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FABRICATION AND INVESTIGATION OF MECHANICAL AND THERMAL PROPERTIES OF HYBRID POLYMER COMPOSITE FROM BAGASSE AND GROUND NUT SHELL

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***Abstract*— The present era is focusing on the alternate material due to advancing their light weight and enhancing mechanical and thermal properties and the last but not least their low cost. To determine the possibility of using SCB and GNSP waste as reinforcing filler in the thermoplastic polymer matrix SCB and GNSP reinforced polypropylene (PP) composites were prepared. The PP and SCB and GNSP composites were prepared by the extrusion of PP with 5, 10, 15, and 20 wt% of SCB and GNSP with 3, 6, 9 and 12% filler in a co rotating twin screw extruder. The extruded strands were cut into pellets and injection molded to make test specimens. These specimens were tested for physical and mechanical properties such as tensile, flexural, Izod impact strength shore D hardness and water absorption.**

***Index Terms*— Natural Fibers, Mechanical Properties, Bagasse Fiber, Composites, Tensile strength.**

I. Introduction

The present era focuses on alternative materials due to the lightness of its materials and the improvement of its mechanical and thermal properties, not to mention its low cost. The hybrid compound is one of the most important of the series of advanced materials. One thing that is also very important to keep in mind is that if the hybrid compound consists of natural fibers extracted from plants or dead debris, its resistance is shown as an artificial fiber. The hybrid compound is a mixture of two different fibers that have their own properties and present their combination in a single material. Natural fibers such as bagasse, coconut, coconut and sisal, animal hair, chicken feathers as material reinforced in the composite material compared to synthetic fiber, the composite material based on natural fiber presents advanced properties of biodegradability. In order to determine the possibility of using SCB and GNSP residues as reinforcement filler in the thermoplastic polymer matrix, reinforced polypropylene (PP) SCB and GNSP compounds were prepared. The PP, SCB and GNSP compounds were prepared by extrusion of PP with 5, 10, 15 and 20% by weight of SCB and GNSP with a loading of 3.6.9 and 12% in a co-twin screw extruder. of the press The extruded strands were cut into pellets and injection molded to form test pieces. These samples were analyzed for their mechanical properties such as tensile strength, bending, Izod and Charpy impacts, density, water absorption and thermal characteristics, that is, temperature of thermal deformation (HDT). , melt index and thermogravimetric analysis. [3]

A. Bagasse

Bagasse is the fibrous residue that remains after crushing the stems of the cane to extract the juice. It is mainly used as raw material in combustion in sugar ovens. The low caloric power of the bagasse makes it an inefficient process. In addition, the administration of the sugarcane plant faces problems of clean air regulation on the part of the Environmental Protection Agency, due to the quality of the smoke that is released into the atmosphere. Currently, 85% of the bagasse production is burned. However, there is an excess of bagasse. In general, this excess is deposited in empty fields, modifying the landscape. About 9% of the bagasse is used in the production of alcohol (ethanol). Ethanol is not only a good substitute for fossil fuels, it is also a fuel that respects the environment.

Fig 1 Bagasse [4]

B. Composition of bagasse.

The performance of the bagasse fiber-reinforced polymer composites depends on several factors, including fiber chemistry, cell size, microfibril angle, defects, structure, physical and mechanical properties and interaction. Fiber with the polymer. To develop the use of bagasse fibers for composite materials and improve their performance, it is essential to know the characteristics of the fibers. The bagasse is composed of approximately 50% cellulose and 25% hemicellulose and lignin. Chemically, bagasse contains approximately 50% α-cellulose, 30% pentosan and 2.4% ash. Due to its low ash content, bagasse offers many advantages over other crop residues such as rice straw and wheat straw, which have 17.5% and 11.0% ash, respectively. Use in microbial cultures.

Fig 2. Figure of Bagasse Fibre [4]

Properties The physical properties of bagasse fiber are critical, and include the fiber dimensions, defects, strength and structure.

