Mechanical Behaviour of Polypropylene And Human Hair Fibres And Polypropylene Reinforced Polymeric Composites

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Abstract - Bio fibres have recently become eye-catching to researchers, engineers and scientist as an alternative reinforcement for FRP (fibre reinforced polymer) composite. Due to their low cost, fairly good mechanical properties, high aspect strength .Three to four ton of human hair fibre wasted in India annually .These fibre pose an environmental challenge In order to find commercial application the wasted human hair fibre mixed with polypropylene.

Polypropylene based composite are prepared using hair fibre obtained from human hair. Human hair fibres are mixed into polypropylene (PP) at 3,5,10 and 15 % by wt. using two roll mills. The composite are compression moulded at specific time and temperature. Polypropylene and hair fibre polymer reinforced composite have better flexural and impact strength than PP (Polypropylene) and lower the tensile strength of polypropylene and hair fibre polymer reinforced composite than (PP) polypropylene.

Keyword : *human hair fibre, composite, mechanical properties, polypropylene*

I. INTRODUCTION

Composite are combination of two or more than two materials in which one of the material, is reinforcing phase(polymer, metal or ceramic) composite material are usually classified by type of reinforcement such as polymer composite ,cement and metal matrix composite polymer matrix composite are mostly commercially produced composites in which resin is used as matrix with different reinforcing material . Polymer (resin) is classified in two types thermoplastic (PE, PP, PEEK, PVC, PS, Polyolefins etc) and thermo set (epoxy, polyester and phenol-formaldehyde resin etc) which reinforces different type of fibre like natural (plant, animal, mineral) and manmade fibre for different application.[1-2]

The hair fibre which is made of mainly keratin protein with primarily alpha-helix structure .approximately 91%of the hair is protein made up of long chain of amino acid .the long chain linked by peptide bond .The average composition of normal hair is composed of 45.68% carbon ,27.9% oxygen, 6.6% hydrogen ,15.72% nitrogen and 5.03% sulphur .Amino acid present in hair contain cytosine , serine, glutamine, threonine , glycine ,leucine, valine ,arginine. Natural fibres, as actual and potential reinforcement composites, offer many advantages: good strength properties, low cost, high toughness, biodegradability, however, in the case of cellulose fibre some disadvantages due to their intrinsic characteristic, incompatibility with hydrophobic polymer matrix, tendency to form aggregates during processing and poor resistance to moisture, finite length and large diameter, pose an important challenge of their use in advanced composite [3-5].

Colom et al prepare HDPE/Wood fibre composite using a compounding step at 160^0C in two roll mills and moulding step at 150^0C in a compression moulders for up to 20 min.Compounds feather fibre in polypropylene on an extruder at 200^0C.

In this paper, human hair fibre is incorporated in to polypropylene at a 3, 5, 10, 15wt%. The composite are mixed in a two roll mill. Following mixing tensile bars are prepared by compression moulding at temperature 180^0C-190^0C over time period 0-10 min in each case virgin PP is prepared in the same manner [6-8].

II. EXPERIMENTAL

Materials: polypropylene homo polymer (PP) (1110MG, Density 0.903 gm/cm^3, MFI 11 gm /10min) supplied by Indian Oil Corporation limited Panipat, Haryana and India. Human hair (density 1.32 gm/cm^3 tensile strength 382 M pa) obtained from local market.

Compounding: The polypropylene are mixed into Human hair fibre at 3, 5, 10, 15 wt% using two roll mill and the compounding temperature is 190^{0}C.Table-1 shows sequential addition of PP and human hair.

Specimen preparation: The mould sample for testing were compression moulded using compression moulding at 190^{0}Cand 60mpa for 10 min. After pressing the sheet are removed from the press and cooled by water.

III. CHARACTERIZATION TECHNIQUES

Mechanical properties: The test specimen for analyzing the Mechanical properties was initially conditioned at 23$\pm$2^{0}C and 50$\pm$ 5%RH for 24 hr prior to testing.

Tensile strength: Tensile properties were evaluated to ASTM D638 using dumbbell shaped samples and an INSTRON Universal testing machine model 3342 tensile tester with a cross head speed 5mm/min [9].

