Effect of Post Chemical Treatment on Mechanical Properties of Jute/Teak Wood Powder Hybrid Composites

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Abstract

This article presents the effects of alkali treatment (NaOH) on mechanical properties of natural fiber reinforced polyester composites. In the current study composite specimens are prepared using treated and untreated jute fiber and teak wood powder as reinforcement phase and polyester resin as matrix through hand layup technique as per the ASTM D256, ASTM D638 standards. The fabricated specimen was subjected to tensile and impact testing for both treated and untreated. The mechanical properties were analysed through load -displacement curves. The mechanical properties increased with increasing fiber content. Further, the densities of composites were decreased with increasing fiber content. The fracture surface analysis on failure region was studied through scanning electron microscopy (SEM) and the nature of failure was reported.

Keywords: Tensile strength, Impact strength, Jute fiber, Teak wood powder and SEM

1. Introduction

In the present era, the natural fiber-reinforced composite is a key subject to many researchers, academicians, and scientists. Over the past, so many decades, different kinds of research were conducted to create novel natural fiber-reinforced polymer composites with superior mechanical characteristics [1]. This natural fiber-reinforced polymer composite material has huge potential to replaceable synthetic materials [2-4]. Now the major research has been focusing on those polymer matrices reinforced with various wood fillers. The addition of wood particulate enhances the numerous features of polymer composites [5, 6]. The wood powder fillers are sufficiently available and it is cost-effective in the utilization of polymer composites as referred to fillers like nano-clays, carbon nanotubes, and various inorganic fillers. The utilization of filler improves the mechanical properties of composites. The high-density polyethylene (HDPE) was loaded with Pinecone filler at various wt% like 5, 10, 15, and 20%. The experimental results exploit that the 10% addition of filler boosted the mechanical properties of composite as well its elastic and flexural modulus [7]. The sal and teak wood powders are used to fabricate hybrid epoxy composites with a distinct composition by keeping the composition of reinforcement within the matrix around 33%. This study reveals that the equal quantity powder reinforced composites have better tensile, flexural, and impact strength, and also it is also noticed that the inclusion of both powders reduces the water absorption [8]. The hardness was improved by reinforcing Fagus Orientalis wood flour in high-density polyethylene. The particle size of filler has a significant effect on the hardness of composites. The increase in the size of particulate reduces the hardness of the composite. On the other hand, 50% of retainment in mechanical properties was noticed and there is a slight decline in impact strength at an elevated proportion of reinforcement [9]. The jute fiber reinforced epoxies composite are fabricated by using Calotropis gigantean filler with various weight percentages and tested for mechanical characterizations. From the results, the 10 wt% of filler composite laminates shows excellent tensile, flexibility, and compression strength [10].

Chemically transformed powder fillers augment the thermal and mechanical qualities of polymer composites. The incorporation of alkali-treated Portunus sanguinolentus shell powder filler results in enhancement of mechanical properties of composites [11]. The polyester -banana fiber laminates were loaded with nano green gram husk filler with various wt. % reinforcements. Among the all fabricated composite the 5% nano green gram husk filler made known the addition of nano filler improve the strength of laminate [12]. Spent Camellia sinensis kernel and Azadirachta indica kernel flours are utilized as a filler material for the fabrication of jute epoxy laminates. The test results of laminates testimony that morphological and physical characteristics of filler have a crucial part in the thermo-mechanical behaviour of composites [13]. The banana fiber-based polyester hybrid composites were fabricated by using red mud filler to rise in vibration, chemical, and physical properties of the composite [14]. The results of clean and hybrid composites are fabricated from jute and coir fibers were tested for their mechanical and swelling characteristics. The results illustrated that coir-jute fibers utilization pick up size constancy and superior mechanical strength [15]. From the wide range of literature review, it was established that there are a few reports that were practically narrated to bio fillers and that too very little work related to teak wood powder as fillers in the polyester composites. In the present work, polystyrene was chosen as a matrix, jute fibers as reinforcements, and teak wood particulates as filler. The hand layup procedure is opted to make up the composites. The fabricated composite laminate was examined for mechanical characteristics. The fractography, destitute, teak powder disbursement qualities of the formed composites were researched by using SEM.

