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Effect of Coupling Agent on Mechanical Properties of Palm Petiole Nanofiber Reinforced Composite

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Abstract. Composites have replaced conventional materials due to their advantages such as low cost, low density, high strength, etc. recently the research has been focused on natural fibers as a suitable replacement for synthetic fibers for reinforcement in composites. Hence, in this work, natural fiber is extracted from palm petiole and this fiber is investigated for reinforcement in epoxy polymer. The fiber is subjected to different chemical treatments for enhancing the surface wetting and Nano cellulose will also be extracted from the fiber. The composite will be fabricated by using handlay-up method by using 1%, 2%, 3% volume fraction of cellulose nanofiber in the epoxy resin. It is observed that the increase of the nanofiber in 3% volume fraction gives the good tensile, flexural and impact strength. So they obtained chemically treated cellulose nanofiber was treated with the amino propyl triethoxysilane and 3% of the silanesilane treated nano-fiber fabricated. Then the mechanical testings of this is compared with the 3% of chemically treated nano-fiber composite. The silane treated nanofiber gives the best results.

1. Introduction

The natural composite have a superior composites compare to the conventional composites [1]. The natural fibers which include banana, coconut, jute, kenaf, palm, sisaletcare widely used as a filler in the composite materials [2]. The applications of the composites are automotive, electronics, packaging, etc... The Cellulose fibers will be low in density, low in the cost, renewable. The cellulose fibers are best in strength and stiffness. The cellulose fibers have a many advantages while compare to the synthetic fiber,they can reduce the environmental problem caused by non-biodegradable materials. The disadvantage of the cellulose fiber is moisture absorption, low thermal stability and poor compatibility with the hydrophobic polymer matrix [3]. In India, Palm trees have a more productive so they are easily available. They also good in the biodegradable.The nano sized cellulose nano-fibers have a good strength and stiffness. They also have good interfacial adhesion with polymer matrices while comparing to the microfibrills [4]. The many processes are used to extract the cellulose nano-fiber and chemical treatment is the one among them. The chemical treatment has a three steps. They are Alkali treatment, Bleaching process and acid hydrolysis process [8]. The commonly used acids are NaOH, NaOCl and H2SO4.The chemical treatment will remove the hemicelluloses, lignin. They can break the hydrogen bonds between the hydroxyl groups and they will improve the surface roughness. The silane coupling agent which bonds with organic and the inorganic materials. They will give a good adhesion, surface modification and a mechanical strength to the composite while comparing to the non silane treated composite materials [6,7]. Here amino propyl triethoxysilane is used for coupling agent.

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2. Experimental

2.1*Materials, Extractions and Fabrications of Cellulose Nanofibers*

Palm petiole fiber was extracted naturally from own source(Pulicat, Tamil Nadu, India), Sodium hydroxide used for alkali treatment (donated by chemistry department) , Sodium hypochlorite (umascientifics) and acetic acid (donated by chemistry Dept) was used for the bleaching process. Sulphuric acid (donated by chemistry Dept) was used for the acid hydrolysis process. Amino propyl triethoxysilane used for a coupling agent (VinayakAuxiChem, Bangalore, India).The natural palm petiole fiber was cut from the tree and it is kept in the room temperature to dry its moisture content for 2 – 4 days. Then the fiber was extracted easily. In the extraction process of the cellulose nanofibers, the alkaline, bleaching and acid hydrolysis process is used. The palm petiole fiber was chopped and sieved. In the alkaline treatment, Thethefiber is dispersed in the NaOHto remove the hemicelluloses content present in the fiber and it is stirred for 1hr at the 350C. Then it is centrifuged for several times by adding the distilled water until the fiber reaches the neutral stage. This treatment can remove the hemicelluloses in the fiber and also used to remove the intermolecular hydrogen bonding. This treatment will repeat once again after the bleaching process. The bleaching treatment, this process is carried out after the alkali treatment. The lignin content was removed during this process and also it uses to remove the color of the fiber. The alkali treated fiber was treated with the sodium hypochlorite and aqueous acetic acid.It is stirred for 1 hr at 350C, then it is centrifuged many times by adding distilled water until the fiber reaches pH.

The alkali treatment is repeated once again after the bleaching process and it washed still it turns neutral. The acid hydrolysis treatment followed. This fiber is dispersed in the sodium hydroxide and it is stirred for 3 hrs at 350C. Then it is centrifuged for 15mins at 7000rpm. Then it is sonicated in the ultrasonic cleaner to obtain the nano sized fiber [5]. The obtained cellulose nano-fiber was treated with aminopropyltriethoxysilane for 8hrs which acts as a coupling agent [9]. They will improve the thermal properties of the nano-fibers.

