oven at 75ºC for 40 minutes, so that the moisture can be removed. Epoxy and hardener were used in the ratio of 10:1.

150 gm of epoxy was taken in a beaker and placed in an electric oven at 75ºC for 40 minutes. Keeping at the appropriate temperature reduces the viscosity. To remove the moisture presents in the bamboo mat;

it was kept at 75ºC for 20 minute. A beaker in which the hardener was taken out properly mixing the epoxy and hardener, keeping the time in mind, was poured over the bamboo mat. The hardener tries to set the mixture by mixing with the epoxy due to its exothermic reaction. Therefore, the process is completed by adding hardener to the epoxy within a span of 5 minutes. Wax was applied before placing the mat in the die, so that the composite could be easily removed. A metallic roller was used to remove air bubbles from the mat[13]. After driving the metallic roller in the bamboo mat placed on the compression molding machine at 550 bar pressure for 24 hours. This process was for single layer bamboo fiber, in which nano particle silica was not used. Similarly, composites were made using 2 layer and 3 layer of natural bamboo fiber. The general method for adding silica was slightly modified the epoxy was taken out of the oven and 2 wt% or 4 wt % of silica was added to it. The silica was placed in the oven for 40 minutes at 60ºC to remove moisture. After this, the silica epoxy mixture was placed in a magnetic stirrer machine at 80⁰C for 40 min. Removed from the magnetic stirrer, the mixture was kept on the ultrsonicator apparatus for 10 minutes, due to which the silica was well dispersed in the epoxy. After this 15 gm of hardener was mixed in it ,by adding 10-15 ml of acetone ,the hardener epoxy and silica spread well, acetone acts as a coupling agents[14]. The prepared mixture was made composite by pouring it on the die as before. Six composites were made with 2 layer and 3 layer natural bamboo fiber with different amounts of silica . Whose details are presented in Table 1.

Table 1 — Different Composite Samples and Composition

S. No.	Coding of hybrid nComposites	Natural Bamboo layer15cm*14cm	SiO_2 Wt. %	Ratio of Epoxy: hardener
1	HC1	1	0	10:1
2	HC2	1	2	10:1
3	HC3	1	4	10:1
4	HC4	2	0	10:1
5	HC5	2	2	10:1
6	HC6	2	4	10:1
7	HC7	3	0	10:1
8	HC8	3	2	10:1
9	HC9	3	4	10:1

2.2 Characterization and Testing

Material characterization is an important aspect in understanding the behaviour of natural fibres[13], water absorption, and mechanical characterization includes testing of tensile, flexural and impact properties according to the ASTM standards. In physical properties test by WA, TST were conducted and the FESEM was used for surface morphology of composites. The thermal stability of hybrid composites of natural fibres was studied using HDT. Whereas the chemical properties were analysed using FTIR and XRD spectroscopy.

2.3 Mechanical Properties

The mechanical effects of composites are essential for understanding their durability and strength. After examining their applications a decision may be taken based on their merit. Before a composite material can be used, it is necessary to test its mechanical properties mechanical testing makes it easy to determine the area of use of the composites[15]. The main properties of a composite are its weight, strength and stiffness. The mechanical tests were carried out in this work and the sample sizes for the various tests are presented in Table 2. Out of the nine-hybrid composite made, the first three composite (HC1, HC2 and HC3) have a single layer of natural bamboo fiber. The mechanical properties of these 3 samples were not good in comparison to the other six (HC4 to HC9) composites. The mechanical properties are the most important factor for any new material for proposing its wide applications in different fields. On the basis of the obtained value of the mechanical properties, separate tests of the other six composites were done. The details of these results are presented in this work.

