FABRICATION AND MECHANICAL ANALYSIS OF JUTE-SISAL HYBRID COMPOSITE

Sharan Chandran M.[1], Sreeja Sadasivan[1], Senthilkumar P.[1], K. Senthil Kumar[2], Arun Jose[1], Shijas A.[1] and Jacob Kuruvila[1]
[1]Department of Mechanical Engineering,School of Mechanical Engineering, VIT University, Vellore, Tamil Nadu, India
[2]Department of Mechanical and Industrial Engineering, Higher College of Technology, Muscat, Oman
E-Mail: sharanchandran.m@vit.ac.in

ABSTRACT

The eco-friendly nature as well as processing advantage, light weight and low cost have enhanced the attraction and interest of natural fibre reinforced composite. The objective of current study is to study mechanical and interfacial properties of jute reinforced low density polyethylene composites and sisal fibre low density polyethylene composites and to compare the properties with jute-sisal reinforced hybrid composite. The composites are to be prepared by film stacking followed by hot compaction process. Tensile, flexural, impact and hardness tests are to be conducted for mechanical characterization.

Keywords: jute, sisal, LDPE, hybrid, natural composite.

1. INTRODUCTION

Natural fibres have received great attention among researchers and scientists as reinforcement for polymer matrix in place of synthetic fibres. [1] Advantages of natural fibres include low cost, low density, easy availability, environment friendly, non-toxicity, high flexibility, renewability, biodegradability, high specific strength and modulus, and easy processing. However, natural fibres possess high moisture absorption, low impact strength and low thermal stability. Hybridization technique is used to overcome these drawbacks of natural fibres. Many researchers used hybridization technique and found its positive effect as increase in mechanical, thermal and dynamic mechanical properties. The current study aims at finding the variation in mechanical properties as a result of hybridization of two natural fibres namely jute and sisal in LDPE matrix which is a commonly used thermoplastic.

The eco-friendly nature as well as processing advantage, light weight and low cost have enhanced the attraction and interest of natural fibre reinforced composite. The objective of current study is to study mechanical properties of jute reinforced low density polyethylene composites and sisal fibre low density polyethylene composites and to compare the properties with jute-sisal reinforced hybrid composite. The composites are to be prepared by hot compaction process.

Prasad *et al.* performed alkali treatment and acrylic acid treatment of composite fibre which led to the enhancement of mechanical and water resistant properties of composite. So in this project NaOH as well as acid treatment was done on the fibre sheets [2]. Arfin *et al.* indicated that the bulk density of the jute composites decreases due to increases the wt% of the jute fiber and also the water absorption is dependent on fibre addition and length of soaking time [3].

Rao *et al.* proved that the jute/sisal (20/20) hybrid composite exhibits higher tensile modulus, than the other fibre reinforced composites. Again the flexural strength of jute sisal hybrid composite is low compared to pure sisal and pure jute composites [4]. Singha *et al.* indicated that the values of the Young's modulus of the natural fibre reinforced composite increased progressively with increasing fibre loading [5]. M.K Gupta *et al* concluded that 70:30 ratio for jute: sisal gave better thermal stability at higher temperature than epoxy resin based composites [6].

METHODOLOGY

The plan of project is to make an analysis of mechanical properties of natural fibre reinforced composite and to study the change in properties in a composite obtained by hybridisation of two natural fibres. This paper also analyse the mechanical properties of a hybrid composite formed by film stacking followed by hot compaction process. The project finally yields necessary analysis required for further studies in hybridisation of natural fibres using sheet type matrix. The main steps to that were involved in the project to list are thermal characterisation of LDPE matrix. To find mechanical properties of individual fibre composites such as tensile flexural tensile and impact. To do comparative analysis and to determine whether the hybrid can successfully used as a substitute for jute composite but with lighter weight.

Thermal characterization

Differential scanning calorimetry in Figure-1 and thermo gravimetric analysis in Figure-2 done on available LDPE sheet material indicates the various stages in temperature treatment of LDPE which is very essential for hot compaction. Glass transition temperature and the melting temperature range are very important observation made and 150 °C was the processing temperature selected.

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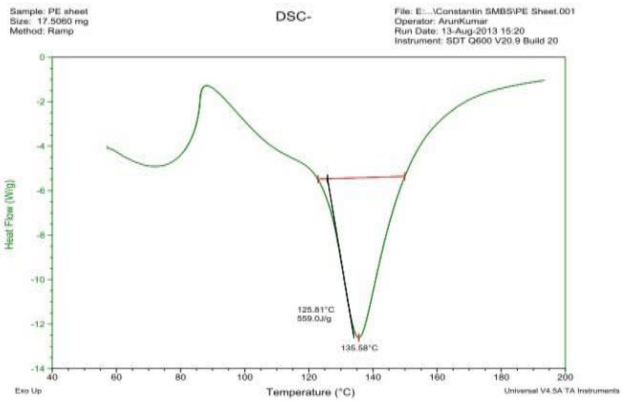

Figure-1. DSC curve.