Tab.1 Physico-mechanical properties of bagasse fibers [10]

Properties	Values
Tensile strength (Mpa)	290
Young’s modulus (Gpa)	17
Density (gm/cm^3)	1.25

C. Groundnut Shell

The peanuts known as arachishypogeae belong to the legume family. It is the fourth largest oilseed crop in the world and India is the second largest producer of peanuts after China. In India, peanut is the largest oilseed in terms of production and represented around 7.5 million tonnesin 2009-2010. A whole peanut seed is called a pod and the outer layerof peanut is called a shell. The hemicellulose content of the peanut shell is lower than that of wood fibers, banana, bagada, rice husk and kenaf. The peanut shell pretreated is used in this study to modify the properties of the surface to ensure interfacial interactions between the particles and the resin.. The hemicellulose content of the fiber is 18.7%, cellulose 35.7%, lignin 30.2% and ash content 5.9% [7], lignin 30.2% and ash content 5.9% [7]

Fig 3. Groundnut Shell [7]

II. LITERATURE REVIEW

JooSeongSohn et al (2019): As coffee consumption increases worldwide, the amount of ground coffee increases gradually every year. Some of these soils are recycled for composting, but most are discarded, resulting in widespread financial and social costs. We develop a plastic pellet of biological origin by mixing polypropylene (PP) with SCG of biomass used to turn it into an ecological, recyclable and sustainable material. It has been confirmed that mixing by extrusion for granules composed of SCG / PP and injection molding with good formability are possible. To evaluate the formability of the composite granules, test samples from the American company ASTM Company (ASTM) were prepared to evaluate the mechanical properties by injection molding. Following the measurementof

In the test samples, the mechanical properties of the SCG / PP composite pellets generally decreased as the SCG content increased. However, the impact resistance of the SCG / PP compound based on the HOMO-PP matrix improved as the SCG content increased. In addition, the SCG / PP Young module increased in parallel with the increase in SCG content. In the future, this study will be applied to the manufacture of products that require non-toxic products, such as disposable products and food packaging, which will allow the commercialization of environmentally friendly products, thus replacing the finished petroleum resources and ensuring circulation of resources and the protection of the environment.

Sandra Maria da Luz * et al. (2015): The use of materials of biological origin as substitutes for synthetic materials has attracted increasing attention in previous years, including their use as natural fiber compounds. Its main use is the selection and replacement of conventional materials by sustainable materials. In this context, life cycle assessments (LCA) can provide a robust analysis to measure the environmental impacts that occur throughout the life cycle of a product. Natural fiber composite materials are materials that may include natural fibers or biopolymers in their composition. However, the combination of these large types of materials, including those obtained from non-renewable resources, can make VAM modeling difficult. In this article, we briefly review the recent literature on LCA of natural fiber compounds, suggest a guide for the scientific community of compounds and apply the results of this work. This article reveals that the most difficult phase of life cycle assessments is the creation of an inventory related to natural fibers and biopolymers of renewableresources.

E.F. Cerqueiraa,C.A.R.P. Baptistab, D.R. Mulinaria et al. (2011): interest in composite materials reinforced with natural fibers has increased considerably due to new environmental legislation and consumer pressure that has forced manufacturing industries to find substitutes for conventional materials. , for example glass fibers. In this way, the purpose of the article was to evaluate the effect of chemical modification on the mechanical properties of the sugar cane / bagasse fiber composites. The fibers were pretreated with 10% sulfuric acid solution and then delignified with 1% sodium hydroxide solution. These fibers were mixed with polypropylene in athermokineticmixer and compositions containing 5 to 20% by weight of fibers were obtained. The mechanical properties were evaluated by tensile tests, 3-point bending and impact. In addition, a fracture analysis by SEM (secondary electronic mode) was performed. The results showed an improvement in the tensile, flexural and impact strength of composite materials compared to purepolymer.