2.4 Water Absorption (WA)

Water absorption test determines the water absorption capacity of the composite. The influencing factors are mainly the material used, temperature, area of matter and type of natural forces. For each hybrid composite to be tested a sample of 50mm*50mm*5mm is drawn for testing as per apparatus ASTM D570 standard. Before testing all samples are heated to a temperature of 60ºC for 2 hours to remove moisture, after this immersed in a glass beaker filled with distilled water for 3 days. After 3 days the test samples were taken out of the beaker to calculate the weight and compared with the previous weight[8,14]. At the time of

Table 2 — Mechanical test and their specifications used in present work

S. no.	Mechanical Test	ASTM Standard Apparatus	Specimen size
1	Tensile test	ASTM D638	115mm×19mm×5mm
2	Flexural test	ASTM D790	127mm ×12.7mm×5mm
3	Impact test (Izod)	ASTM D256	12.7mm×64mm×5mm
4	Hardness test (barcol)	ASTM D2583	50mm×50mm×5mm

testing room temperature was 25°C and RH 55%for the entire test. All the samples were examined and the weight gain were measured. WA% was evaluated by mathematical-1.

$$\text{Water Absorption (\%)} = \frac{W1-W0}{W0}\times 100\% . \qquad ..(1)$$

Where,

W0- Test Specimen Weight, at Dry Condition

W1- Test Specimen Weight , at Wet Condition

2.5 Thickness swelling test (TST)

Before water absorption test, the thickness of all the six composites was carried out by us through vernier caliper. After the water absorption test, the thickness measurement of all the same composites was again done[14]. Thickness swelling was calculated from the difference of both values. For this test the standard value of the specimen was 50mm*50mm*5mm. Thickness swelling can be easily calculated from the following Equation-2.

$$\text{Thickness Swelling} = \frac{T1-T2}{T1}\times 100\% \qquad ...(2)$$

Where,

T1- Test Specimen Thickness, at Wet Condition
T2 – Test Specimen Thickness, at Dry Condition

2.6 Heat Defection Temperature (HDT)

The HDT test is a short-term test, which displays the rate of increase in temperature over time in the test samples[16]. To check the thermal properties of hybrid composite HDT test has been done. The sample were cut in (120mm*8mm*5mm) size as per the ASTM D648 standard. The HDT test of the composite was carried out at a standard pressure of 1.82MPa (induced stress) up to deflection of 0.25mm, the temperature is raised at a rate of 2°C per minute. Silicon oil GE SF 81-50 AK 1000 was used for heater medium under minimum flash temperature set at 20°C test temperature.

2.7 X- ray Diffraction (XRD)

XRD analysis was performed to ascertain the crystalline of the hybrid composite. The XRD is a non-destructive testing technique, used to analyze the structure of crystalline materials, identifying the crystalline phases present in the material and revealing information about the chemical composition. XRD analysis of hybrid composite executed to find the crystallinity of composite film[17] at an angular incidence of 5° to 90° using Cu K-alpha radiation by RIGAKU Miniflex-600 X -ray diffracto meter from Tokyo Japan.

2.8 Field Emission Scanning Electron Microscope (FESEM)

The surface of the composite film was analyzed by FESEM the sample was sputter- coated by means of carbon tape[18]. FESEM was used for surface test (part of matter)[14]. The FESEM set -up JSM -7610 FPlus (made by: Jeol Japan) was used for the analysis of surface.

2.9 Fourier Transform Infrared (FTIR)

It is an analytical technique (AT) used to identify organic and inorganic polymers. Infrared light was used to scan the composite sample[10]. The functional group of the nano SiO_2particle was analyzed at 4 cm^{-1}(resolution) to be investigated 3 scans were performed using an imaging microscope ASTM E1252 JASCO model 4700 Tokyo Japan. FTIR was used to characterize the chemical composition of the composite matrix. The FTIR process was carried out on the transmittance mode within the range of 400 to 4000 cm^{-1}.The FTIR has been used only for filler material nano silicain this work.

