REVIEW ON NATURAL FIBER REINFORCED POLYURETHANE COMPOSITE

[1]Manavdeep Singh, [2]Prem Singh, [3]Gurinder Singh Brar
[1]M. Tech Student, [2]Assistant Professor, [3]Associate Professor
[1]Department of Production Engineering
[1]GNDEC, Ludhiana

Abstract **:** The worldwide demand of natural fibers is increasing day by day. These natural fibers are bio-degradable and eco-friendly in nature. The natural fibers are extensively used nowadays to make composite material. The natural fiber reinforced polyurethane polymer is used to fabricate low cost, light weight, bio-degradable and eco-friendly composite. Different types of natural fiber are used currently i.e. sisal, rice, wheat, hemp, jute, etc. as a replacement for the synthetic fibers. This article discusses the properties and different types of natural fiber used in the polyurethane reinforced composite.

Index Terms **- Fiber reinforced composite,Natural fibers, Polyurethane, Polymer matrix composite**

I. INTRODUCTION

In recent years, the increasing environmental awareness among the society the natural fibers are used for making the eco-friendly product. The natural fibers are obtained from the natural resources and have fewer prices compared to the synthetic fibers. The fibers are nowadays reinforced with other material i.e. polymer to make natural fiber reinforced polymer composite. These fiber reinforced composite have better mechanical properties than the other composites. The Polyurethane polymer is the thermoset which do not melt on heat but ignite. The polyurethane polymer is formed when polyol and isocayante mixed together in a fixed ratio. The polyurethane foam is divided into three group i.e. flexible, semi-rigid and rigid PU foam. The polyurethane can be fabricated with various techniques depending upon the type of polyurethane required (Azmi, 2012 and Bledzki et al,2011). Some of the polyurethane flexible foam is fabricated with the addition of the fibers. The natural fillers used in the fabrication of foam were walnut and hazelnut shells. These natural fillers are the wastes generated from the food and agricultural industry. The fillers are collected and reinforced with polyurethane to check the impact of fiber on the polyurethane (Bryskiewicz et al, 2016). Nowadays, soy based polyol is used and mixed with di-isocayante to make the polyurethane. Pour method is one of the techniques to fabricate the polyurethane composite. Wood fiber is one such fiber that improves the cell structure of the foam (Gu et al, 2013). Natural lingo cellulosic fibers such as sugarcane, rice and sisal are used nowadays to improve the strength of the composites. These fibers have high lignin and hemo cellulose which decreases the adhesion between the fibers and the polymer matrix, due to these reason, these fibers are firstly treated with chemical to increase the interfacial bonding between the filler and the polymer (Otto et al, 2016).

II NATURAL FIBERS

Natural fibers are the fibers which are collected from the natural resources. The natural resources like plant, mineral and animal from which the fibers can be extracted. Basically plant fibers are used in the composite to make environmentally product. Some of the natural fibers which was used in the previous works is given in the Table 1

Table 1 Natural fibers used in PU composite

S. No.	Natural Fibers	References
1	Woven flax and jute fiber	Bledzki et al, 2001
2	Wood flour	Mosiewicki et al, 2009
3	Sisal fiber	Bakare et al, 2010
4	Coconut coir fiber	Azmi et al, 2012
5	Tea leaf fiber	Ekici et al, 2012
6	Wood fiber	Gu et al, 2013
7	Rice husk ash	Silva et al, 2013
8	Walnut and hazelnut shells	Brsyskiewicz et al, 2016
9	Natural lingo cellulosic	Otto et al, 2016
10	Carrot nano fibers	Zhou et al, 2016
11	Hemp fiber	Sair et al, 2017
12	Hemp fiber	Sair et al, 2018