III. MATERIALS AND METHOD

A. FABRICATION AND TESTING

- Compounding of materials (PP, SCB,GNSP)with twinscrewcompounder.
- Preperation of specimen by injection moulding machine for these tests-
- MECHANICALPROPERTIES STANDARD
- Tensile Strength ASTMD638
- Flexural Strength D790
- Impact Strength D256
- Hardness D2240

B. MATERIAL PREPERATION:

Treatment of fibre-The fibres (Bagasse and Ground Nut Shell) were collected from local area . Bagasse and Ground Nut Shell were washed several times with warm water in order to remove the cellulose content and other impurities and then were soaked in 5% NaOH concentrated water for 30 minutes. The soaked fibres were then washed with detergent water followed by pure water then were dried in sun rays. Clean fibres from dirt and impurities are obtained.[4]

Fig. 4. Bagasse

Fig 5. Ground Nut Shell [10]

C. Compounding and Specimen Preparation

SCB and GNSP were mixed with PP pellets in a high speed mixer (model FM 10 LB, Henschel, Germany). The mixed material was extruded in a twin screw extruder (Berstorff, Germany) with an L / D ratio of 33 with a temperature profile of 190, 190, 180, 180 and 190 ° C. The extruded strand was palletized and stored in sealed packages containing a desiccant. Four load levels (5, 10, 15 and 20% by weight) were designed for the preparation of the sample. Samples of tensile, bending, Izod, Charpy, thermal distortion (HDT) and water absorption were prepared using an automatic injection molding machine RH WINSOR INDIA, SP. -130 with a clamping pressure of 100 tons at 2008C and an injection pressure of 1200 psi. After molding, samples were conditioned at (23 + -2) ° C and (50 + 5)% RH for 40 hours according to ASTM D 618 before the test.

Fig 6. Compounding Machine For Mixing

IV. RESULT AND DISCUSSION

A. Testing performed: - Mechanical Testing

a) Tensile test
b) Flexural test
c) Izod Impact test
d) Shore D Hardness test

Table 2. Melt temp for PP and fibers is given in table:

Nozzle zone			Compression/transition zone		Feed zone	
	NH3	NH1	H4	H3	H2	H1
WITHOUT FILLER	180	180	220	210	240	150
WITH FILLER	160	180	200	200	195	150

Where,

H1=Heater 1, H2=Heater 2 , H3=Heater 3 , H4=Heater 4, NHI=Nozzle Heater 1

NH2=Nozzle Heater 2

Machine specification:

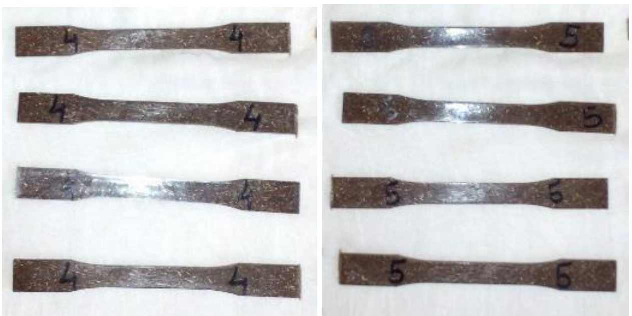
MoldTemp=28*c-35*c Screw Speed = 24RPM
BACK PRESSURE = 50-150 PSI INJECTION SPEED =3SEC MELT CUSHION = 8.72mm
Optimum Cushion = 8.72 mm
CYCLE TIME:

Injection Time =2.99Sec Dwell Time =4Sec Cooling Time = 35 Sec Ejection Time =3 Sec
Total Cycle Time = 44.99Sec

B. Tensile Testing

Tensile testing, also known as tension testing, is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces.

Batch 1 Batch 2 Batch 3



Batch 4 Batch 5

FIG 7. Specimen before Fracture

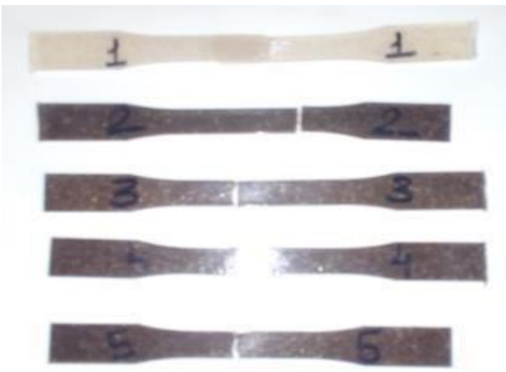


FIG 8. Specimen after Fracture

1) SUMMARY OF TENSILE TEST FOR ALL 5 BATCHS

It is found that ultimate tensile strength is maximum for second batch when there is a reinforcement of 5% SCB and 3% GNSP. There is a continuous increase in modulus as there is increase in reinforcement of ground net shell particle and sugar cane baggase.