2. Materials and Methodology

Unsaturated polyester resin of grade ECMALON 4411 was purchased from ECMASS Resins Pvt., Ltd. (Hyderabad, India). The resin has a density of 1242 kg/m^3, Young's modulus of 615M Pa, tensile strength of 29.2M Pa, and elongation at break of 4.5%.

Extraction of Fibers: The extraction of fibers involves the retting process followed by decorticating. The stems of jute plant were cut at their base and immersed in a water-retting tank for two weeks. Then they were removed, the fibers were stripped from the stalks by hand, washed, and dried in the sun. After drying, any extraneous matter that might still be adhering to them was removed. The extracted fibers were used for composite making.

Teak wood powder: The teak wood powder collected from different local sources and the size of teak powder particle measured with the help of Vibrating Sieve Shaker Machine at three different levels.

2.1 Fabrication and Testing of Composites

Fabrication of composites: Unidirectional composites were prepared using polyester matrix to assess the reinforcing capacity of jute fiber and teak wood powder. The quantity of accelerator and catalyst added to resin at room temperature for curing was 1.5% by volume of each resin. The hand lay-up method was adopted to fill up the prepared mould with an appropriate amount of polyester resin mixture and unidirectional jute fiber and teak wood powder, starting and ending with layers of resin. Fiber deformation and movement should be minimized to yield good quality unidirectional fiber composites. Therefore, at the time of curing, a compressive pressure of 0.05 MPa was applied on the mould and the composite specimens were cured for 24 h. The specimens were also post-cured at 70^{0}C for 2 h after removal from the mould. Composite samples were prepared with five different percentage volumes of jute fibers and teak wood powder. The picnometric procedure was adopted for measuring the density of the composite.

The impact and tensile properties of the composite, the specimens are prepared according to ASTM D256, ASTM D638 standard by using hand lay-up technique with different weight ratio as shown in table 1.

Table.1 Composite specimen Preparation weight Percentages

Test specimen	Weight percentages of specimens
T1	0.5g Teakwood powder(untreated)
T2	0.5g Teakwood powder(treated)
T3	1.5gm fiber (untreated)
T4	1.5gm fiber (treated)
T5	0.3gm Teakwood powder +1.5g fiber (untreated)
T6	0.3gm Teakwood powder + 1.5g fiber (treated)
T7	0.5gm Teakwood powder + 1.5g fiber (Untreated)
T8	0.5gm Teakwood powder + 1.5g fiber (treated)

2.2 Tensile testing

The tensile properties of the composites were measured as per the standard test method, ASTM D 638 M. Test specimens 160 mm long, 12.5 mm wide, and 3 mm thick were prepared. Five identical specimens were tested for each percentage volume of fiber. Overlapping aluminum tabs were glued to the ends of the specimen with araldite filling the space at the tab overlap to prevent compression of the sample and also for effective gripping in the jaws of the chuck. The specimens were tested at a crosshead speed of 2 mm/min, using an electronic tensometer (METM 2000 ER-1), supplied by M/s Mikrotech (Pune, India).

2.3 Impact testing.

Izod impact test specimens were prepared in accordance with ASTM D 256 M to measure impact strength. The specimens were 63.5 mm long, 12.7 mm deep, and 10 mm wide. A sharp file with included angle of 45 was drawn across the center of the saw cut at 90 to the sample axis to obtain a consistent starter crack. The samples were fractured in a plastic impact testing machine (capacity 21.68 J), supplied by M/s International Equipments (Mumbai, India), and the impact toughness was calculated from the energy absorbed and the sample width. The materials were used to prepare the specimens are teak wood powder, Jute fibre and polyester resin. To improve the bonding strength between fiber and matrix heat treatment was conducted for jute fibre and take wood powder. The tensile experiments are conducted on universal testing machine with transfer speed of 2 mm/min and the impact study was conducted izod impact testing machine.

