International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 1
January 2018

Thermal Characterization of Coir Reinforced Poly Butylene Succinate

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ABSTRACT

Composites are one of the most advanced and adaptable engineering materials. The strength of any composite depends upon volume/weight fraction of reinforcement, L/D ratio of fibers, orientation angles and other factors.

In this proposed work, the task is to figure out the effect of the various blend ratios of the biopolymers, fibres and filler material on mechanical properties. The test specimens were prepared and tested according to ASTM standards. Several characterization and mechanical tests such as TGA, tensile test, flexural test, and SEM test and water absorption property are proposed to be carried out to figure out the correct blend ratio of biopolymers and fibres for the natural fiber reinforced plastic. The objective of the idea is to develop biodegradable roofing sheet with entirely agricultural based product and check the commercial viability.

Keywords

Biodegradable roofing,PBS, tensile test, flexural test, and SEM test, weight fraction

INTRODUCTION

The plastic industry has started looking for alternative sources of raw materials in the last few decades, and considerable interest is being shown in natural, renewable solutions [2]. One of the fast developing alternatives is Bio-based polymer. These polymers are produced from renewable feedstock; biomass in general, might replace fossil sources and also have considerable environmental benefits like decreased carbon-dioxide emission [3]. The usage of biopolymers has increased rapidly at higher rate due to the economic effects. Because of very good degradation property, the biopolymers can be used anywhere and many researches have been going on to improve the mechanical properties of the biopolymers to make it usable in various applications [4, 5]. There are numerous natural fibres available like bamboo fibres, jute fibres, sisal fiber that show very good mechanical properties over the synthetic fibres. Modification is a key tool for improving the property of the biopolymer-natural fiber reinforced plastics material [6, 7]. In this proposed research work, the task is to figure out the effect of the various blend ratios of the biopolymers, fibres and filler material on mechanical properties [8, 9]. PBS based bio-polymer will be used (which has good mechanical properties) and jute fibers as fiber reinforcement and carbon nano powder will be used as a filler material for the natural fiber reinforced plastic. Several characterization and mechanical tests such as TGA, tensile test, flexural test, and SEM test and water absorption property are proposed to be carried out to figure out the correct blend ratio of biopolymers and fibres for the natural fiber reinforced plastic [10, 11]. The objective of the idea is to develop biodegradable roofing sheet with entirely agricultural based product and check the commercial viability. Other aspects like maximum durability, transparency and cooling effect of roofing sheet etc. may also be computed. Composite material is a material made from two or more materials with different physical and chemical properties but the individual components remain separate and distinct in final product [12**].** There are mainly three categories of constituent materials: 1. Matrix 2. Reinforcement 3. Additives