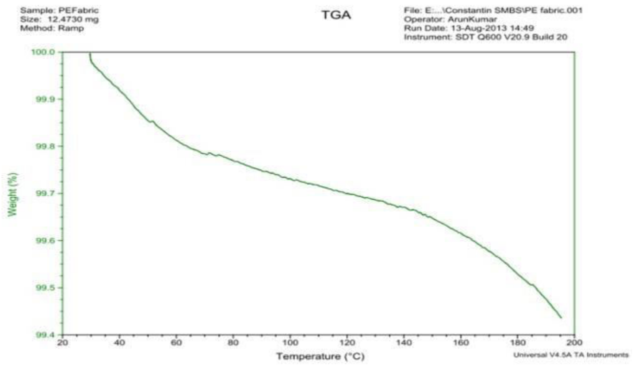

Figure-2. TGA curve.

Fabrication

Alkali and acid treatment

Fabrics are thoroughly washed using distilled water and dried followed by alkali treatment and acid treatment using 10% NaOH solution and dilute acrylic acid to neutralize the pH level.

Fibre-matrix preparation

Volume fraction was decided to be 50% fibre and matrix sheets were cut into 30*30 cm dimension accordingly.

Thermal processing (Hot compaction method)

Step 1: As per the observations made in Thermogravimetric analysis (TGA) and Differential scanning calorimetry (DSC) the processing temperature is set to be 150 °C.

Step 2: As per volume fraction determined, 12 sheets of LDPE and 1 sheet each of jute, sisal are packed together and enclosed within nylon ply sheet as nylon ply has higher melting point .Silicone spray is used to prevent LDPE from sticking onto the surface.

Step 3: Metal clamps are used to ensure a tight sealing of the sheets between metal tiles.

Step 4: The specimen sheets are securely placed inside the electric industrial oven and set to a temperature of 150 °C. 10-12 hours of curing time was given as in Figure-3a.

Mechanical testing

For the processed laminate as shown in Figure-3b, static and dynamic mechanical properties are determined by mechanical testing. These tests could be carried out using different ASTM standards and the testing was done using the codes and standards. Tests were carried out in VIT University, Microlabs Chennai and Central Institue of Polymer Technology, Guindy, Chennai. The tests carried out were

Tensile test (Specimen size: 25*250 cm) with ASTMD 3039-76

Flexural test (Specimen size: 25*200 cm) ASTMD 3039-76 (Figure-4)

Impact test (Specimen size**:** 75*100 cm) ASTMD 6110 which determines the amount of energy absorbed by a material during fracture.

Figure-3(a). Thermal processing.

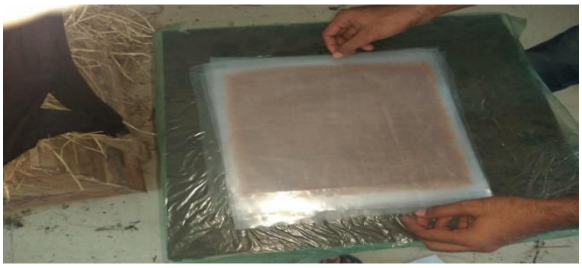

Figure-3(b). Processed laminate.

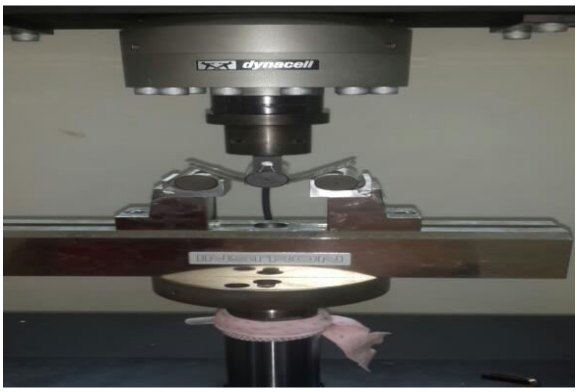

Figure-4. Flexural test.

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RESULTS AND DISCUSSIONS

Tension test

Jute-LDPE composite is elastic to an extent and as from the graph the Figure-5 and from Table-1, we can see that maximum load that can be applied or the yield strength of the material is 655 N at an extension of 7.4 mm making jute LDPE composite very useful in variety of application.

Light weight Sisal-LDPE composite is elastic to a lesser extent and as from the graph and it can be observed that maximum load that can be applied is 350 N at an extension of 3.6 mm.

The elasticity of light weight sisal fibre composite was significantly increased by the hybridization using the higher strength jute fibre and we could thus obtain a maximum load as 550 N and the material did produce an extension of 6.5 cm at maximum load with the weight of composite significantly reduced.

