Influence of Teakwood Particulates on Mechanical Behavior of Biodegradable Polyester Hemp Fiber Reinforced Composites

K VenkataRao[1], Y Kalyansai[2], B Saisuryavarun[3], P Rakesh[4], V Mouryachandra[5]

[1]Assistant Professor, ME Department, P V P Siddhartha Institute of Technology, Kanuru, Vijayawada, A.P, India.

[2,3,4,5] UG, ME Department, P V P Siddhartha Institute of Technology, Kanuru, Vijayawada, A.P, India.

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 D638, ASTM D790 and ASTM D256 standards. The fabricated specimen was subjected to tensile, flexural and impact testing for both treated and untreated. The mechanical properties were analyzed through load -displacement curves. The fracture surface analysis on failure region was studied through scanning electron microscopy (SEM) and the nature of failure was reported.

Keywords: Hemp, Jute-fiber, alkaline, hybrid, tensometer

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 Portunussanguinolentus 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 Azadirachtaindica 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 Methods

The materials were used to prepare the specimens are teak wood powder, Hemp fibre and polyester resin. To improve the bonding strength between fiber and matrix heat treatment was conducted for hemp fibre and take wood powder.

2.1 Fabrication of composites:

The tensile, flexural and impact properties of the composite, the specimens are prepared according to ASTM D638, ASTM D790 and ASTM D256, standard by using hand lay-up technique with different weight ratio as shown in table 1.

Table 1: Test specimens of different compositions and weight percentages.

Test specimen	Weight percentages of specimens
T1	0.5 gm teakwood powder (treated)
T2	0.5 gm teakwood powder (untreated)
T3	1.5 gm hemp fiber (treated)
T4	1.5 gm hemp fiber (untreated)
T5	1.5 gm hemp fiber and 0.3gm teakwood powder(treated)
T6	1.5 gm hemp fiber and 0.3gm teakwood powder(untreated)

2.2 Testing of composites:

Tensile test, bending test and impact test were performed on the specimens for the analysis. Tensile and bending test are performed on the tensometer and impact test is performed on the izode impact testing machine. The Tensometer and Izode impact testing machines are shown in below figure 1 and figure 2.