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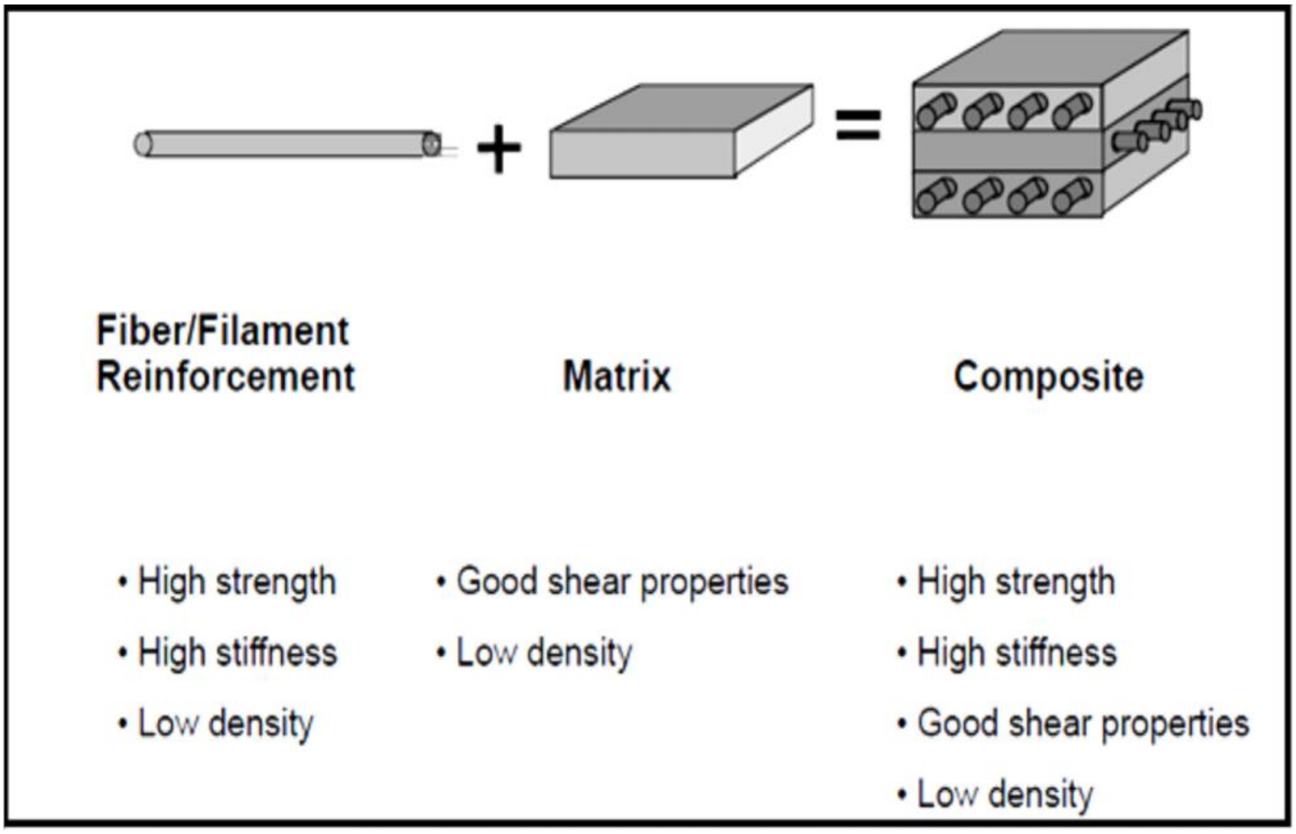

Fig. 1: composite material

The main objective of this work is to make coir Fiber Reinforced Polymer composites suitable for outdoor use by modifying its properties by optimizing the composition.

Reinforcement: Coir fiber- abundant in India. Matrix: Poly butylene succinate (PBS) resin- Biodegradable

Coir fibre : Coir fiber is extracted from the outer shell of a coconut [25]. It is the natural fiber of the coconut husk where it is a thick and coarse but durable fiber. Coir consists of fibers ranging in length from 4-12 inches [26]. Minimum 8 inches long fiber is called bristle fiber. Less than 8 inches shorter fibers, are called mattress fiber. A 10-oz (300-g) coconut husk yields about 3 oz (80 g) of fiber, one-third of which is bristle fiber. Coir is recommended as substitute for milled peat moss because it is free of bacteria and fungal spores [27]. Total world coir fibre production is 250,000 tonnes. India, mainly the coastal region of Kerala State, produces 60% of the total world supply of coir fibre [28]. Sri Lanka produces 36% of the total world fibre output. Over 50% of the coir fibre produced annually throughout the world is consumed in the countries of origin, mainly India.

EXPERIMENTAL SET UP : Compression molding machine

The below image, machine is a CMM (Composite Molding Machine), it is an assembled machine used for making composites. It has a MCB (Miniature Circuit Breaker), which is used to control the temperature and pressure. There is a directional control valve which is used to give the pressure to the plates while making composites maximum pressure 150Bar. Temperature is controlled by the knobs, and the maximum temperature limit is 350 c. Timer is also there to see and note the time for attaining the temperature. There are 2 plates with same dimensions of 200mm x 200mm. which has a heating coil attached with the plates to give the temperature to it. The upper plate are attached to the piston and allowed to give the pressure. The piston cylinder is connected to the 2 HP motor. Energy consumption is 1.5 kW. and rpm is 1415