Table 3- Summary of Tensile test

Batch.no.	Modulus (MPa)	Elongation (%)	Ultimate tensile strength (MPa)	Max load(N)
1	323.2	23.67	28.14	1143.7
2	552.0	12.67	32.68	1336.9
3	623.2	10.50	31.05	1262.0
4	643.9	9.33	30.43	1240.0
5	648.9	8.85	29.21	1210.3

2) CONCLUSION FROM TENSILE TEST:

To obtain the value of modulus of elasticity, Elongation and Ultimate stress of the composite material the tensile test is performed tensile testing machine (ASTM D638) and the following result is obtained.

- Mean Value of Modulus of Elasticit = 627.0 MPa
- Mean Value of Elong = 9.75 %
- Mean Value of Ultimate tensile stress = 31.09
- MPa Mean Value of max'mload = 1264.45N

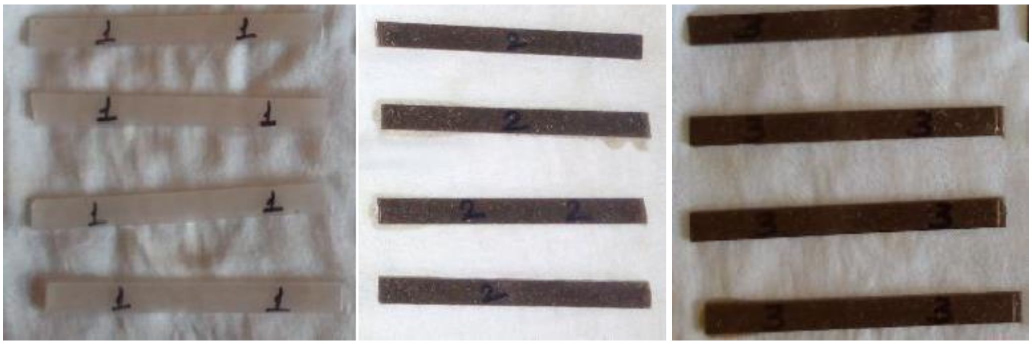
3) PURE PP TEST RESULTS ARE:

- Modulus of Elasticity = 323.2MPa
- Elongation = 23.67%
- Ultimate tensile stress = 28.14MPa
- Max'mload = 1143.7N

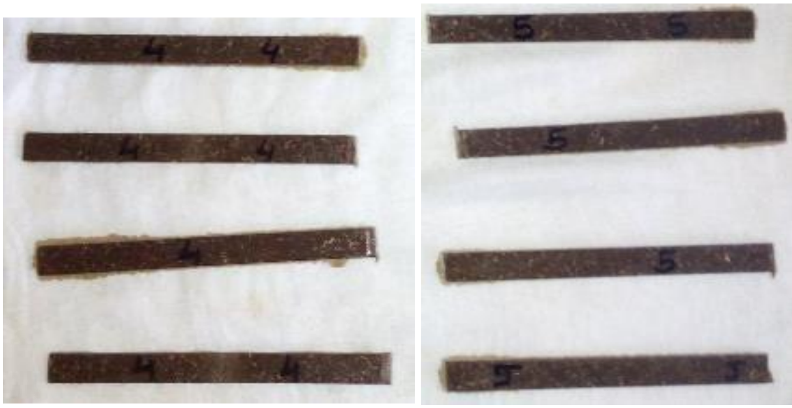
There are comparison has been done on the basis of various mechanical properties for the composite polypropylene reinforced with SCB and composite that I have prepared by polypropylene reinforced with SCB and GNSP.Itis found that intensile test the tensile strength is maximum among all the batches that consist of 5% SCB and 3% GNSP is 32.79 MPa, while the tensile strength of the composite based on the SCP & PP is 23.06 MPa. Because of introducing the GNSP in PP there is a increase in cellulose fibrein the composite.