Fig.1. Tensometer

Impact test before impact load

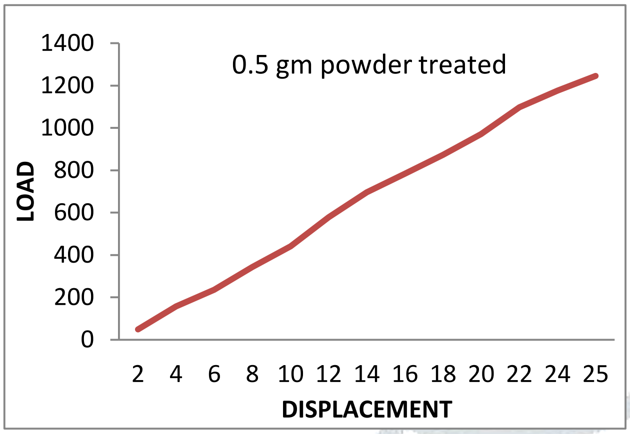
Impact test after impact load

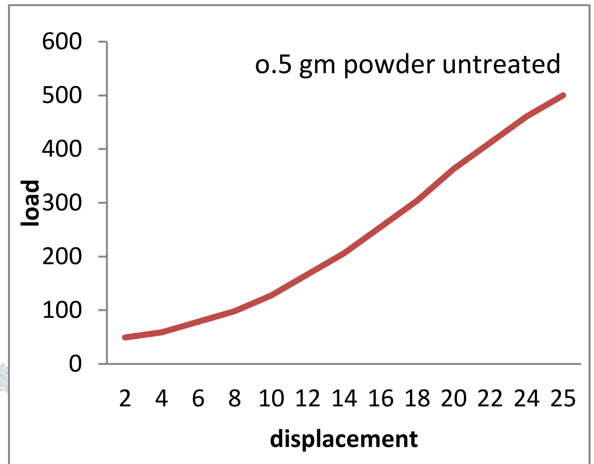
fig.2. Izode impact testing machine

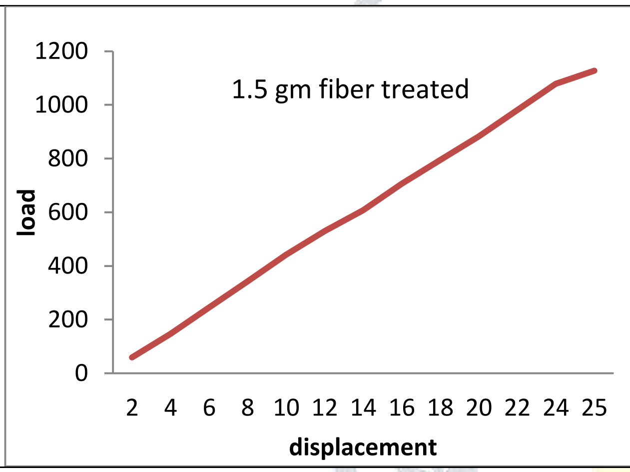
Since the specimens acquired the specific shape, the dimensions for the each test should be different according to ASTMD256 and ASTMD638. According to the weight percentages and compositions, the specimens made for each test with respective dimensions. The powder and the fibers are treated both with heat and chemical (NaOH). The respective figures are shown below in figure 3.

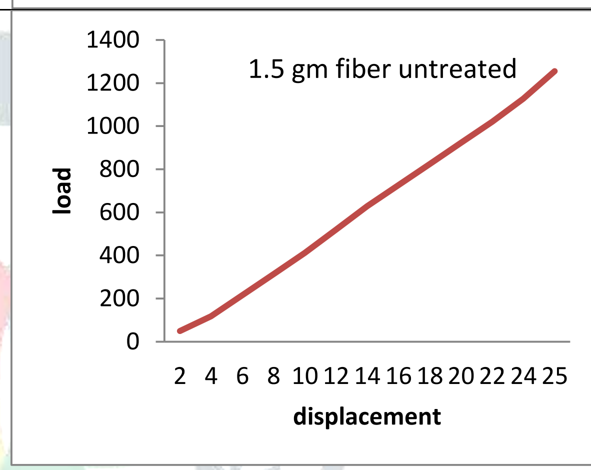
fig.3; a. standard mould; b. chemical treated fiber; c. chemical treated powder; d. heat treated powder; e. tensile test specimens; f. impact test specimens; g. bending test specimens.

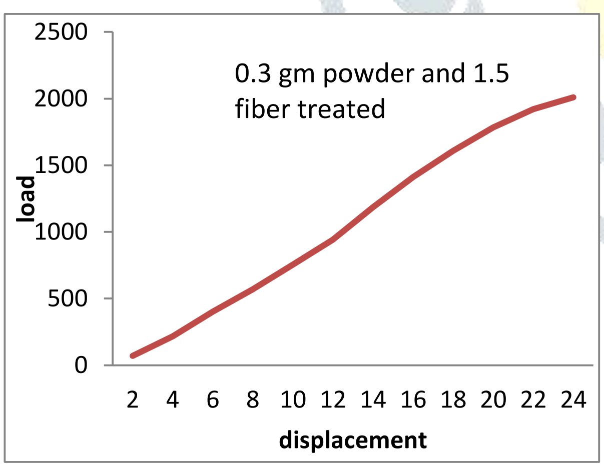
3. Results and Discussions:

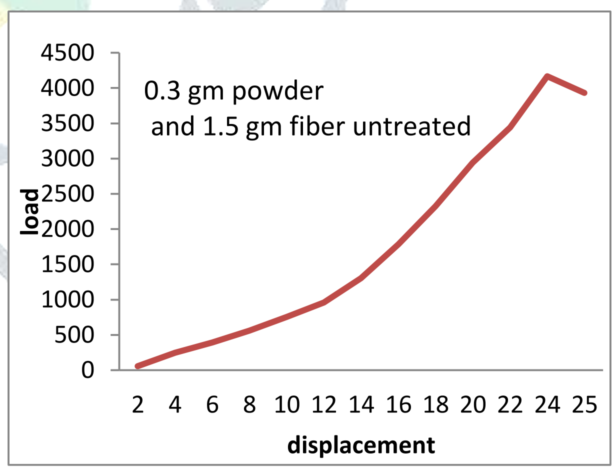












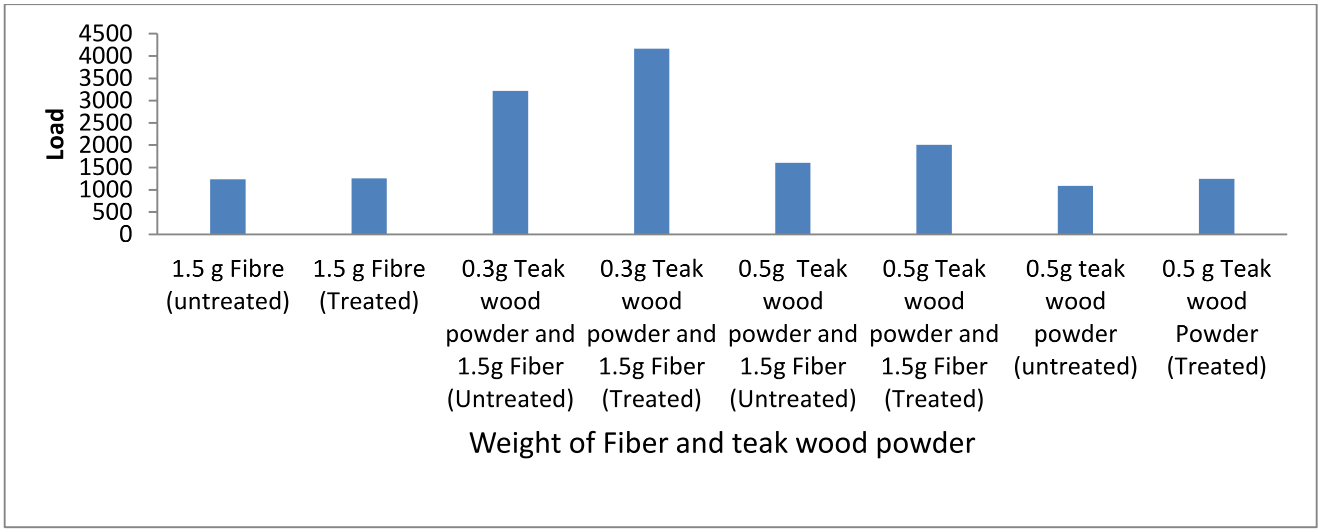
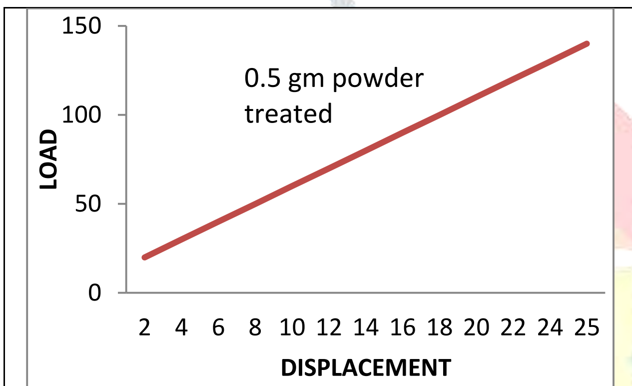
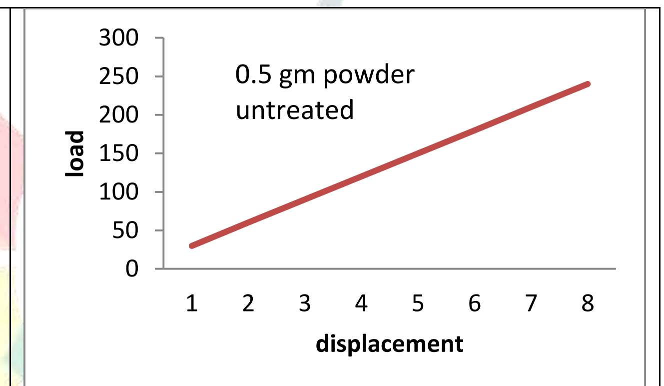
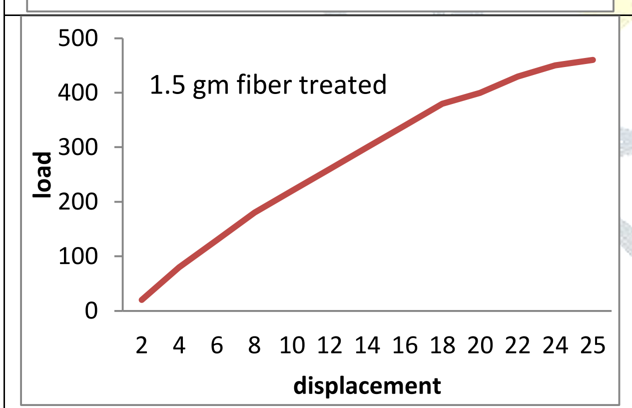