Fig. 2- Compression Molding Mach

Mold preparation : Material used for making mold is high carbon steel. The mold cavity is made by using unconventional machining (Electrical Discharge Machining). Surface finishing is done and holes are drilled from the lower side. • base plate dimension - 240mm x 150mm x 20mm , middle plate dimension - 200mm x 90mm x 20mm . Die plate connected to top plate dimension- 200mm x 50mm x 20mm , upper plate dimension - 240mm x 150mm x 10mm . Mould cavity dimension - 200mm x 50mm x 20mm

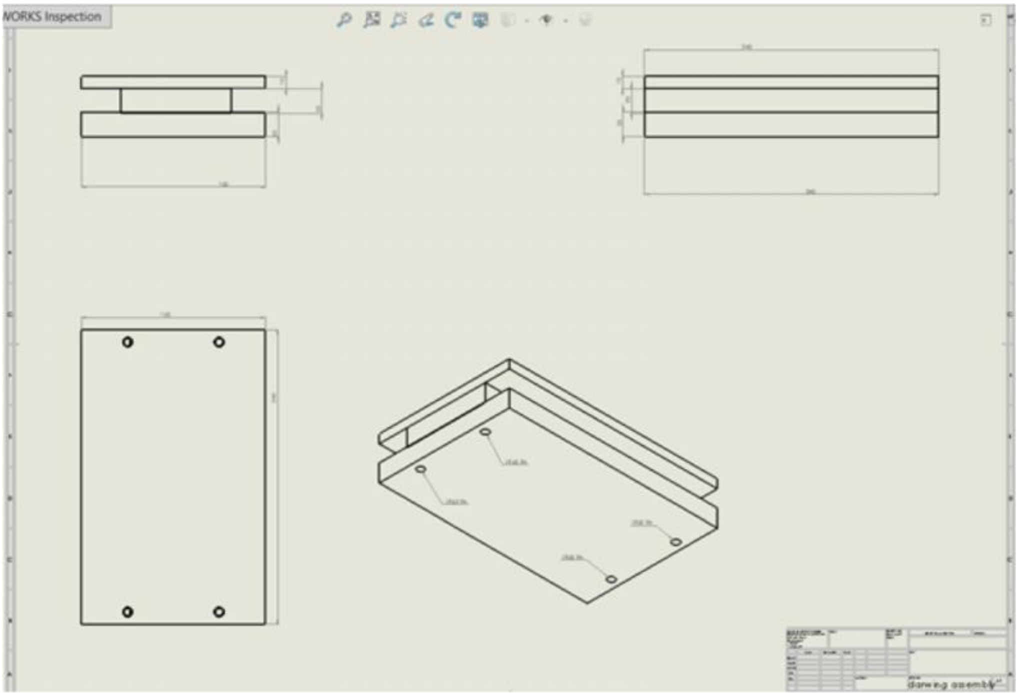

Fig. 3(a) mold solid model parts

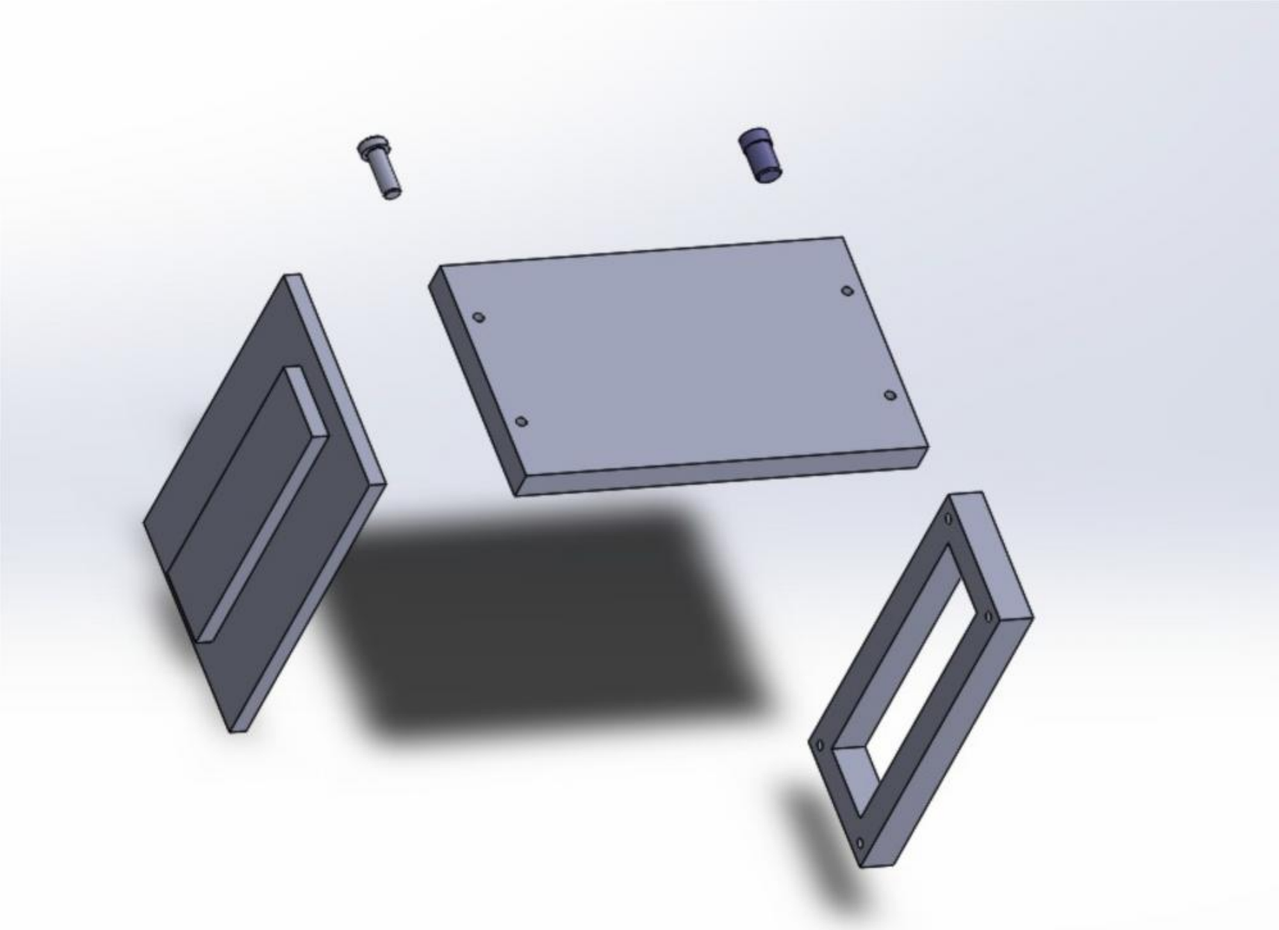

Fig. 3(b) mold 3D model

Fig. 4(a) fabricated mold parts

Fig. 4(b) Assembled mold

Composite Preparation

The mold must be assembled by attaching the base plate to the middle piece. The threading on all screws should be coated with oil. This will make it easier to dismantle the mold. Diagonally opposite screws must tightened first to ensure proper load distribution. An even layer of silicon mold release agent should be sprayed inside the mold to facilitate the removal of completed sample. Complete the mold assembly and check for any gaps and crevices. The machine temperature has to be set at 180ºC. The fully assembled mold has to be placed in the machine. The setup should be monitored constantly until the set temperature is achieved. Once the sufficient temperature is achieved, the PLA has to be poured in the mold and allowed to liquidity. Once a consistent composition is observed, the coconut powder has to be added and thoroughly mixed with the PLA. Allow the mixture to stand for 5 minutes. Distribute the mixture evenly into the mold and expose it to 180ºC for another 10 minutes. This shall ensure even distribution of the filler in the matrix. Fibers are added to the mixture in the mold and mixed to get a uniform paste. Replace the top lid after redistributing the obtained paste in the mold. Increasing pressure up to 5 bar has to be gradually applied on the mold. Once the mold is completely compressed, it has to be left at 180ºC for 20 minutes. The material will melt and homogeneously mix with the fillers and Fibers. The machine temperature is now reduced to 120ºC, which is the glass transition temperature of PLA. The mold should be allowed to cool on its own to this temperature. Once this is achieved, pressure of 50 bar, 100 bar and 150 bar should be applied separately for 5 minutes each. This is done in order to remove any accumulated vapors inside the mix. The mold should be allowed to cool for 5 hours after the machine is switched off. The mold must open with utmost care so that the sample is not damaged.

