Investigation on the Effect of Nano Fillers on Tensile Property of Neem Fiber Composite Fabricated by Vacuum Infused Molding Technique

M. Shunmugasundaram¹, A. Praveen Kumar¹, M. Ahmed Ali Baig¹, Yamini Kasu¹
¹Department of Mechanical Engineering, CMR Technical Campus, Kandlakoya, Hyderabad-501 401.

E-Mail: sundarprithiv@gmail.com

Abstract: Now a days, natural fiber based polymer composites are having more attention because of it is good mechanical properties and environment friendly. The foremost aim of this investigation attempt is for examine the effect of the nano-filler over the tensile properties of natural based polymer composite. Just one nano-material is used in most of the research for the production of new composites. In this analysis, the vacuum assisted by infusion molding method uses the neem fiber and two different nano-filler materials for creating new nano infused composites. Neem fiber is chosen as a fiber and LY556 epoxy-resin is selected as polymer materials for the production of reinforced polymer matrix composites of this natural fiber material. Composites of the neem fiber based polymer composites is developed by infused the neem fiber with the nano to examine the tensile property of the neem fiber infused composite and the effect of nano-filler materials. By infusing nanofiller materials to build nano based natural fiber polymer composites; the average ultimate tensile strength for the polymer matrix composite is 15.5 percent.

Keywords: Neem fiber, Vacuum infusion molding, natural based polymer composite, Nano filler materials, Nanofiller infused composites, Tensile strength, Vacuum infusion moulding

1. Introduction

The use of polymer composite began centuries before, and the usage of composites began with natural fibers. The emergence of composites produced by using glass fibers in amalgamation with hard rigid resins over a wide scale took place for the duration of the 1960s [1]. There is rehabilitated attention in the usage of natural fibers as a replacement of glass over the last decade, powered by possible benefits of credence reduction, minimal raw material costs, and environmental benefits [2,3]. These natural fibers are through of many fibrils that run all down the fibers’ length. Hydrogen bonds and other connections are found to give the fibers the requisite strength and stiffness [4].

Many researchers have conducted several studies to improve fiber mechanical properties and the fiber-matrix adhesion for better joining and load relocate, particularly while high fiber stacking is used. Reinforced composite materials of natural fiber are mainly used as low-cost materials with functional structural properties [5]. It is used in applications like as vehicle interior coating, padding of upholstery of electronic [6, 7]. Kenaf has been largely used as a thermoplastic polymer reinforcement.
In addition, kenaf fibers have been used in the automotive, clothing, fibreboard, civil and electronic sectors as nonwoven mats. The addition of particulate reinforcement for matrix/polymer materials often results in certain strength improvements by bonding improvement. The addition of particulate reinforcement for matrix/polymer materials often results in certain strength improvements by bonding improvement [8 -10]. The addition of nano clay increases the macrobonding strength of plywood with uniform strain distribution and also enhances water and heat resistance with the addition of nano-material reinforced plywood panel and found that 3% nano Al2O3 plywood panel has improved flexural properties and screw withdrawal resistance values [11].

Neem fiber is a fiber often used as herbal in medicinal fields, harvested from the neem tree. There have been few studies on neem fiber as a reinforcing material in polymer composites. The thermal steadiness and thermal characteristics of the epoxy composites based on neem/banyan resulted in the 90/45 weight percentage of neem/banyan increasing the composite working temperature to 427 °C and improving the performance to 75 percent [12,13]. The effect of the neem wood epoxy composite stacking series and studied the mechanical properties. The findings showed that the mechanical properties were influenced by the orientation of neem wood fiber in the composite and the higher mechanical properties compared to other combinations were shown by the 0°/90° neem wood epoxy composite [14].

In the present investigation, neem fiber is selected as a fiber material, epoxy-resin as matrix and graphene and multiwalled carbon nano tubes are chosen as nano-filler materials for preparing nano-infilled polymer matrix natural composites. The vacuum infused molding is employed to prepare the natural based composites. Based on ASTM typical the tensile test is used for checking the influence of the developed composites.

2. Materials and Methods

2.1. Materials

The neem fiber has selected as reinforcement and the epoxy-resin has chosen as matrix for preparing natural-fiber reinforced epoxy polymer composite materials. The Araldite LY556 is selected as resin and HY-951 selected as hardener. The neem fiber is supplied by Gogreen composites, Chennai and the resin and hardener is supplied by Pranav industries, Hyderabad. The carbon nano tubes and graphene are chosen as nano materials for preparing nano imparted polymer composites. The weight and ratios for the selected materials are displayed in Table.1.

| Materials used          | Weight and ratios |
|-------------------------|-------------------|
| neem fiber              | 124 Grams         |
| Epoxy-resin - LY-556    | 75 Grams          |
| Hardener - HY-951       | 7.5 grams         |
| Ratio of Resin : Hardener | 100:10        |
| Nano filler materials   | 4 grams           |

2.2. Methods

There are different types of method are available for developing epoxy based polymer based composites. In most the polymer infused composite materials, hand layup process used for preparing polymer based composites. But, the physical and mechanical characteristics of polymer composite
materials are developed by hand lay-up process is less. So, in this experimental investigation the vacuum infusion molding method is employed to prepare the composite materials. The vacuum infusion molding setup is shown in Figure 1 for developing the polymer based composite and nano-filler added polymer composites.