Flexural modulus: flexural properties are evaluated according to ASTM D790 using an INSTRON universal testing machine model 3342 with a cross head speed of 1.3 mm/min .the dimension of the specimen were 127mm in length,12.7mm in width and 3mm thickness[10].

Izod impact strength: Izod impact properties were evaluated according to ASTM D256 using impact tester model impact104 with a notch angle 45^{0}and depth of 2.54 mm .the dimension of the specimen were 63.5mm in length, 12.7mm in width and 3mm thickness[11].

IV. RESULT AND DISCUSSION

The mechanical properties such as impact strength flexural strength and flexural modulus and tensile strength and elongation at break, mm(table-3)of the human hair fibre and pp composite increase with the increase in fibre loading from 3 to 5wt% and then the value are decrease at 10 to 15wt%. The increase was more in composite because of improved interfacial adhesion between the matrix and the fibre. The overall performance of any fibre – reinforced polymer composite depend to a large extent upon the fibre – matrix interface which in turn is governed by the surface topography of the fibre and by the chemical compatibility of fibre surface and resin properties.

PP with human hair fibre resulting in an improved interfacial adhesion between the matrix and the fibre. This improved interfacial adhesion allows a more efficient transfer of stress along the fibre matrix interface .the liner increase with increase in fibre volume is due to availability of more fibre for increased stress transfer. The decrease in mechanical properties at higher volume fraction of fibre loading is due to the increase in fibre- fibre interaction, the fibre not being perfectly aligned with matrix and poor dispersion of fibre in the matrix more over higher void content (which might be due to the presence of moisture in trace amount) and low interfacial strength resulted in a lower efficiency of load transfer with increase fibre loading.

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Table-1 : Mechanical properties of the pure resin

	Flexural strength,Mpa	Flexural modulus.Mpa	Tensile strength,Mpa	Elongation at break%	Izod impact strength,j/m
Polypropylene	30.08	992.83	40.41	31.52	11.93

Table -2 : Mechanical properties of human hair fibre

	Linear density,gm/cm^3	Fibre length,mm	Tensile strength,Mpa	Elongation at break%
Human hair fibre	1.32	3-10	384.79	216.94

Table -3 : Mechanical properties of human hair fibre and PP reinforced polymeric composite

	0%	3%	5%	10%	15%
Tensile strength,Mpa	40.41	24.87	32.26	13.35	9.7
Elongation at break, mm	31.52	7.02	10.47	10.20	7.7
Flexural strength,Mpa	30.08	30.13	38.89	30.07	25.01
Flexural modulus,Mpa	992.83	1450.85	1539.25	1363.63	1064.91
Izod impact strength,j/m	11.93	6.20	12.55	5.08	5.02

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The tensile strength result of control (0%) and different fibre loaded composites were demonstrated and compared in fig.1. These results show that the control composites tensile properties were significantly higher when compared to the human hair fibre reinforced composites. In all cases the control (0%) composites had better tensile properties than the human hair reinforced composites. It was expected that when the fibre loading percentage increases some of the mechanical properties decreases due to the random short fibre distribution inside the composite matrix and also lack of adhesion between matrix and fibre. The main concern with short fibre reinforced composite is the difficulty in controlling.

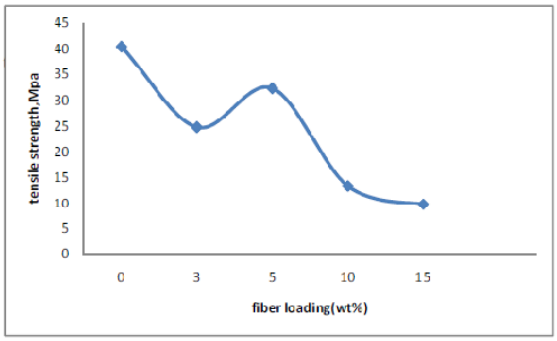

Fig. 1. Tensile strength result of composite

The breaking elongation results of the composites are given in fig.2. The breaking elongation results were found to be similar to the tensile result, when fibre loading increased the breaking elongation decreased. Elongation at break for polypropylene is just above at 31.52mm at 0%fibre loading. The lowest breaking elongation occurred at the 15% human hair reinforced polypropylene composite which was 7.02 mm.