3 Results and Discussion

3.1 Result of Mechanical Properties

The mechanical properties are used to determine how a material will behave in a given application and are helpful during material selection for a given product. Values of mechanical properties are presented in Table 3.Tensile strength and flexural strength test value of composite gradually increase fromHC1 to HC8 then slightly decrease due to non-uniform dispersion of nano particle in the polymer material matrix[19]. The impact test value increased in increasing order for HC1, HC2, and HC3 and again for HC4, HC5 and HC6. The highest value was obtained for HC8 composite. Also, as before, the value of impact strength for composite HC9

Table 3 — Mechanical Properties of Hybrid Composites

Composites Mechanical Properties	HC1	HC2	HC3	HC4	HC5	HC6	HC7	HC8	HC9
Tensile strength MPa	8.94	12.60	14.20	21.20	22.00	26.00	27.30	31.80	28.70
Flexural strength MPa	32.30	32.40	32.50	35.35	38.40	39.60	41.26	41.60	35.50
Impact strength (Izod test) KJ/m^2	39.03	41.20	42.90	39.40	41.50	43.21	32.27	43.66	38.09
Hardness Barcol	11	13	18	19	20	21	17	15	10

decreased. The main reason for which is the uneven distribution of nano particles in the polymer, due to increasing the percentage of nanoparticle in the polymer matrix[3], the particle keeps on joining with other particles (cluster), due to which there was a decrease in strength. The hardness value depends on the presence of SiO_2 in the composite and the spot (point) of the indentation during the test. The mechanical properties of the composite made from one layer of bamboo mat were less than that of the composite made from two layer and three layer of bamboo mat. The mechanical properties of the composite with 2 wt.% of the filler material nano silica were higher than the mechanical properties of the composite made of 4 wt.% of nano silica. With further increase of the layer, the mechanical properties generally decreased after a fiber/filler material loading. The use of 4 wt% of nano silica with three layers of natural bamboo fibers, in this case the silica agglomerates with its own atoms. This effects weakness the bond between the fiber and the matrix. While with two layers of natural bamboo fiber, the use of 2 wt.% of silica strengthens the bond between the matrix and the fiber. Due to these reasons a decrease in mechanical properties was observed for composite HC8 to HC9 for tensile, flexural and impact test.

After mechanical testing natural bamboo fiber hybrid composite we observed that the mechanical properties of the composites fabricated through single layer were not good as compared to the other six composite fabricated by two layers and three layers of natural bamboo fiber. We found composite made of two and three layers of natural fiber to be better. We had done morphology test of only six (HC4, HC5, HC6, HC7, HC8 and HC9) composite, in which HDT test, XRD and FESEM. Physical properties of same six composites water absorption test and thickness swelling test were done. FTIR test of filler material nano-silica has been done.

3.2. Water Absorption Test

The water absorption value of composites is shown in the Fig. 1. The water absorption capacity of the composite formed is low due to the hydrophobic nature of the epoxy[26]. As the silica wt.% increased, the water absorption capacity also increased[20]. The water absorption capacity of epoxy and nano fiber alone is comparatively less than the absorption capacity of the composite reinforced with nano silica. Maximum absorption was found in the composite sample HC9 sample. It has been observed that there is a big difference in the water absorption percentage of the composite made with only epoxy and natural bamboo fiber and the composite made with nano SiO_2 (HC4 to HC5). The composite made with SiO_2 has a smaller water absorption percentage (HC5-HC6)[21]. The composite HC9 will have highest water absorption value due to the three layers of natural fiber. The water absorption capacity is directly related to the density, which includes the presence of voids and the bond between the fiber and the matrix. This factor causes water to become trapped in the voids and increase the overall weight.