S.NO	CONTENT OF GNSP	PERCENTAGE (%)
1.	HEMICELLULOSE	18.7
2	CELLULOSE	35.7
3	LIGNIN	30.2
4	ASH CONTENT	5,9

C. FLEXURALTEST:



Batch 1 Batch 2 Batch 3



Batch 4 Batch 5

FIGURE 9. OF SPECIMEN AFTER FRACTURE

1) FLEXURAL TEST RESULT

To obtain the value of modulus of elasticity, Elongation and Ultimate stress of the composite material the Flexural test is performed testing machine (ASTM D790) and the following result is obtained.

Mean Value of Modulus of Elasticity	=	1716.02 MPa
Mean Value of Elongation	=	5.12 %
Mean Value of Ultimate tensilestress	=	42.07 MPa
Mean Value of max'm load	=	71.7 N

FOR PURE PP TEST RESULTS ARE

Modulus of Elasticity	=	862.1 MPa
Elongation	=	5.24 %
Ultimate tensile stress	=	29.20 MPa
Max'm load	=	49.79 N

It is found that the flexural strength is maximum in third batch, when there is a 10% SCB and 6% GNSP are used, or reinforced in PP. The flexural strength is maximum 42.63 MPa, while if we compare to pp reinforced with SCB then the flexural is 35.8 MPa. The reason behind it is the cellulose content in the composite.

D. IMPACT TEST

Impact test are perform to assess shock absorbing capability of the material subjected to suddenly applied shock load. This capability is expressed as impact strength of the material.

E. CONCLUSION FROM IMPACT TEST

To obtain the impact strength of composite material IZOD test is performed as per ASTM D256 standard. The mean value impact strength of this composite material is found to be 31.93 J/m2. Which shows better impact strength than plain PP material.

IMPACT STRENGTH FOR ALLSAMPLES

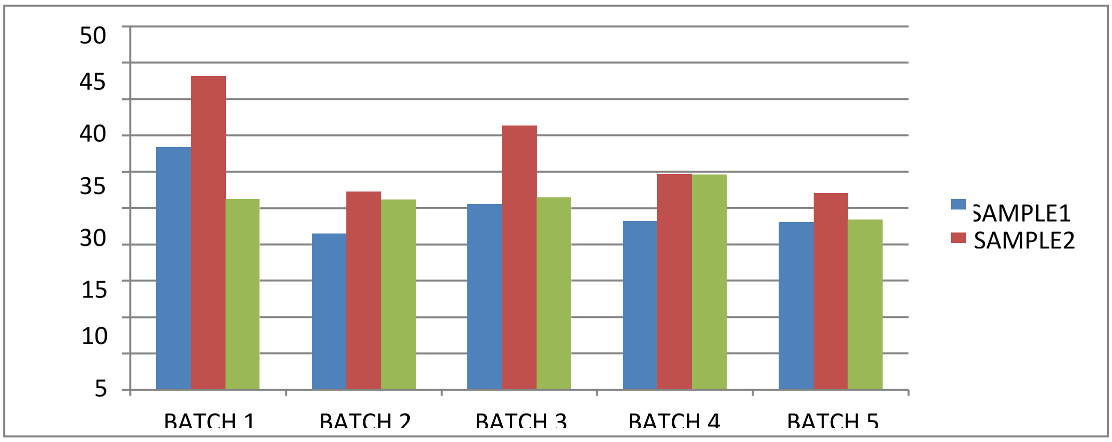


Fig 10. Impact Strength for All Samples

The impact strength is maximum in the first batch for the reinforcement of 5% SCB and 3% GNSP is 24.98 J/m2 while it is continuously decreases with the reinforcement, while compare to pp with reinforcement with bagasse is maximum upto 52 J/m2.

F. SHORE D HARDNESS TEST: ASTMD2240

Shore Durometer (as shown in Fig.4.5) is used for measures of the hardness of a material and itis typically used for measure of hardness of polymers, elastomers and rubbers.