2.1 Natural fiber reinforced polyurethane composites

A different type of natural fibers was used to fabricate polyurethane composite as listed in the Table 1.For making the panel, the coconut fiber was used as a reinforcement fiber. In this the fibers was chemically treated with sodium hydroxide (NaOH) to remove the grime and then wash with water. The fibers were added into the polyurethane up to 20% by weight. The polyol, iso-cyanate and coconut was mixed and poured in the mould and then the fabricated composite is taken out from the mould (Azmi et al, 2012). In some cases, the compression technique was used to fabricate the composite. In this woven flax and jute fibers was reinforced upto 40% by weight and then treated with Tinozym Al and placed in convection for 2 hrs. The treated fiber was placed between the steel plates and resin is poured between them. The pressure caused the resin to flow within the fibers and the foaming process started (Bledzki et al.2001). To fasten the foaming process calcium oxide catalyst was used to fabricate sisal fiber PU composite. In this polyurethane was foamed with the rubber seed and NaOH chemical was use for treatment of the fiber. The unidirectional fiber was pre heated and spread inside the mould to create a mat. The polyurethane was poured on the fiber mat and pressure is applies on the mould for the fabrication of the composite (Bakara et al, 2010). The particle size walnut and hazelnut was used to developed flexible foam. These fibers were obtained from the waste generated in agricultural industry and grinded in the mill. The particle fiber walnut and hazelnut was reinforced with polyurethane at 13.5 % and 18% respectively (Bryskiewicz et al, 2016).

The tea leaf fibers were used as reinforcement filler in polyurethane composites to improve the sound absorbing capacity of a composite. The polyol and isocyanate was mixed in the 1:1 proportion and then fiber was added into the mixture. The mixture was poured into the steel die for the fabrication of the composite (Ekici et al, 2012). In some study biodegradable polyol was selected to form a polyurethane polymer. In this polyol is obtained from the natural oil and mixed with isocyante to form polyurethane. The polyurethane is reinforced with wood fiber and wood flour to developed eco-friendly composite (Gu, 2013 in Mosiewicki et al, 2009).The natural lingo cellulosic fiber like sugarcane, sisal and rice husk were used to developed hybrid polyurethane composites. In this fibers were reinforced with polyurethane (PU) at a different proportion to find the best hybrid combination. The fiber was chemical treated with sodium hydroxide (NaOH), sodium peroxide and mixed with the final mixture. The mixture was then poured into the wooden mould and left for 24 hours to cure (Otto et al, 2016). The hemp fiber is one of the most common used fiber to developed environmentally composites. In previous work the hemp fiber was chemical treated with two types of chemical i.e. alkaline and saline. This treatment helps to improve the interfacial bonding between the fiber and polyurethane matrix which results in increase of the properties. In another work the hemp fiber is reinforced with PU at different loading weight i.e. 5-30%. The different loading weight is to find the best reinforcement percentage for the bio-degradable composite (Sair, 2017 and Sair et al, 2018).

Rice husk ash was used as a reinforcement filler to fabricate polyurethane composite. In this RHA was collected from the rice industry and natural polyol was mixed with methyl diphenyl di-isocyanate (MDI) along with different additives to prepared polyurethane mixture (Silva et al, 2013). To improve the cell wall rigidness the carrot nano fillers was used to developed bio PU foams. The CNF was reinforced with PU at different reinforcement percentage i.e. 0.25, 0.5 and 1 phr. The castor oil polyol is mixed with fiber and then stir for 30 seconds. Then mdiwas mixed with mixture and again stirrer for 20 seconds (Zhou et al, 2016).

III. MECHANICAL PROPERTIES

The mechanical properties of the composite is depend on the following factors i.e. concentration of the fiber, interfacial bonding, fiber length, type of fiber, density, porosity, reinforcement percentage. The Table 2 shows the various properties for different natural fibers.For compression strength the concentration of the fiber in the matrix is one of the important factors. With increasing concentration of the fillers the compressive strength decreases because the fibers considered being non-deformable and acts as a defect (Mosiewicki et al, 2009). Sisal fiber is one of the natural fiber with non-homogeneous properties which have good compressive property then the other fibers (Otto et al.2016). In case of flexural strength the micro-void in the composite is the main factor. With increase of fiber content in the matrix microvoid content increase this results in decrease of stress transfer between the fiber and the matrix (Bledzki, 2001 and Bakare at al, 2010). For tensile properties the fiber length plays an important role in the fabrication of the composite. The use of hemp fibers as a reinforcement filler in the polymer matrix due to its good tensile properties. The hemp fiber up to 15% loading rates gives best tensile strength for the polyurethane composite (Sair et al, 2017).