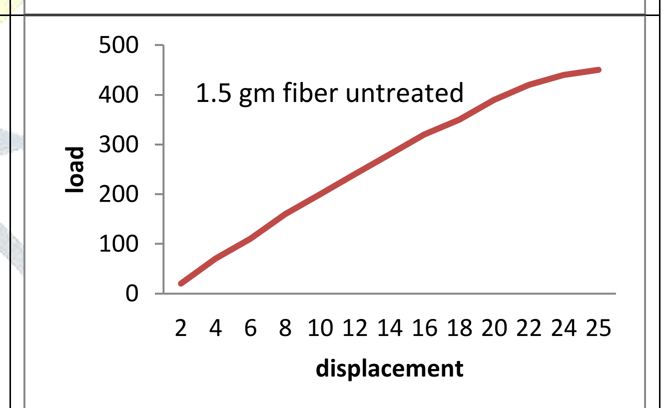
fig 4. Tensile Behaviour of test specimens

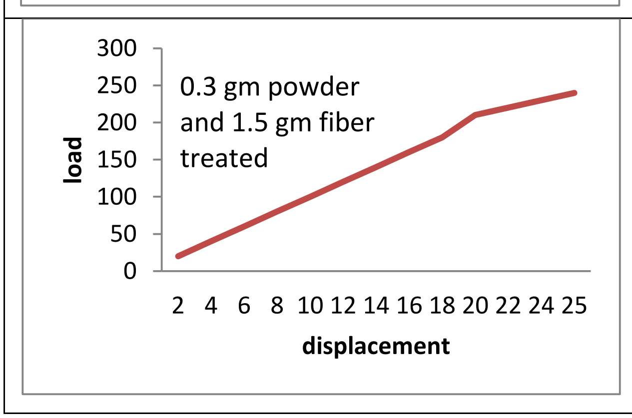
From the above observations, we can conclude that, the tensile strength increases with the increase in the weight composition of the fiber and powder, but further increase in the weight composition, the tensile strength going to be reduced.