Fig. 4.5 Shore Durometer

SPECIMEN SPECIFICATION Shore hardness test allows for hardness measurement on plastic specimen using a specified standard indenter. ASTM D2240-00 refers several rubber hardness measurement scales (A, B, C, D etc.). The thickness of the specimen should be at least 6.0 mm. The specimen for Shore hardness test is as shown in Fig. 4. 5 The two most common scales, using slightly different measurement systems, are the ASTM D 2240 type A and type D scales. The A scale is for softer plastics, while the D scale is for harder ones. Each scale results in a value between 0 and 100, with higher values indicating a harder material.

1) HARDNESS RESULTS

Table 4. Hardness Results

S.NO	WITHOUT FILLER	5% SCB &3% GNSP	10% SCB &6% GNSP	15% SCB &9% GNSP	20% SCB &12% GNSP
1	67	67	71	70	68
2	65	73	65	60	80
3	63	65	70	69	78
4	64	75	67	75	80
5	65	72	68	73	79
AVG	64.8	70.4	68.2	69.4	77

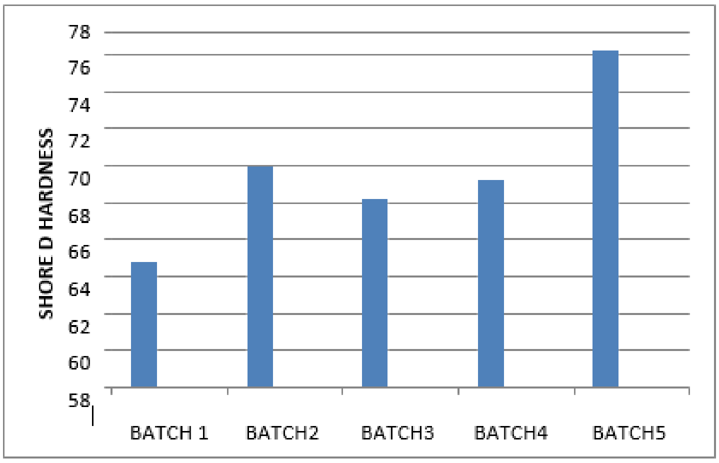


Fig 11. For Hardness

2) CONCLUSION FROM SHORE D HARDNESSTEST

To obtain the strength of composite material Shore D Hardness test is performed as per ASTM D2240 standard. The mean value of this composite material is found to be 76.20 for (batch 5). Which shows better results than plain PP material.

G. RESULT

Table 5. All Mechanical Testing Results

S.NO	Mech. Prop.	STANDARD	UNIT	PP WITH 0% FIBER	PP WITH 5% SCB & 3% GNSP	PP WITH 10% SCB & 6% GNSP	PP WITH 15% SCB & 9% GNSP	PP WITH 20% SCB &12% GNSP
1	Tensile Strength	ASTM D638	MPa	28.06	32.79	30.68	29.04	30.38
2	Flexural Strength	ASTM D790	MPa	27.62	39.63	42.63	40.94	41.07
3	Notch Izod Impact Strength	ASTM D 256	J/m^2	34.31	24.98	31.93	27.50	24.53
4	Shore D Hardness	ASTM D2240	-	64.75	70.00	68.25	69.25	76.20

V. THERMAL TESTING

A. THERMOGRAVIMETRIC ANALYSIS (TGA)

The thermal stability of reinforcement of polypropylene with SCB and GNSP composite material was analyzed up to 900 0C under a purging nitrogen gas with a flow rate of 100 cc/min by a thermo gravimetric analyzer (DTG-60, Shimadzu). About 10 mg of specimen was loaded for measurement at a heating rate of 10 o C/min. The TGA and differential thermal analysis (DTA) curves were recorded. Thermo gravimetric analysis or thermal gravimetric analysis (TGA) is a method of thermal analysis in which changes in physical and chemical properties of materials are measured as a function of increasing temperature (with constant heating rate), or as a function of time (with constant temperature and/or constant mass loss).

B. TGA ANALYSIS

TGA is a useful method that based on the measurement of weight change in relation to temperature for the quantitative determination of the degradation behavior and the composition of the fibreand the matrix in a composite. The magnitude and location of peaks found in the derivative thermogravimetric (DTG) curve also provide information on the component and the mutual effect of the composite components on the temperature scale. Thermal stability of reinforcement of polypropylene with SCB and GNSP composite material was shown in graph.