Composition of composites

Table 1- Composition of composites

Composite specimen	Coir fiber weight %	PBS weight%
A	**5**	**95**
B	**10**	**90**
C	**15**	**85**
D	**20**	**80**

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Preparation of nano composites

PBS was incorporated with various Coir Fibre (5, 10, 15, 20 gms) to form the composites. A mould was used to prepare the composites. The mould was kept in the machine with a set temperature of 153°C. The PBS was then poured into the mould and allowed to melt. Followed by this, the coir fibre was added as an additive in the melted PBS and mixed evenly for 5 mins. After this step, a uniform pressure was applied on it so that the top plate could easily slide into the mould cavity. The mould with the mixture was kept for 15 mins so that the inside material could melt & get mixed completely with the fibres. The temperature was then set to glass transition temperature and the mould was allowed to cool up to 110°C. To remove the air inside the mould, pressure of 50, 100 & 150 bar was applied on the mould. The mould was then allowed to cool after which it was opened.

Fig. 5: Sample of Composite 80:20

Fig. 6: Sample of Composite 80:20

Fig. 7: Sample of Composite 80:20

Fig. 8: Sample of Composite 80:20

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Characterisation of Composites

The composites prepared had different compositions. Four composites were prepared with different compositions which included changing percentage of Poly Lactic Acid (PLA) and Coconut Shell Powder while the percentage of Jute fiber remained constant throughout the composites.

The first sample consisted of only PLA and Jute fiber in the ratio of 80:20. From here on the percentage of PLA was decreased by 1% with an increase of Coconut Shell Powder (CSP) by 1% giving the compositions as 79:20:1. The compositions of third sample were in ratio of 78:20:2(PLA: JUTE: CSP). The compositions of fourth sample were in ratio of 77:20:3(PLA: JUTE: CSP). The effects of various testing have been studied on all the four samples and the best one is identified.

Tensile strength

Ultimate tensile strength (UTS) often shortened to tensile strength (TS) or ultimate strength is the capacity of a material or structure to withstand loads tending to elongate, as opposed to compressive strength, which withstands loads tending to reduce size. In other words, tensile strength resists tension (being pulled apart), whereas compressive strength resists compression (being pushed together).

Ultimate tensile strength is measured by the maximum stress that a material can withstand while being stretched or pulled before breaking. In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently.