Table 2 Properties of natural fibers reinforced polyurethane composite

S. No.	Natural Fibers	Properties	Reinforcement Percentage by weight (wt%)	Strength (kPa)
1	Carrot nano fibers	Compression Strength	0 0.25 0.5 1	3.5 4.3 5.7 4.4
2	Rice husk ash	Compression Strength	0 1 2 3 5	4.33 4.77 3.57 3.44 2.74
3	Coconut coir fiber	Flexural Strength	0 5 10 15 20	50 60 30 10 9

4	Wood fiber	Tensile Strength	0	104.4
			13.3	92.4
		Compressive Strength	0	29.9
			13.3	28.2
5	Wood flour	Compression Strength	0	178.8
			10	135.6
			15	116.8
6	Hemp Fiber	Tensile Strength	0	1029
			5	1150
			10	1260
			15	1413
			20	1182
			25	871
			30	675
		Flexural Strength	0	1090
			5	1430
			10	1860
			15	2150
			20	3830
			25	3410
			30	2610

IV. MICROSTRUCTURE PROPERTIES

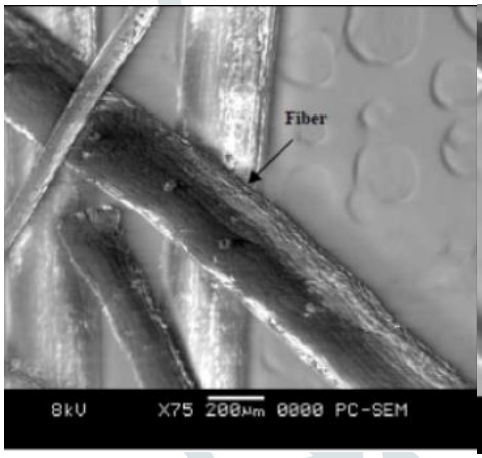

Fig.1 Untreated fibers (azmi et al.2012)

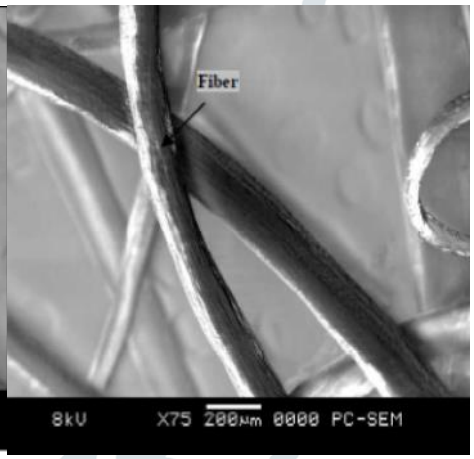

Fig.2 Treated fibers (azmi et al.2012)

The fig.1shows an untreated cocunut fiber surface which has impurities presents in them which decrease the interfacial adhesion between the matrix and fiber. The decrease in adhesion decreases the mechanical properties of the polyurethane composites. In figure.2 shows an treated fibers with 5 wt% Sodium Hydroxide (NaOH) which removes the hemicelluloses and lignin from the fibers which improves the interfacial adhesion between the matrix and fiber (Azmi, 2012 and Otto et al, 2016). It was found that with the increasing fiber content the viscosity increases which disturbs the cell wall structure of the composite (Mosiewicki at al, 2009).

V. CONCLUSION

Natural fiber reinforced polyurethane composite have many advantages such as less expensive, low density and can be used in commercial applications. Using natural fibers in polyurethane polymer improves the mechanical and morphological properties. This paper evaluates the types of natural fibers used in polyurethane and properties of the reinforced polyurethane composite. Also the effects of chemical treatment on natural fibers were also discussed.

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