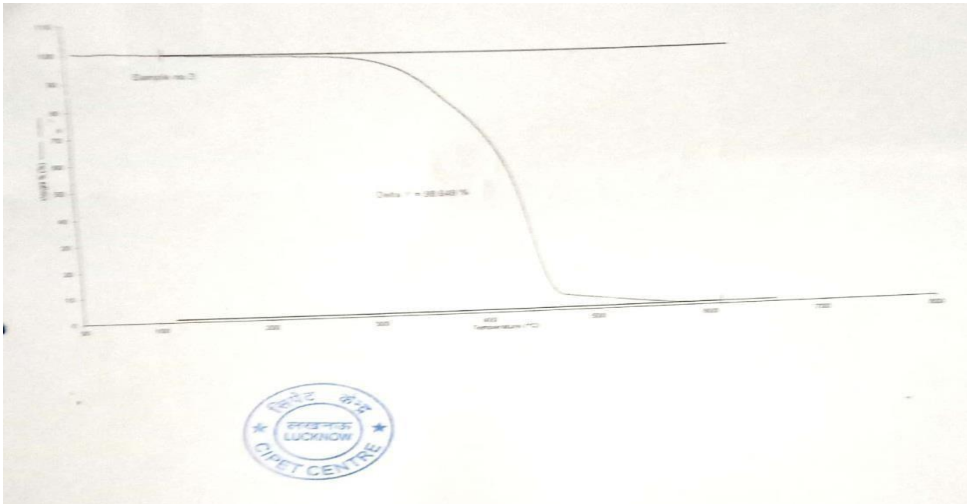


Fig.12. TGA THERMOGRAMS SHOWING THE THERMAL PROPERTIES OF SCB AND GNSP FIBER WITH POLYPROPYLENE COMPOSITES

VI. CONCLUSIONS

1. There is improvement in tensile strength of composite by adding SCB and GNSP reinforced in Polypropylene. Tensile Strength increases of composite (32.79MPa) which is higher as compared to Polypropylene (28MPa).

2. The impact strength Composite is 24 kJ/m2 which is lower as compared to Polypropylene 34 kJ/m2.

3. On D-scale the hardness reading is 76.20 which shows that it is more than Polypropylene's hardness, i.e,74.75

4. To obtain the value of modulus of elasticity, Elongation and Ultimate stress of the composite material the Flexural test is performed testing machine (ASTM D790) and flexural strength is increased from 29.20 to 41.46MPa.

5. TGA test-Curve of hybrid composite as shown in Figure. Thermal treatment covered of bagasse fiber & GNSP composite gave an initial weight loss below1500C.due to loss of moisture. The weight loss observed with composite at this reason might be due to the molecular weight of the compounds. The initial weight loss is due to complex secondary reaction and formation of volatile product. From above Figure shows, it isobvious that no degradation occurred until 1000C for the sample the onset being above 1500C.The maximum rate of weight loss was observed in the range of 1500C– 6000C. The amount of residue left is 0.33%.

Table 6. Comparison between different reinforcement of polypropylene

S.NO	PROPERTY	COMPOSITES (PP+GNSP+SCB)	COMPOSITE (PP+SCB)
1	TENSILE STRENGTH	32.79 MPA	23.06 MPA
2	IMPACT STRENGTH	46.63 J/M^2	35.8 J/M^2
3	FLEXURAL STRENGTH	42.63 MPA	35.8 MPA

In the conclusion we found that the mechanical properties are enhanced by the reinforcement with SCB and GNSP as compare to polypropylene and reinforced with bagasse only.

VII. FUTURESCOPE

- Natural latex of other trees / plants like banana, papaya, banyan, babul, etc. may be used for fabrication of bio composites.
- The composite may be replaced to other biodegradable adhesives etc. in the fabrication of bio composites.
- Thermal characterization, SEM, AFM etc. can also be carried out to study fracture surfaces in bio composites.
- Natural materials like enzymes should be developed for treatment of fibers to make them more eco-friendly.

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