In the fabrication, the 1% of chemically treated nano-fiber was incorporated with the 99% of the epoxy resin. The2% of chemically treated nano-fiber was incorporated with the 98% of the epoxy resin. The3% of chemically treated nano-fiber was incorporated with the 97% of the epoxy resin. After obtaining the better mechanical properties [10] in the above plates. The silane treated nano-fiber is fabricated in that ratio.

3. Result and Discussion

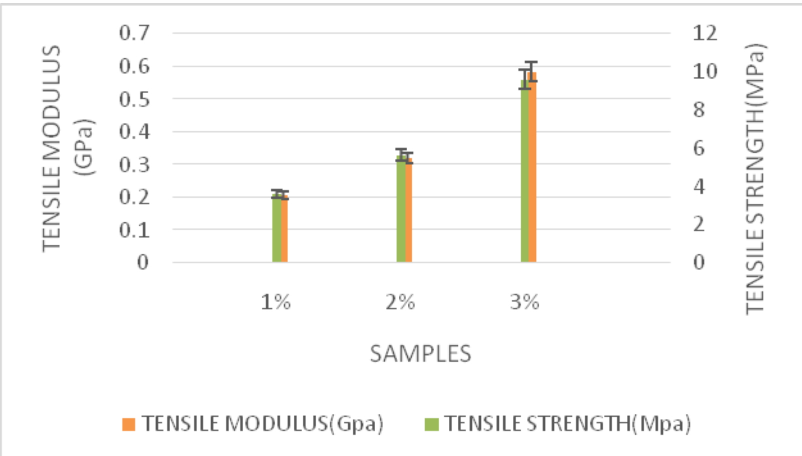

Figure 1. Graph of tensile strength and tensile modulus.

In the case of tensile strength and tensile modulus. Figure 1, shows that the 3% chemically treated nano-fiber reinforced composite have a better tensile strength and modulus while compared to the 1% and 2% chemically treated nano-fiber reinforced composites. It has 9.615 MPa tensile strength and 0.584GPa of tensile modulus. While 1% and 2% of chemically treated nano-fiber reinforced composites have 3.615MPa, 5.641MPa of tensile strength and 0.206GPa, 0.321GPaof tensile modulus respectively.

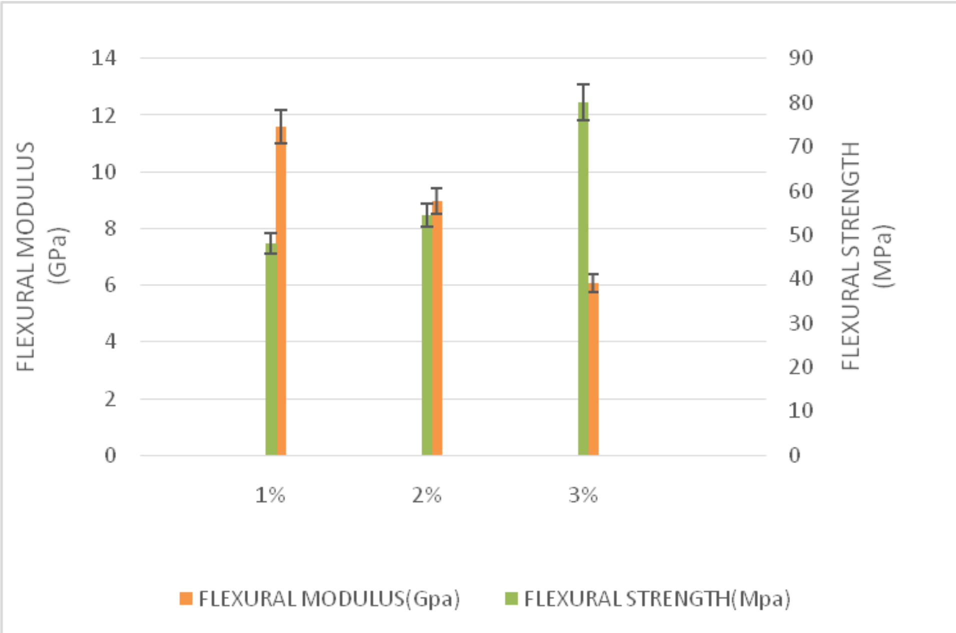

Figure 2. Graph of flexural strength and flexural modulus.

From the figure 2, The composite with the 1% and 2% of the chemically treated nano-fiber have a flexural strength 48.076 Mpa and 54.48 Mpa. Here we can see the rise in the flexural strength due to the addition of nano-fibers. In the 3% of the nano-fiber composite, they give 80.12 Mpa of the flexural strength. Which is greater than the 1% and 2% of the nano-fibers.In the flexural modulus, the 1% of the fiber composite have 11.61 GPa and 2% of the nano-fiber composite. The 3% of the nano-fiber composite have very low flexural modulus of 6.07% compared to the 1% and 2% of the nano-fiber composites. Here we can see the fall in the flexural modulus due to the addition of the nano-fibers.