3.3 Thickness swelling test

Swelling thickness tests were performed on the natural bamboo fiber hybrid composite to analyze the changes of dimensional stability of the composite sample. The results of the thickness swelling test are displayed in Fig. 2. Thickness swelling is very low due to the hydrophobic nature of epoxy[6]. Neat epoxy swelled to a low thickness before being raised[14]. When nano silica particle and natural fiber were reinforced in the matrix the thickness swelling behavior was increased[8]. By increasing the percentage of silica, also the thickness swelling of composite was increased. Due to the maximum water absorption

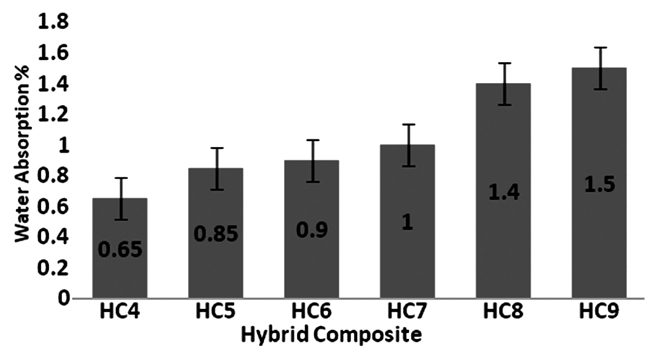

Fig. 1 — Water Absorption v/s Hybrid Composite.

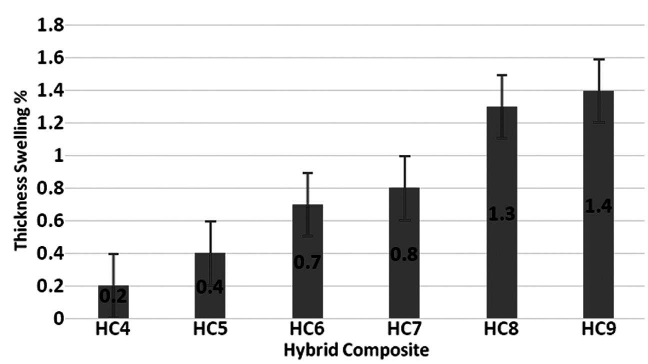

Fig. 2 — Thickness Swelling v/s Hybrid Composite.

capacity of composite, thickness swelling will also be maximum. Furthermore, the poor contact thickness between the fibers/matrix and the distribution of the fibers affects the swelling behavior.

3.4. Heat Defection Temperature (HDT) Test

Heat deflection temperature tests results demonstrate an improvement in the heat resistance capability of the hybrid composite. Made with only natural fiber and epoxy the composite is a soft material that exhibits low heat resistance properties. The addition of nano filler material silica showed an improvement in the heat resistance performance[22]. The uniform dispersion of the nano silica particle increased the heat absorption capacity (HC4 to HC5), thereby reducing the heat deflection tendency of the composites. From observation, it was observed that composite HC4 has a value of 88.8°C and HC5 has a value of 93.2°C there is a difference of 4.4 °C between the two values. The value of HDT increase by 5% on the HC5 compared to the HC4, the reason for this is the uniform dispersion of nano silica in epoxy[7]. Whereas with the rest, the difference was not seen here, the value of HDT for sample HC9 is 95.5°Cis maximum. The presence of fibers can act as nucleating agents in the crystallization process, thereby improving the strength and thermal stability of composites[16]. The HDT results are shown in the Fig. (3).

3.5. X- ray Diffraction (XRD) Test

The XRD result fig (4) shows variation of intensity with sample HC4, HC5, HC6, HC7, HC8and HC9 the intensity maximum was found with HC6composite sample. The maximum intensity ranges from 20 to 25-degree, due to proper mixing of silica and natural bamboo fiber in the epoxy. The results show that the intensity of natural bamboo fiber hybrid composite are in the range of 300-8500au. This reflects the crystalline behavior of the hybrid composite[23]. X-ray diffraction of hybrid composite showed an amorphous peak located at 20.8°(2θ). The highest intensity in XRD graph was found for HC6, which is 8500au. The intensity of HC5 remained around HC6. The graph shows that the intensity of the normal composite in which silica was not added was low. By increasing the fiber loading and keeping 2 wt. % (HC8) of silica, the intensity was good but it was less than HC5. When increasing the fiber loading to 4wt. % Silica, the intensity was obtained less than rest of the composites[10].