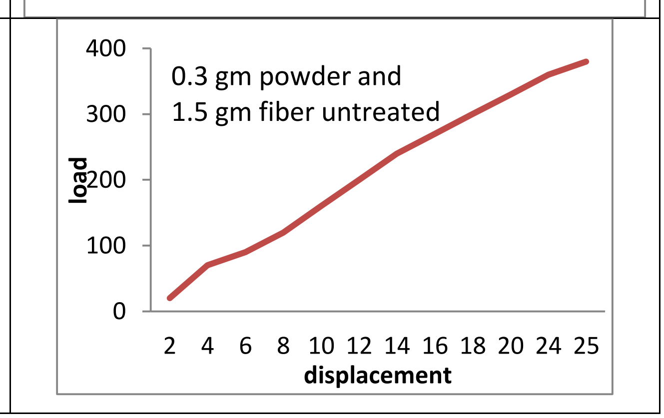












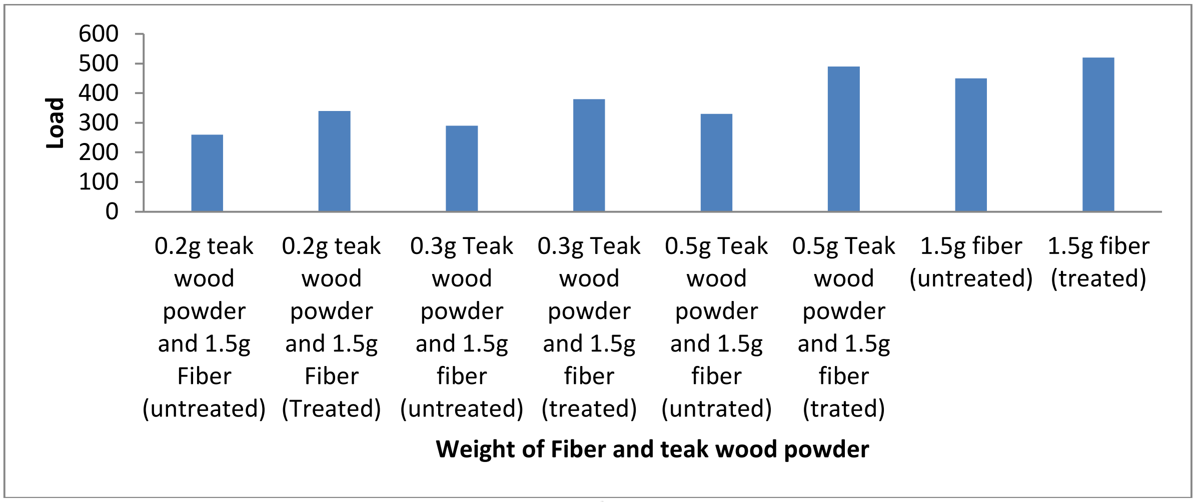


fig.5. bending behaviour of test specimens.

From the above graphs, we can conclude that the specimen which has the composition of 1.5 gm fiber treated.

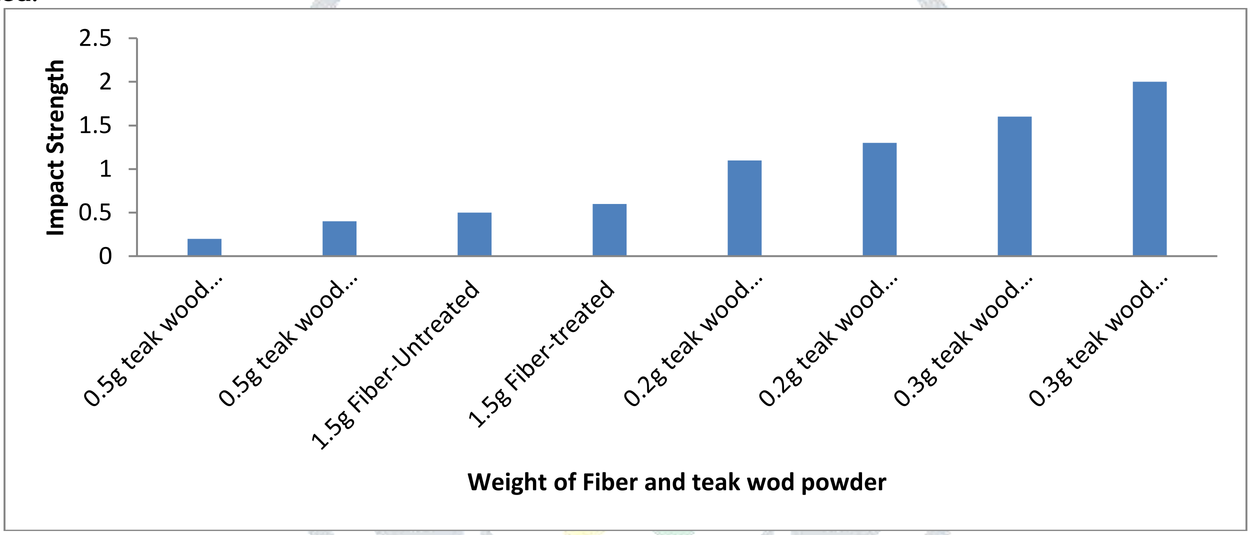


Fig.6. Impact strength of specimens

From the above graph we can conclude that the specimen which has the composition of 0.3 gm fiber and 1.5 gm fiber treated one, because with the chemical treatment, the impact strength strength increases due to the roughness of the fiber. Specimen T1 has low impact strength because the bonding strength is less. The impact strength of the composite was enhanced through the chemical treatment of both fiber and powder.