![Vacuum bagging setup for developing composites](image)

**Figure 1.** Vacuum bagging setup for developing composites

### 2.3 Preparation of composites

The seven untreated neem mat species are 20 X 20 (cm) in size and the weight of the neem is 124 g. In order to produce polymer matrix composites, the epoxy-resin is in use at 100:60 percent in reinforcement weight; hardener use as 100:10 from epoxy-resin. The nano-filler is applied to the production of nano-filler added polymer based composites as 4 percent of epoxy-resin. First the 124g of neem fiber is kept on the marble surface, the feel ply in kept over the the neem fiber, the resin infusion mesh is kept over the peel ply and the vacuum film in kept over the mesh. The vacuum pump is on and the resin is infused with neem mat and the developed neem polymer matrix composites are shown in Figure 2.

![Neem mat](image) ![Neem composite](image) ![Graphene infused composite](image) ![Multiwalled carbon infused composite](image)

(a) Neem mat  (b) Neem composite  (c) Graphene infused composite  (d) Multiwalled carbon infused composite

**Figure 2.** Neem based polymer composites
2.4. Specimen extraction

The polymer composite based on neem is developed and permitted for drying (24 hours) and is removed from the setup of the vacuum bagging. The standard of the ASTM is employed for extraction of tensile examination samples. To identify the tensile property for the formed neem composite and nano-filler added composites, the tensile test samples is cut based on ASTM D3039. Different types of examination by engineers and exclusive often identify the proper use of the produced composite. The sample is taken from each of the composites with a scale of 200 X 15 X 3 X 3 (mm). Tensile strength is the most significant mechanical property and for tensile tests are extracted according to ASTM standard sample specimens, and the specimens are shown in Figure 3.

![Figure 3. ASTM standard and extracted samples for tensile examination](image)

| S.No. | composite                                           | Tensile strength (MPa) |
|------|-----------------------------------------------------|------------------------|
| 1    | Neem based polymer matrix composite                 | 57.24                  |
| 2    | Graphene infilled neem composite                    | 82.68                  |
| 3    | Multiwalled carbon nanotubes infilled neem composite| 79.45                  |
3. Results and Discussion

Composite materials and nano-filler added natural fiber composites are prepared from neem fiber-based polymer matrixes. The neem fiber is used to prepare the effect of neem fiber and nano-fillers on composites tensile strength for testing. The specimen is taken from each composite with a scale of 200 X 15 X 3 (mm). Employed an automated universal testing machine, the elongation strength of the specimens is deliberate, and examined specimens are displayed in Fig.4. The Table 2 and Fig.5 show the outcome for the neem toughened polymer-matrix and nano-infilled composite of tensile examination. The maximum tensile property of the neem-reinforced polymer composite materials are 57.24 MPa and the maximum tensile strength of the nano infused composite (multi-walled nano tubes and graphene) is 67.45 MPa and 68.37 MPa respectively. The mean value of tensile strength of the untreated type of neem fiber composites is 58.58 MPa and is almost equal to the developed composites [15]. It shows that the adhesion within the reinforcement and matrix material is so good for developed composites.

![Tested natural based composite and nano infused composites specimens](image)

**Figure 4.** Tested natural based composite and nano infused composites specimens

The result evidently shows that the nano materials are increasing the tensile strength of the neem based composites. By incorporating carbon nanotubes and graphene for the preparation of natural based nano-infused composites. The tensile characteristics of graphene nano-composite nearly is augmented from 57.24 MPa to 68.37 MPa and multi-walled carbon nano tube composite is increased from 57.24 MPa to 67.45 MPa. The tensile property of natural based composite in augmented by infusing graphene and multi-walled carbon nano tubes are 11.13 MPa and 10.21 MPa. By combining the 4 percent graphene nano-filler for the production of graphene-infilled polymer matrix composites, almost 16.38 percent of the maximum tensile strength is elevated. correspondingly, 4 present of multi-walled carbon nano-tubes improved the composite's tensile property by 15.13%. It evidently demonstrates that, due to the bonding between the reinforcement, resin and fillers, the tensile strength is increased. The bonding between the resources used in these developments of neem fiber composites has been produced by the vacuum bagging process.
Figure 5. Tensile strength of natural polymer composites

4. Conclusions

From the above investigation, the neem fiber is chosen for reinforced material, epoxy based resin as matrix material and graphene, multiwalled carbon nano tubes are chosen as nanofiller materials for developing nanofiller infused neem fiber polymer based composites. The vacuum created by vacuum infusion molding is utilized to develop the composites and the tensile test is employed to examine the maximum tensile strength for the developed composites.