Figure-1 (a) Jute fiber, (b) Teak wood powder, (c) Chemical treatment, (d) Mould preparation, (e) Specimen for impact test (f) Specimen for tensile test

3. Results and Discussions

The chemical treatment effect on composites specimens shows an important role in tensile behaviour of polyester composites and it was gradually increased with increase with reinforcement phase. The higher tensile load bearing capacity was recorded for T6 specimen because of excellent bonding strength and combination of fiber and teak wood powder. In maximum cases the specimen shows high level strength after chemical treatment because of surface roughness of fiber enhances the superior bonding strength, and it is observed from scanning electronic micrographs. The composite samples are exhibited lower-level displacement with irrespective load and chemical treatment. The diminished tensile strength and bearing capacity is noted at T1 sample. The figures 3 shows the load versus displacement curves for better understanding of mechanical behaviour of polyester composites.

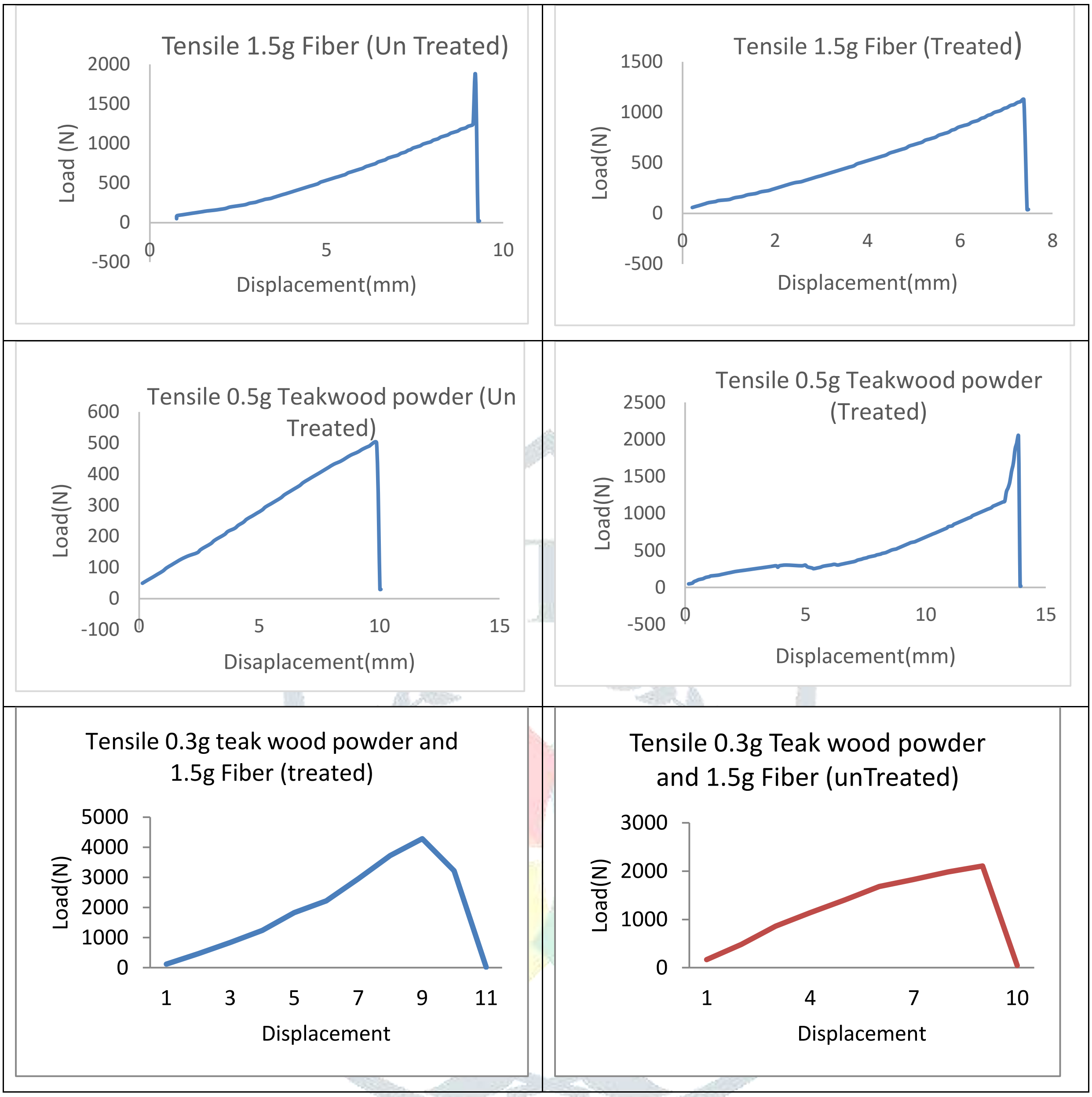


Fig.3 Tensile Behaviour of Composite Specimens

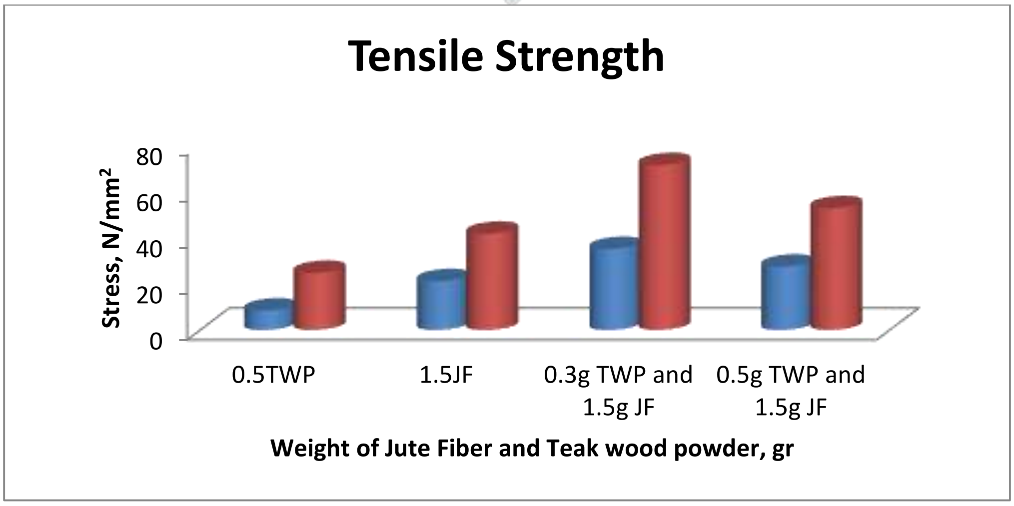


Fig.4 Tensile Behaviour of Composite Specimens

From the comparative graphs, it is observed that increasing in weight fraction of fiber and teakwood powder, the tensile strength of the proposed composite material also increased up to 0.3 g of TWP and 1.5g JF and further increase in weight fraction leads to decrease in strength of composite materials.