3.1 Fracture analysis of polyester hemp fiber reinforced composites:

The fracture surface was examined using the scanning electron microscope micrographs of T1,T6 which gone for tensile loading condition, This micrographs discloses the nature of failure of composite specimen. The Fig 7a discloses the uniform teak wood powder distribution in the polyester matrix. The internal cracks were observed from the figure 7b due to tensile load and shows the brittle failure of specimen. The fiber pulls out and de-bonding is observed from the figure7d for tensile specimen T6 under tensile load. The fiber distribution is captured at figure 7c.

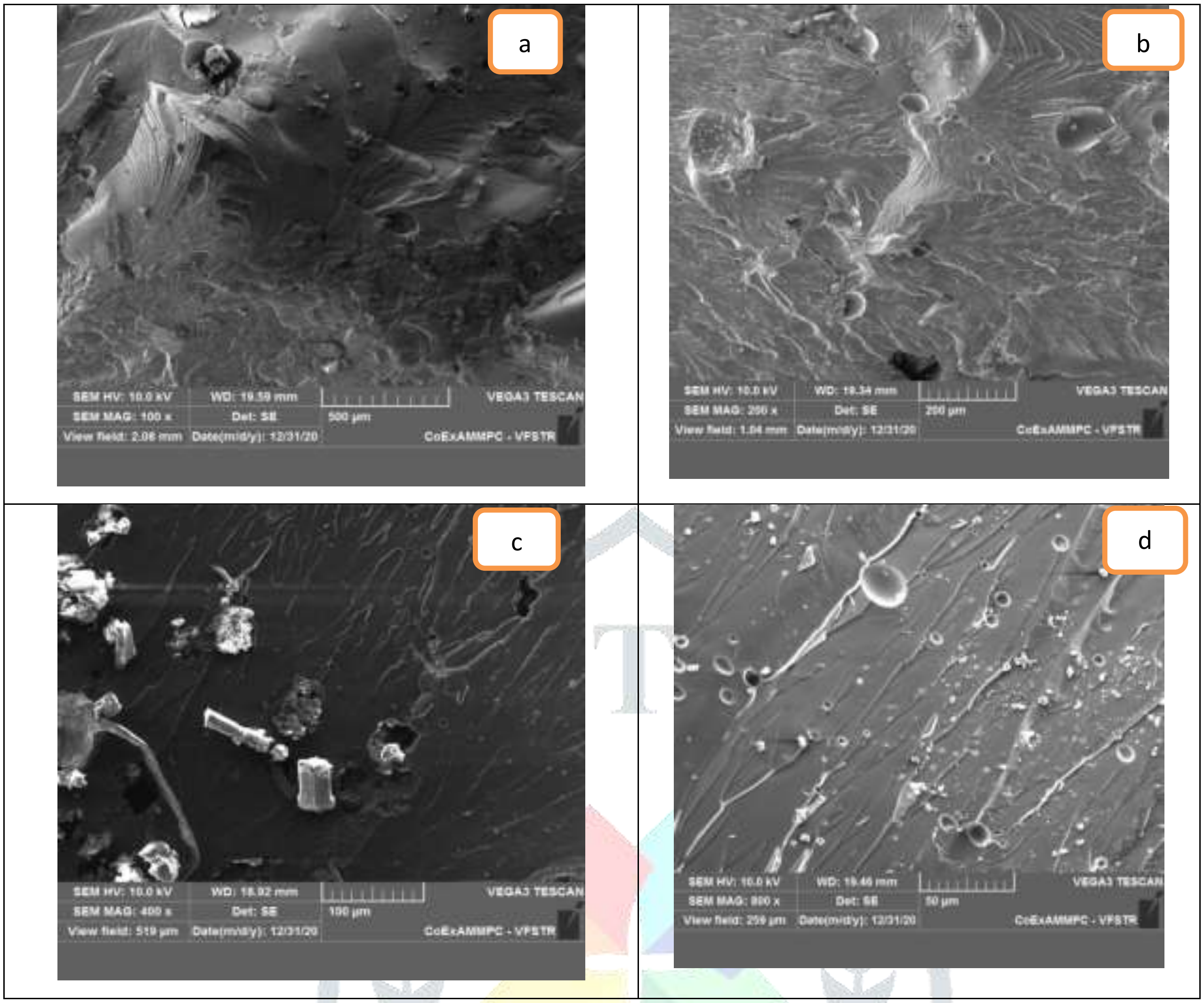


Figure.7. SEM Images of the Tensile, Flexural and impact samples.

4. Conclusions

By the analysis, the following conclusions were stated that

i. Samples are fabricated according to ASM standards with varied compositions of materials.
ii. To find the mechanical properties of Tensile, Flexural and Impact tests are conducted.
iii. The impact strength was increased for all specimens after chemical treatment and tensile strength was reduced.
iv. The fracture surface studied through the SEM images.

5. References

1) Thakur VK, Thakur MK, Gupta RK (2014) Review: raw natural Fiber-based polymer composites. Int J Polym Anal Charact 19: 256–271.
2) Wang X, Wang L, Lian W, Zhou A, Cao X, Hu Q (2018) The influence of carbon spheres on thermal and mechanical properties of epoxy composites. J Polym Res 25:1–7.
3) Oladele IO, Akinwekomi AD, Agbabiaka OG, Oladejo MO (2019) Influence of biodegradation on the tensile and wear resistance properties of bio-derived CaCO 3 /epoxy composites. J Polym Res 26: 1–9.

4) Tavassoli F, Razzaghi-Kashani M, Mohebby B (2018) Hydrothermally treated wood as reinforcing filler for natural rubber bio-composites. J Polym Res 25:1–11. https://doi.org/10.1007/ s10965-017-1394-1