- The tensile strength of graphene nano composite nearly is increased from 57.24 MPa to 68.37 MPa and multi-walled carbon nano tube composite is increased from 57.24 MPa to 67.45 MPa.
- The tensile strength of natural based composite material is augmented by infusing graphene and multi-walled carbon nano tubes by 11.13 MPa and 10.21 MPa respectively.
- By combining the 4% graphene nano-filler with epoxy-resin for the production of graphene infused polymer matrix composites, almost 16.38 percent of the maximum tensile strength is augmented. Similarly, 4 present of multi-walled carbon nano-tubes improved the polymer-matrix composite's tensile strength by 15.13%.

References

1. Hazarika, S.B., Choudhury, S.U., , Panja, S.S., Dolui, S.K., Ray b.C., (2015) ‘Natural fiber reinforced polyester based biocomposite: agro waste utilization’, Journal of Scientific & Industrial Research 74 (5), pp. 589-594.
2. Loganathan, T.M., Sultan, M.T.H., Jawaid, M., Shah, A.U.M., Ahsan, Q., Mariapan, M., Majid, M.S.B.A., (2020) ‘Physical, thermal and mechanical properties of areca fibre reinforced polymer composites — an overview’, Journal of Bionic Engineering 17(1), pp.185-205.
3. Shunmugasundaram, M, Praveen Kumar,A, Amudhavalli, NK, Sivasankar, S, (2020) ‘Investigations on the Tensile and Flexural Properties of Vacuum-Infused Areca Polymer
Nanocomposites., Advances in Lightweight Materials and Structures. Springer Proceedings in Materials, 8 (1), pp. 243-251.

4. Jothibasu, S., Mohanamurugan, S., Vinod, A., (2018), ‘Influence of chemical treatments on the mechanical characteristics of areca sheath-flax fibres based epoxy composites’, Rasayan Journal of Chemistry, 11(3), 1255-1262.

5. Prabakaran, J., Santhosh, S., Saravankumar, C., Rabins, R. S.: Investigation of mechanical properties in Areca (betel nut) and sisal fiber with epoxy composite. Journal for Research 3(1), 23–27 (2017).

6. M Shunmugasundaram, P Anand, M. Ahmed Ali Baig, Y Kasu, (2020) ‘Experimental Investigation on Tensile Property of Vacuum Infused Kenaf-Based Polymer Composite with the Presence of Nanofillers’, Advances in Lightweight Materials and Structures. Springer Proceedings in Materials, 8 (1), pp.265-272.

7. Dhanalakshmi, S., Ramadevi, P., Basavaraju, B.: A study of the effect of chemical treatments on areca fiber reinforced polypropylene composite properties. Science and Engineering of Composite Materials, 24(4), 501–520 (2017).

8. Padmaraj, N., Keni, L.G., Chetan, K., Shetty, M (2018): ‘Mechanical characterization of Areca husk-coir fiber reinforced hybrid composites’, Material Today: Proceedings, 5(1), pp.1292–1297.

9. Srinivasa Rao, K., Srinivasa Varma, B., Ahmed Ali Baig, M., Santosh. V Kulakarni, ‘Prospective Use of Sustainable Royal Palm Fiber for Substitution of Particle Board Applications’, Journal of Green Engineering, 10(9), pp. 5104–5117.

10. Sridhar Babu, V. Srikanth, Y. Balram, Vishnuvardhan, T. Maugal Ahmed Ali Baig, ‘Numerical Analysis on the indentation behavior of Ti-6Al-4V Alloy’, Materials Today: Proceedings, 19(1), pp.827–830.

11. Shunmugasundaram, M. Maugal Ahmed Ali Baig, Ajay Kumar, M. ‘A Review of Bio-Degradable Materials for Fused Deposition Modeling Machine’, Materials Today: Proceedings 27 (1), pp. 1596 -1600.

12. Ajmeera Ramesh, Ramu, K. , Maugal Ahmed Ali Baig, Dinesh Guptha, E. (2020) ‘Influence of Fly Ash Nano Filler On the Tensile and Flexural Properties of Novel Hybrid Epoxy Nano-Composites’, Materials Today: Proceedings 27(1), pp.1252 -1257.

13. Arjmand, M., Chizari, K., Krause, B., Potschke, P., Sundararaj, U.(2016), Effect of synthesis catalyst on structure of nitrogen-doped carbon nanotubes and electrical conductivity and electromagnetic interference shielding of their polymeric nanocomposites. Carbon, 98(1), pp.358–372.

14. Deep, N., Mishra, P., (2018). ‘Evaluation of mechanical properties of functionalized carbon nanotube reinforced PMMA polymer nanocomposite’. Karbala International Journal of Modern Science 4(1), pp.207–215.

15. Ramesh, M., Deepa, C., Aswin, U.S. et al. (2017), ‘Effect of Alkalization on Mechanical and Moisture Absorption Properties of Azadirachta indica (Neem Tree) Fiber Reinforced Green Composites’, Trans Indian Inst Met 70(1), 187–199 (2017). https://doi.org/10.1007/s12666-016-0874-z