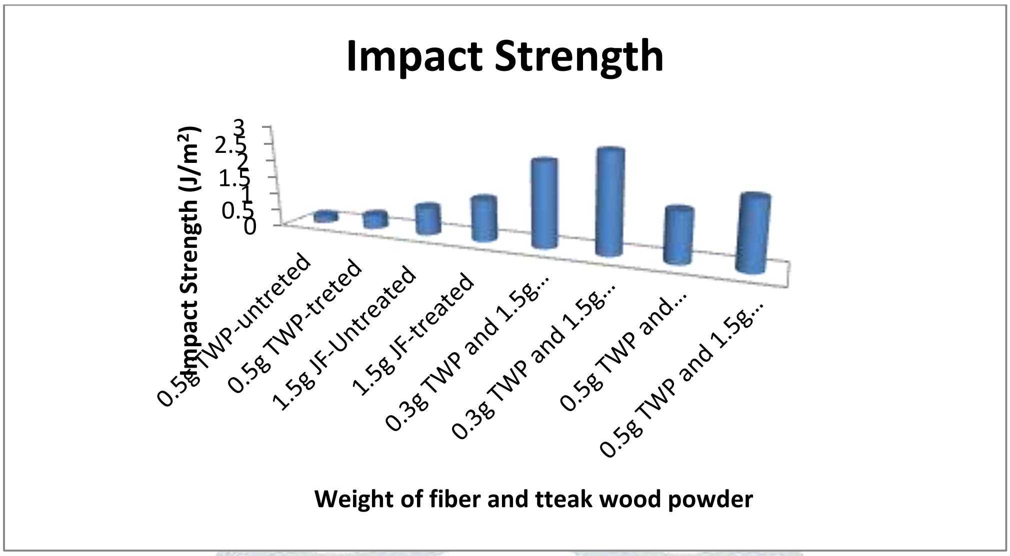
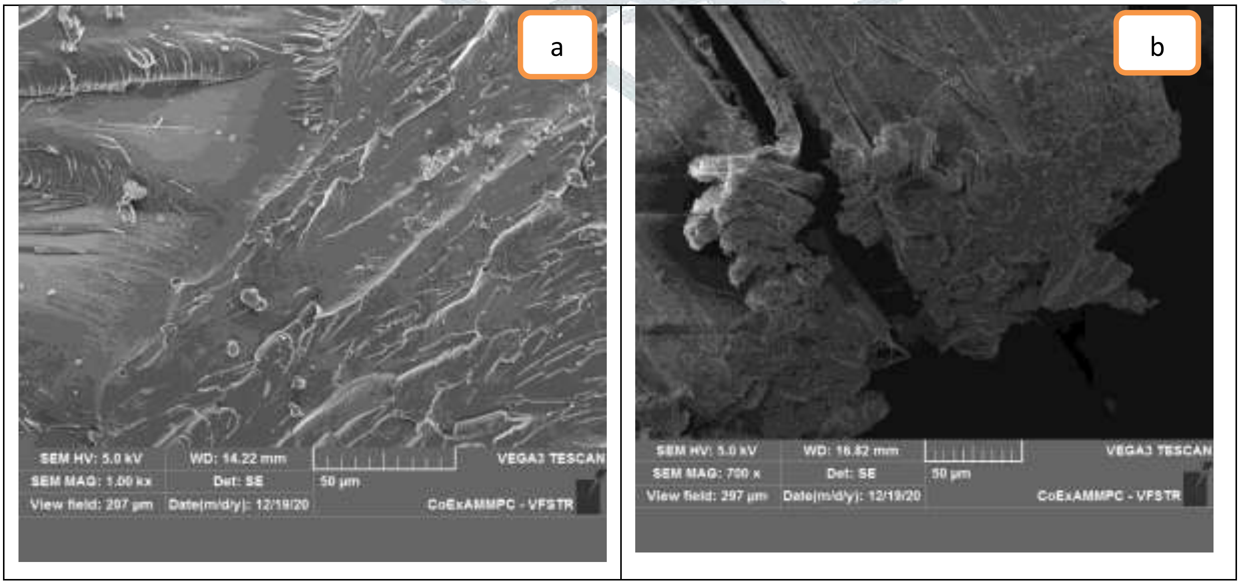


Fig.5. Impact strength of specimens

The figure 5 shows the impact strength of polyester composites. The impact strength significantly enhanced through alkaline treatment of polyester composite. After chemical treatment the impact strength of composite increased due to the roughness on the surface of fiber which affects the impact strength. The maximum impact strength is observed at T6 specimen due to the presence of teak wood powder and bonding strength jute fiber in sufficient level. The specimen T1 has low impact strength due to it contain untreated fiber which has lower bonding strength among the fiber and matrix phase. It is clearly noticed that the impact strength of composite was enhanced with treatment of fiber as well teak wood powder.