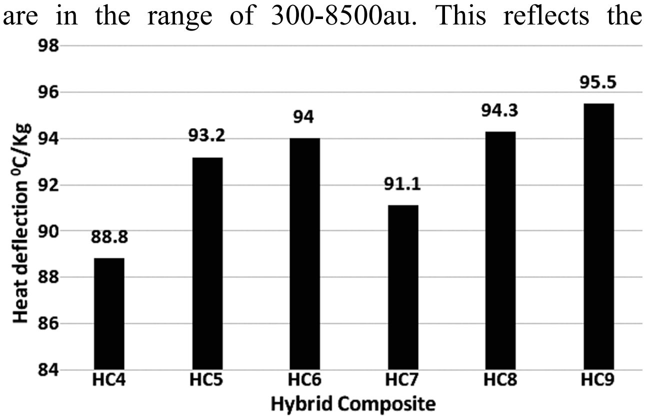

Fig. 3 — Heat Deflection Temperature v/s Hybrid Composite.

3.6. Field Emission Scanning Electron Microscope (FESEM) of Hybrid Composite

The surface morphology of natural bamboo fiber hybrid composite HC4, HC5, HC6, HC7, HC8 and HC9 was performed. Figure 5 it can be seen in composite HC5 that the particle of nano silica are uniformly dispersed in the epoxy[24]. In Fig. 6 composite HC9 this process of cluster formation was accelerated, with greater loading of the silica particle and natural bamboo fiber resulting in larger size of the silica cluster, this reduces the strength of the hybrid composites[14]. Comparatively, HC5 contains 2wt.%

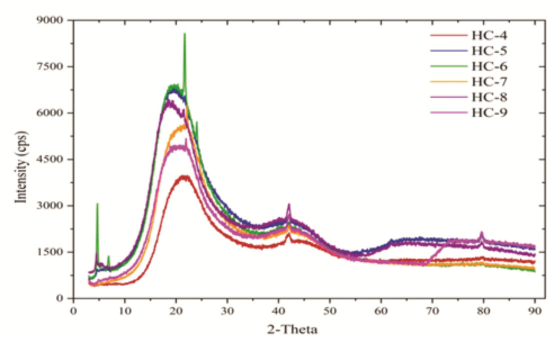

Fig. 4 — Variation of the Intensity of a Hybrid Composite (XRD Graph)

Fig. 5 — FESEM Image of sample HC5 composite

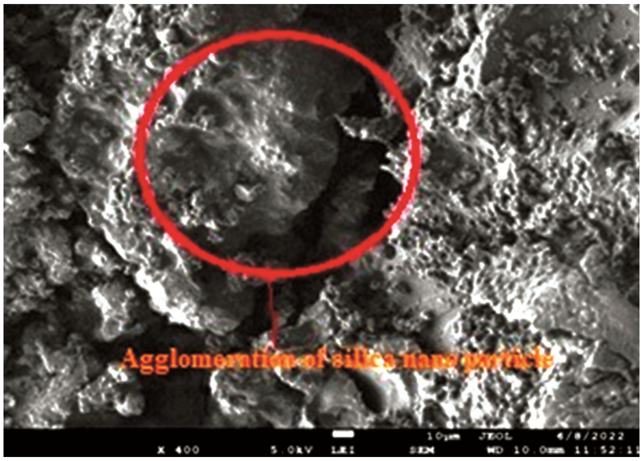

Fig. 6 — FESEM Image of sample HC9 composite.

silica, but we did not find silica clumps in Fig. 5. From this it is possible to say that increasing the percentage of silica with bamboo fiber loading does not allow silica to disperse uniformly with epoxy. The rough surface can be assumed to improve the interfacial bonding between bamboo-fiber and epoxy-matrix through mechanical interlocking. The reduced strength for improved silica awareness can also be attributed to the partial elimination of cellulose, resulting in excessive silica particle damage to the mechanical properties of reinforced hybrid composites[18].