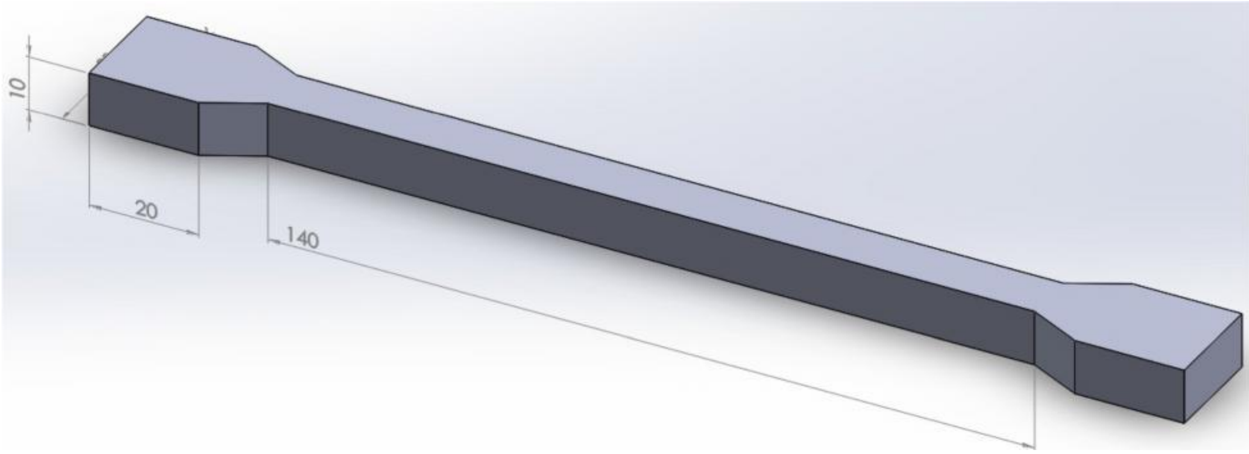

Fig. 9: tensile specimen sample

Table 2: Tensile & Yield Strength results

Sr.No	Sample Code	Tensile Test (KN/mm2)	Yield Strength (KN/mm2)	Elongation %
1	80PBS/20CF	0.055	0.038	6.250
2	85PBS/15CF	0.066	0.039	6
3	90PBS/10CF	0.058	0.044	5.5
4	95PBS/05CF	0.057	0.037	5.25

The tensile properties of Coir Fibre reinforced PBS composites were investigated by varying the fibre loading as shown in table 2. The tensile strength of PBS with Coir fibre in the ratio of 85:15 was tested to be maximum at 66 MPA whereas the yield strength of PBS with coir fibre in the ratio of 90:10 was tested to be maximum at 44MPA. These studied composites showed a tendency that yield strength increased with increasing fibre loading up to an optimal point, after that the yield strength tended to decrease.

Impact strength

Izod impact testing is an ASTM standard method of determining the impact resistance of materials. A pivoting arm is raised to a specific height (constant potential energy) and then released. The arm swings down hitting the sample, breaking the specimen. The energy absorbed by the sample is calculated from the height the arm swings to after hitting the sample. A notched sample is generally used to determine impact energy and notch sensitivity. The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture.

This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply. A disadvantage is that some results are only comparative.

Table 3: Izod Test Results

Coir Fibre: PBS Composition	**Izod Impact Strength (J)**
80:20	4
85:05	6
90:10	7.5
95:05	9.7

The purpose of impact testing is to measure an object’s ability to resist high rate loading. The energy absorbed at fracture is generally related to the area under the stress-strain curve which is termed as toughness in some references. Izod Impact is a single point test that measures a material's resistance to impact from a swinging pendulum. Izod impact testing is an ASTM standard of determining the impact resistance of materials. The results of the Izod notched impact test are shown in table 3. The incorporation of coir fibre obviously increases the impact strength of neat PBS. The highest impact strength of the composites is 9.7 J.

Hardness strength

The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. The Hardness is evaluated by the amount of permanent deformation or plastic flow of material. The table 4 shows hardness of the composites. It was found that these values decreased with the reduction in Coir Fibre content.

There was no difference in the values of hardness obtained for composites of composition 80:20 & 90:10 which show the maximum hardness which is 99.91 BHN. By one of the most common methods of hardness testing (Rockwell), hardness is determined by the depth of indentation in the test material resulting from application of a given force on a specific indenter. In the Brinell test, by comparison, hardness is determined by the impression created by forcing a specific indenter into the material under a specific indenter into the test material under a specific force for a given length of time. However, in highly automated Brinell testing hardness is evaluated by depth of impression, which makes it similar to Rockwell in basic principle. The Brinell scale characterizes the indentation hardness of materials through the scale of penetration of an indenter, loaded on a material test-piece. It is one of the several definitions of hardness in material sciences. The Brinell scale characterizes the indentation hardness of materials through the scale of penetration of an indenter, loaded on material test piece. It is one of the several definitions of hardness in material science. The typical test uses a 10 millimetre (0.39") diameter steel ball as an indenter with a 3000 kgF (29KN; 6600 lbF) force. For Softer materials, a smaller force is used; for harder materials, a tungsten carbide ball is substituted for the steel ball.

The indentation is measured & hardness is calculated by using this formula.