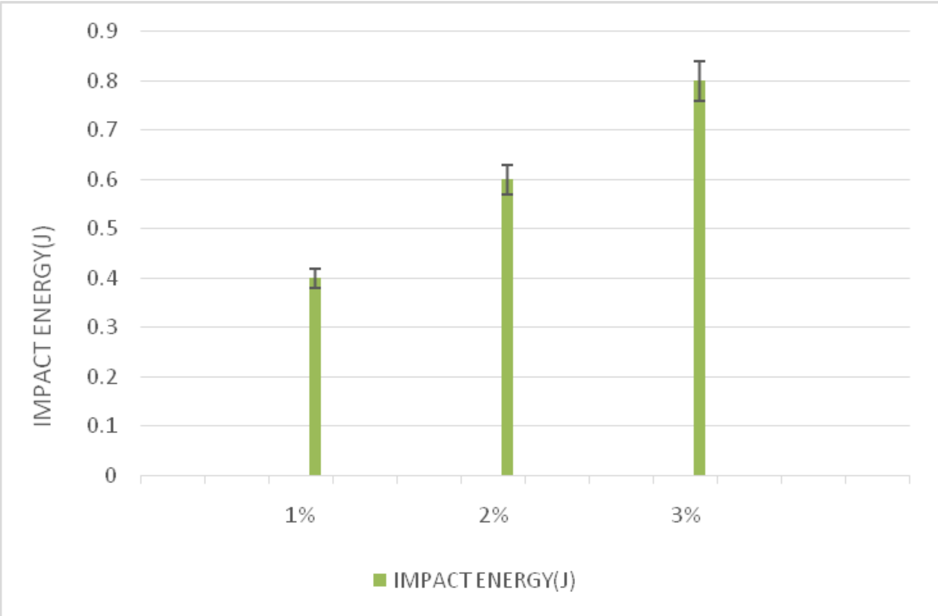

Figure 3. Graph of the impact energy.

In the case of impact energy from the figure 3, it shows that 1% and 2% of the chemically treatednano-fiber composites have a low impact energy of 0.4 J and 0.6 J while compare the 3% of the nano-fiber composites which have 0.8 J.

From this above study, we obtain that 3% of the chemically treated palm petiole nano-fiber have a good mechanical properties while compared to the 1% and 2% of the nanofiber composites. So it is compared with the silane [11]coupling agent treated nano-fiber in the same 3% of the coupling agent treated nano-fiber.

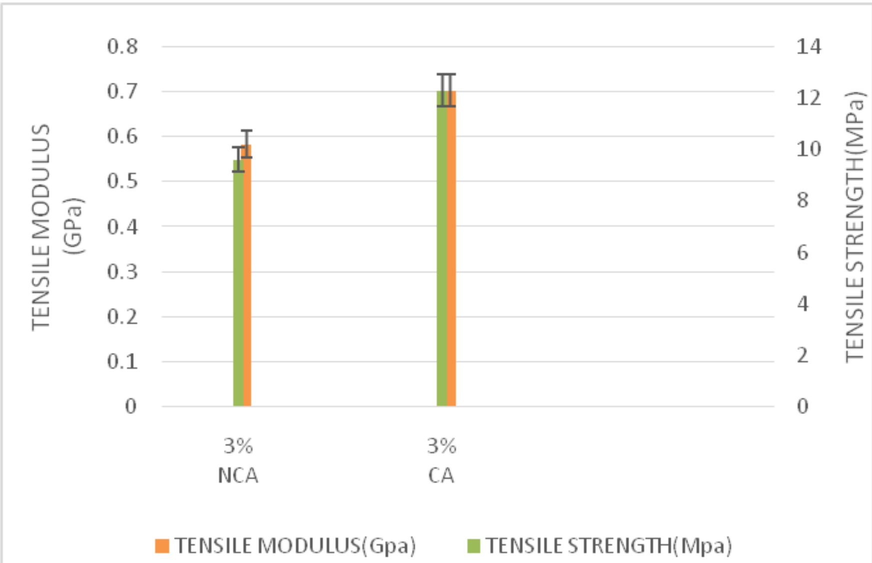

Figure 4. Comparison of NCA and CA for tensile modulus & tensile strength.

From the figure 4, we can see that the chemically treated nano-fiber after treated with the coupling agent (CA) have an improvement in the tensile properties while compare the non coupling agent(NCA) composite.
The tensile strength and tensile modulus of the 3% of the coupling agent nano-fiber composite have 12.308 MPa and 0.703GPa. But the 3% of non coupling agent composite have 9.615Mpa and 0.584Gpa of tensile strength and tensile modulus.