5) Burzic I, Pretschuh C, Kaineder D et al (2019) Impact modification of PLA using biobased biodegradable PHA biopolymers. EurPolym J 114:32–38.
6) Ramesh P, Prasad BD, Narayana KL (2019) Morphological and mechanical properties of treated kenaffiber/MMT clay reinforced PLA hybrid biocomposites. AIP Conf Proc.
7) Agayev S, Ozdemir O (2019) Fabrication of high density polyethylene composites reinforced with pine cone powder: mechanical and low velocity impact performances. Mater Res Express.
8) Jain NK, Gupta MK (2018) Hybrid teak/Sal wood flour reinforced composites: mechanical, thermal and water absorption properties. Mater Res Express.
9) Khonsari A, Taghiyari HR, Karimi A, Tajvidi M (2015) Study on the effects of wood flour geometry on physical and mechanical properties of wood-plastic composites. MaderasCienc y Tecnol 17:545–558.
10) Vinod A, Vijay R, Singaravelu DL (2018) ThermoMechanical characterization of Calotropisgiganteastem powder-filled jute Fiberreinforced epoxy composites. J Nat Fibers 15:648–657.
11) Kumaran P, Mohanamurugan S, Madhu S et al (2019) Investigation on thermo-mechanical characteristics of treated/untreated Portunussanguinolentus shell powder-based jute fabrics reinforced epoxy composites. J Ind text:1–33.
12) Movva M, Kommineni R (2019) Effect of green gram husk Nanocellulose on Banana Fiber composite. J Nat Fibers 16:287– 299.
13) Vijay R, Vinod A, Kathiravan R et al (2018) Evaluation of Azadirachtaindica seed/spent Camellia sinensis bio-filler based jute fabrics–epoxy composites: experimental and numerical studies. J Ind text:1–26.
14) Arumugaprabu V, Uthayakumar M, Manikandan V, et al (2014) Influence of redmud on the mechanical, damping and chemical resistance properties of banana/polyester hybrid composites. Mater Des 64:270–279.