$BHN=2(D-\sqrt{D2-d2})$

Where f = Applied Force ~ 187.5 Kg

D = Diameter of indenter ~ 2.5 mm

d = Diameter of indentation

Samples	Observation 1	Observation 2	Observation 3	Average Observation	BHN
80:20	1.5	1.4	1.5	1.47	99.91
85:15	1.6	1.4	1.6	1.53	91.31
90:10	1.4	1.5	1.5	1.47	99.91
95:05	1.6	1.6	1.5	1.57	86.11

CONCLUSION

These studied composites showed a tendency that yield strength increased with increasing fibre loading up to an optimal point, after that the yield strength tended to decrease. The results of the Izod notched impact test are shown in table.3 the incorporation of coir fibre obviously increases the impact strength of neat PBS. The highest impact strength of the composites is 9.7 J. The table 1 shows hardness of the composites. It was found that these values decreased with the reduction in Coir Fibre content. There was no difference in the values of hardness obtained for composites of composition 80:20 & 90:10 which show the maximum hardness which is 99.91 BHN.

RERENCES

1. P. Pradeep, J. Edwin Raja Dhas, M. Ramachandran, Mechanical Characterization of jute fiber over glass and carbon fiber reinforced polymer composites, International Journal of Applied Engineering Research. ISSN 0973-4562 Volume 10, Number 11 (2015) pp. 10392-10396.
2. Shyamkumar Shah, AkshaykumarPatil, M. Ramachandran, KanakKalita,Effect of coal ash as a filler on mechanical properties of glass fiber reinforced material, International Journal of Applied Engineering Research, ISSN 0973-4562 Volume 9, Number 22 (2014) pp. 14269-14277.
3. R. Petrucci , C. Santulli , D. Puglia , E. Nisini , F. Sarasini , J. Tirillò , L. Torre , G. Minak , J.M. Kenny, IMPAct and post-iMPAct damage characterization of hybrid composite laminates based on basalt fibres in combination with flax, hemp and glass fibres manufactured by vacuum infusion, Composites: Part B 69 (2015) 507–515.
4. Rakshit Agarwal, M. Ramachandran, Stanly Jones Retnam, Tensile Properties of Reinforced Plastic Material Composites with Natural Fiber and Filler Material, ARPN Journal of Engineering and Applied Sciences, Vol. 10, No. 5, 2015, pp. 2217-2220.
5. Priyanka, Sanjay Palsule , Banana fiber/chemically functionalized polypropylene composites within situ fiber/ matrix interfacial adhesion by Palsule process, Composite Interfaces, 2013, Vol.20, No.5, 309–329.
6. C. Elanchezhian, B.VijayaRamnath, KaosikR., NellaiappanT.K, SanthoshKumar.K, Kavirajan .P, Sughan M.U, Evaluation of mechanical properties of kenaf based hybrid composite for automotive components replacement,Vol.10, No.13, 2015.
7. G. Caprino, L. Carrino, M. Durante, A. Langella, V. Lopresto , Low iMPAct behavior of hemp fibre reinforced epoxy composites; Composite Structures 133 (2015) 892–901.
8. D. Bino prince raja, B. Stanly Jones Retnam, M. Ramachandran, Analysis of mechanical properties of glass and carbon fiber reinforced polymer material, International Journal of Applied Engineering Research. Vol 10, No 11 (2015) pp. 10387-10391.
9. Sudha J, HarishKumarPadmakumar, Ranjani R, SheelaRamani G, Naviyarasan M, CoMPArative Study of IMPAct Properties of Coir & Aloe Vera Based Composites With GFRP, Vol 10, No 8 (2015) pp.20517-20528.
10. NabiSaheb.D and J. P. Jog, Natural Fiber Polymer Composites: A Review, Advances in Polymer Technology, Vol. 18, pp. 351–363, 1999
11. Chana Prapruddivongs and NarongritSombatsompop, Biodegradation and Anti-bacterial Properties of PLA and Wood/PLA Composites Incorporated with Zeomic Anti-bacterial Agent. Advanced Materials Research Vol. 747 (2013) pp. 111-114
12. R.Kannan andB.Paramanathan, Studies on biodegradability of Ricehusk/Polypropelene/Eglass hybrid composites, Global Engineers and Technologists Review,2014, Vol4,pg1-15
13. Oksman.K, Skrifvars.M and Selin J.F, Natural Fibers as reinforcement in poly latic acid composites, Composites and Science Technology, 2003, pp. 1317-1324.
14. MayaJacobJohn and Sabu Thomas, Biofibers and bio composites, Carbohydrate polymers, 2008, pg343-364.
15. Chen, W., and B. Song. "Dynamic Compressive Response of Polymeric Nanocomposites." In *ICCES: International Conference on Computational & Experimental Engineering and Sciences*, vol. 3, no. 1, pp. 51-56. 2007.
16. Han, Seong Ok, Mehdi Karevan, Md A. Bhuiyan, Jung Ho Park, and Kyriaki Kalaitzidou. "Effect of exfoliated graphite nanoplatelets on the mechanical and viscoelastic properties
17. Li, Shasha, Xiaoli Shi, Changqing Fang, and Nailiang Liu. "Effect of graphite and Ag-plated graphite nanoplatelets on the thermal properties of polypropylene nanocomposites: Experimental studies and modeling."*Thermochimica Acta* 630 (2016): 11-20.
18. Arjmandi, Reza, Azman Hassan, M. K. M. Haafiz, Zainoha Zakaria, and Md Saiful Islam. "Effect of hydrolysed cellulose nanowhiskers on properties of montmorillonite/polylactic acid nanocomposites." *International journal of biological macromolecules* 82 (2016): 998-1010.
19. Vaisakh, Sadasivan S., Peer Mohammed, Abdul Azeez, Mehrdad Hassanzadeh, Jean F. Tortorici, Renaud Metz, and Solaiappan Ananthakumar. "Effect of nano-modified SiO2/Al2O3 mixed-matrix micro-composite fillers on thermal, mechanical, and tribological properties of epoxy polymers." *Polymers for Advanced Technologies* (2016).
20. Arjmandi, Reza, Azman Hassan, MK Mohamad Haafiz, and Zainoha Zakaria. "Effects of Micro-and Nano-cellulose on Tensile and Morphological Properties of Montmorillonite Nanoclay Reinforced Polylactic Acid Nanocomposites." In *Nanoclay Reinforced Polymer Composites*, pp. 103-125. Springer Singapore, 2016.
21. Kumar, MS Senthil, N. Mohana Sundara Raju, P. S. SaMPAth, and L. S. Jayakumari. "Effects of Nanomaterials on Polymer Composites-An Expatiate View." *Reviews on Advanced Materials Science* 38, no. 1 (2014): 40-54.
22. Liu, Lifang, Jianyong Yu, Longdi Cheng, and Xiaojie Yang. "Biodegradability of poly (butylene succinate)(PBS) composite reinforced with jute fibre." Polymer Degradation and Stability 94, no. 1 (2009): 90-94.