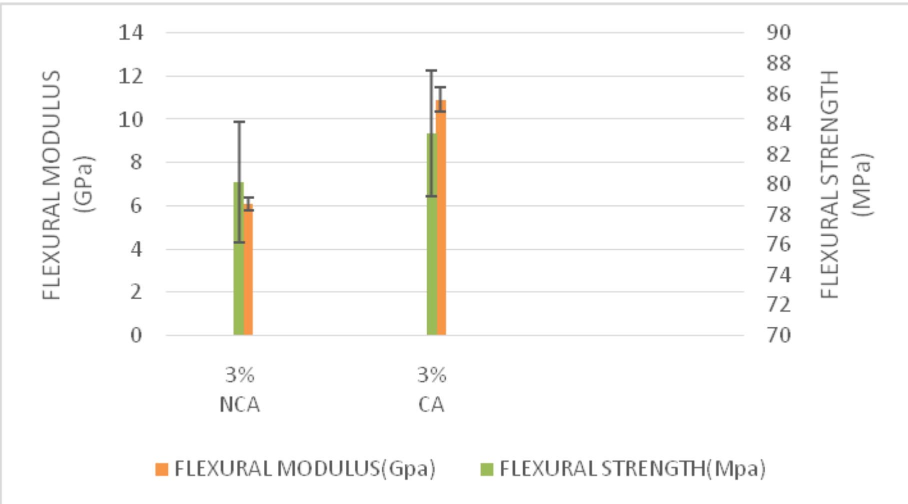

Figure 5. Comparison of NCA and CA for flexural strength and flexural modulus.

In the figure 5, it shows that 3% of the coupling agent composite have 83.33maps of flexural strength and 10.93GPa of flexural modulus. In the 3% of the non coupling agent composite have a 80.12MPa and 6.07GPa of flexural strength and flexural modulus. The coupling agent gives better adhesion with fiber and resin which helps in improving its flexural properties.

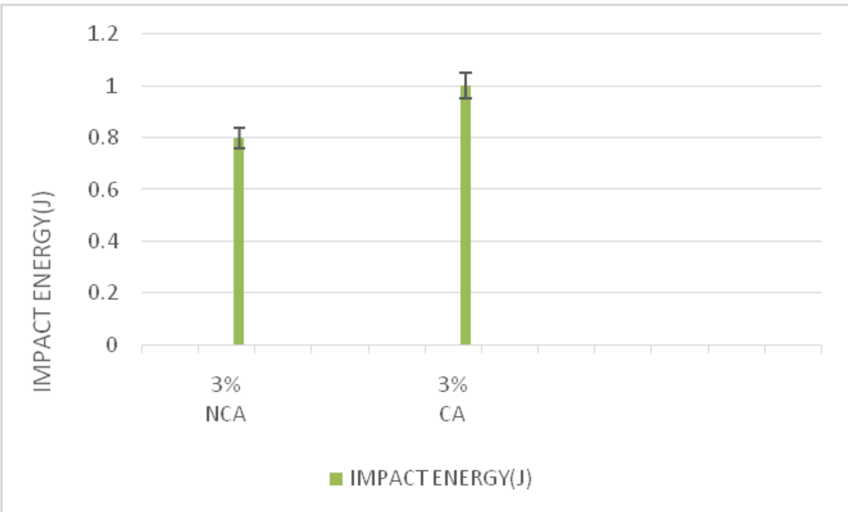

Figure 6. Comparison of NCA and CA for impact energy.

In the figure 6, impact testing also we can see that coupling agent treated composite have an impact energy of 1J while the impact energy of the non coupling agent composite has 0.8J. Which is lesser than the coupling agent treated composite.From this above study, we can observe that the silane coupling agent treated composite have a good mechanical properties while compare to the non silane treated coupling agent.

4. Conclusion

The cellulose nano-fiber was extracted through the chemical process. It is fabricated with the epoxy resin with various amounts of the nano-fiber in 1%, 2% and 3% .For the 3% of the chemically treated nano-fiber composite gives tensile strength and tensile modulus of 9.615MPa and 0.584GPa respectively. In the flexural testing they have 80.12maps of flexural strength and 6.07GPA of flexural modulus. They have a 0.8J of the impact energy. The 3% of nano-fiber composite gives better mechanical while compared to 1% and 2% of the nano-fiber composites. But 3% of the silane coupling agent treated nano-fiber gives a 12.308MPa tensile strength and 0.703GPa tensile modulus. In the flexural testings, they give 83.33maps of flexural strength and 10.93GPa of flexural modulus. In the impact testing they give 1J of impact energy. From this, we can obtain that 3% of silane coupling agent treated composite gives a better improvement in tensile, flexural and impact testings.

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