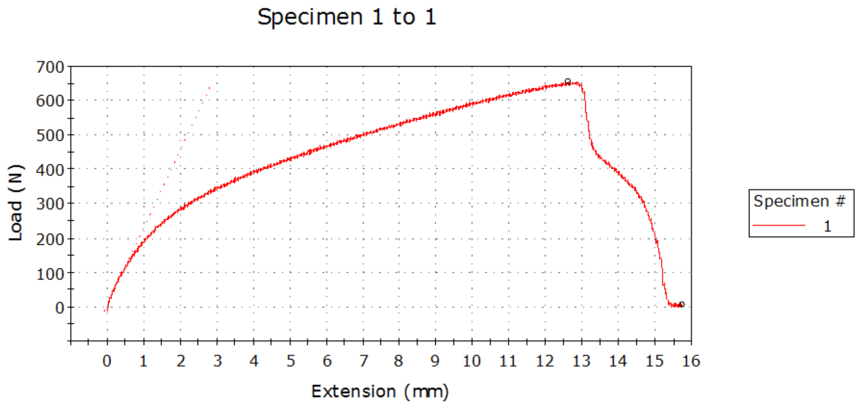

Figure-5. Load vs deflection plot for tension test.

The hybridization improve tensile properties of sisal LDPE composite and makes it close to jute LDPE so the hybrid can be used as an alternative to sisal LDPE composites which are useful due to their light weight and water absorption properties. The tensile stress of hybrid is lesser than jute composite but the tensile strength of sisal composite improves on hybridization.

Table-1. Average values of tension test data.

Material	Maximum load (N)	Ultimate tensile stress (GPa)	Young's modulus	Tensile strain at maximum load (%)
JUTE	655.54	0.01	9.266	7.4201
SISAL	360	0.006	4.202	3.623
HYBRID	550	0.009	7.688	6.584

Flexural test

All the three composites appeared to be highly flexible and the material did not fail under flexural laoading. The flexural modulus of the material was obtained to be 450.867 MPa. The maximum fleural stress is 19.63066 MPa. Sample Load Vs Deflection plot is given in Figure-6. It could be concluded from all the results that composites were greatly flexible and hybridization did not affect the flexural strength to a significant extent as the flexural strength of individual composites were similar. But it can be observed from the table that the flexural modulus increased as a result of hybridization. As the flexural modulus obtained for the hybrid composite is 597.629 MPa

There is no significant change in flexural strength with hybridization. It could be seen from the data that flexural strengths of both jute and sisal individual composites were almost similar and thus hybridization of both these materials did not cause a major change in the flexural strength. So the produced hybrid composite could be used as an alternative to jute and sisal LDPE composites with slight reduction in weight due to its comparable strength.

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Table-2. Average flexural test data.

Material	Maximum load (N)	Ultimate flexural stress (GPa)	Flexural modulus (MPa)	Flexuralstrainat maximum load
JUTE	20.31	19.4950	460.159	0.04722
SISAL	19.1	18.3334	417.936	0.04507
HYBRID	18.88	18.12744	597.536	0.03208

The flexural modulus improves due to hybridization. It could be inferred from the Table-2, that the flexural modulus was increased due to hybridization which means that the hybrid has higher rigidity compared to other two composites.

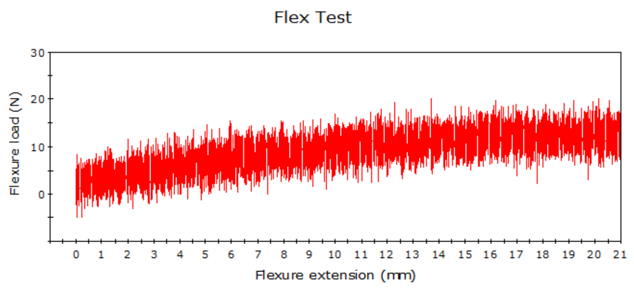

Figure-6. Flexural load vs extension curve.

Impact test

The impact analysis in Table-3 shows that hybridisation causes a slight decline in impact stregth. The weight of the jute composite decreases by 22.7% when hybridised using sisal fibre due to this the hybrid can be used for applications in transport sector as the weight reduction can improve the fuel efficency.

Table-3. Average charpy impact test data.

Material	Jute	Hybrid	Sisal
Impact strength J/m	314	287.8	318.4

CONCLUSIONS

The use of more biodegradable composites is one of the main deals involved with sustainable development so the project focuses on production of a hybrid composite of which both fibres are natural. A comparison of mechanical properties of Jute, sisal and hybrid composites prepared with LDPE matrix reveals that the hybrid composite of jute and sisal with LDPE yields a better flexural modulus. The properties of sisal fibre are improved due to hybridisation so the hybrid can be used as an alternative to sisal composites as the hybrid also promises better strength and higher flexural modulus.

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