23. Sahoo, Saswata, Manjusri Misra, and Amar K. Mohanty. "Enhanced properties of lignin-based biodegradable polymer composites using injection moulding process." Composites Part A: Applied Science and Manufacturing 42, no. 11 (2011): 1710-1718.
24. ZHANG, Min, Fang-fang DING, and Dong-cai YU. "Study on the Effect of Straw Fiber on Properties of PBS Composite [J]." China Plastics Industry 12 (2009): 017.
25. Arrakhiz, F. Z., M. El Achaby, A. C. Kakou, S. Vaudreuil, K. Benmoussa, R. Bouhfid, O. Fassi-Fehri, and A. Qaiss. "Mechanical properties of high density polyethylene reinforced with chemically modified coir fibers: iMPAct of chemical treatments." Materials & Design 37 (2012): 379-383.
26. Rout, J., M. Misra, S. S. Tripathy, S. K. Nayak, and A. K. Mohanty. "The influence of fibre treatment on the performance of coir-polyester composites.
27. Njoku, R. E., I. Ofili, D. O. Agbiogwu, and C. V. Agu. "Effect of alkali treatment and fiber content variation on the tensile properties of coir fiber reinforced Cashew nut shell liquid (CNSL) composite." Nigerian journal of technology 31, no. 2 (2012): 108-110.