3.7 FESEM of Silica Particle (SiO_2)

The FE-SEM images of amorphous SiO_2 particles at different magnifications. Most of the primary SiO_2 particles ranged in size from 20 to 40 nm. These elementary particles showed a tendency to form larger particles (aggregates). Energy dispersive spectroscopy (EDS) spectrum of the amorphous SiO_2 particles[14], this spectrum only showed the presence of silicon and oxygen. The excess of oxygen with respect to the stoichiometric ratio Si:O = 1:2 may be attributed to the presence of water and Si-OH groups[10]. According to S. Mus et al, the sulphate is not present in EDS spectrum, chloride or sodium ions, thus indicating that these ions were well removed in the mother liquor[23].

3.7 Fourier Transform Infrared (FTIR) of SiO_2

From the FTIR graph of the induced SiO_2. The infrared (IR) band at 3433.64 cm^{-1} is due to the stretching vibrations of the HO molecules[17]. In contrast, the IR band at 1596.77 cm is due to the bending vibrations of the H_2O molecules. The IR band at 2954.41 cm^{-1} can be assigned to the stretching vibrations of the Si–OH group within the structure of amorphous SiO_2. The presence of the Si–OH group is proved to form bonded water[9]. The very strong and broad IR band at 1102.12 cm-1 is assigned to the TO and LO modes of Si–O–Si asymmetric stretching vibrations. The IR band at 950.743 cm can be assigned to the silanol group. Inside the case of alkali silicate glass, this band is assigned to Si–O stretching vibrations. In the IR band at 800.314 cm-1 can be assigned to Si- o - is symmetric stretching vibrations[23]. While the IR band at 469.582 cm-1 is due to the O-Si-O bending vibration.

4 Conclusions

In this research work, polymer matrix composites were prepared through hand lay-up methods by taking 0, 2 and 4 wt.% of nano SiO_2 with different layers of natural bamboo fibers. After preparing the composite, the mechanical properties were tested by making the samples in accordance with the ASTM standard. In which mainly tensile, flexural, impact and hardness test were conducted. WA, TST, HDT, FESEM and XRD test of six hybrid composites with good mechanical properties were conducted, based on the values obtained from mechanical test. Silica is the main component in this work which is to provide good strength to the composite being used. The purpose of current work to develop a polymer blends with high properties, which is environment friendly. FESEM and FTIR analysis of silica particles was also done. The conclusions based on current study are as follows: -

a The value of tensile strength and flexural strength increased continuously from HC1 to HC8, but decreased for HC9, because of the forming a bundles of nano silica particles.

b The value of impact strength increased from HC1 to HC8 with increasing silica wt.% with loading of natural bamboo fiber but for the HC9 a decrease in impact strength was observed. The reason for this is the non-uniform distribution of nano SiO_2in epoxy with fiber loading.

c HDT for the hybrid composite significantly improve by the addition of natural bamboo fiber with silica wt.%. HDT is maximum for the HC9.

d FESEM results show the proper distribution of nano silica particle in HC5 and agglomeration of silica in HC9 samples.

e FTIR result shows the enhancement of inter molecular bond strength between the epoxy.

Proper percentage of silica particles enhances the mechanical properties of the composite.

f XRD is the method for crystallographic characterization for different layers material. XRD results shows, for composite HC8 the intensity was good but it was less than HC5.

From the obtained analysis we found that the composite made of two layer of natural fiber and 2 wt% of silica was better in use than others. It was possible to determine the use of the composite, on the basis of mechanical and morphological properties. Composite HC5 can be used to make parts for vehicles.

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