Fracture analysis of polyester jute fiber reinforced composites

The fracture surface was examined through the scanning electron microscope micrographs of T1,T6 under tensile loading condition, This micrographs discloses the nature of failure of composite specimen. The Fig 5a discloses the uniform teak wood powder distribution in the polyester matrix. The internal cracks were noticed from the figure 5b due to tensile load and exhibit the brittle failure of specimen. The fiber pulls out and de-bonding is observed from the figure 5d for tensile specimen T6 under tensile load. The fiber distribution is captured at figure 5c.



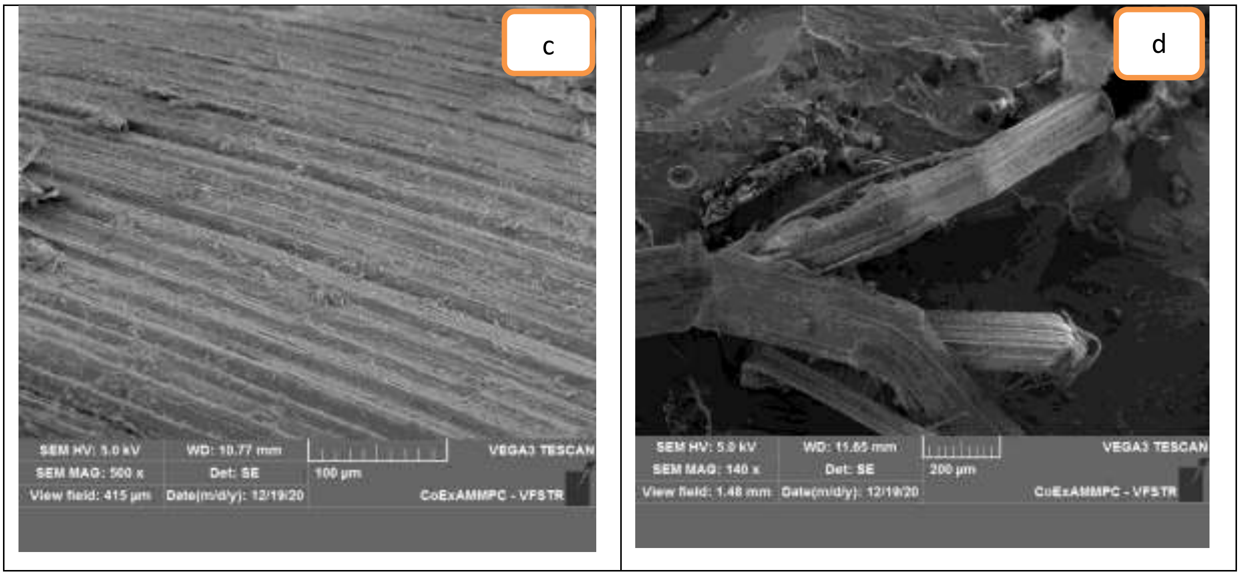


Fig .5. Sem Images of impact and Tensile samples

4. Conclusion

In this work the fiber- reinforced polyester hybrid composites were prepared as per ASTM standards. The jute fiber and teak wood powder is available abundantly in nature and offers low material density. The impact strength and tensile strength of the investigated material composite with the fiber and teak wood powder were found to be comparatively higher than novel composite material. The density of the composite decreased with increasing fiber content. Thus, the hybrid composites were found to be in light in weight and proposed better mechanical properties and insulating properties. The fracture surface studied through the SEM images.

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