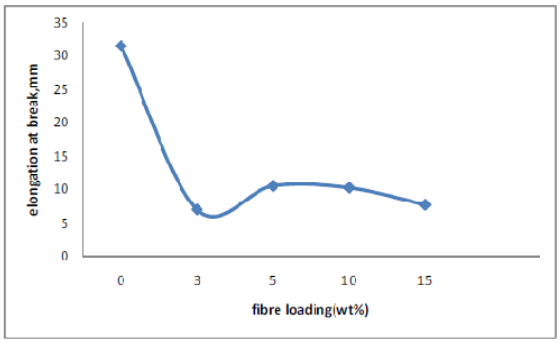

Fig.2 elongation at break result of composites

The flexural strength results are demonstrated in Fig-3 the flexural strength increase with the increase fibre loading from 3 to 5wt%. The flexural strength values are reduced from 10 to 15wt% due to random short fibre distribution inside the composite matrix

The flexural modulus values are illustrated in Fig.4. The flexural modulus values of human hair fibre reinforced composite increases up to 3 to 5% when the fibre loading percentage rises and then decreases from 10 to 15 wt%. PP control composites have lower.

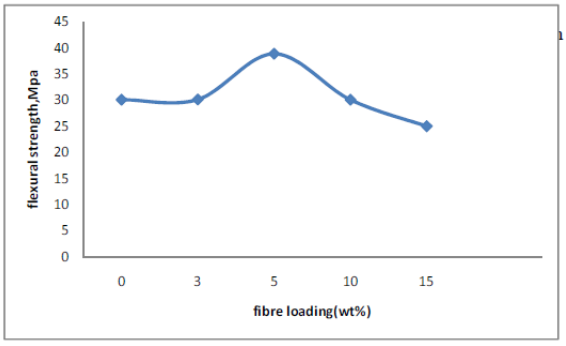

Fig.3. flexural strength result of composites

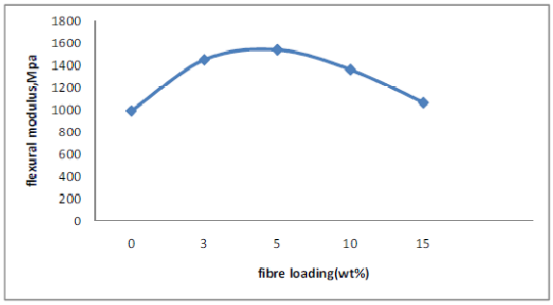

Fig .4.flexural modulus result of composite

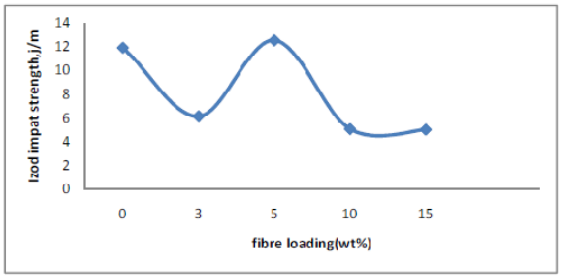

Fig-5 Izod impact result of composites.

The Izod impact values of composites increases with the fibre loading up to 3 to 5 wt% due to the test and the random short fibre reinforcement nature both the impact test and short fibre reinforcement have multidirectional (unidirectional) characteristics. Therefore if the unidirectional short fibre percentage increases for the composite structure, the impact values will increase for the composite structure, the impact values will increase in relation. The Izod impact values of composite decreases form 10 to 15 wt%.

V. CONCLUSION

In this paper, it is shown that human hair fibre act to reinforce the PP polymer matrix. Composite with 3 to 5wt% of bio fibre shows higher flexural strength, flexural modulus and Izod impact strength than non-reinforced polymer but at 10 to 15 wt% lower the flexural strength, flexural modulus and Izod impact strength than the non-reinforced polymer. The tensile strength of the reinforced composites lower than non-reinforced composite. The tensile and flexural properties decrease when the fibre loading percentage increases. Utilizing whole fibre not only provided good properties but will also eliminate the need for processing the fibre leading to lower costs and superior characteristics. The tensile properties can be enhanced with the increasing percentage of the human hair fibre and also with different resin. Another way to enhance the composite properties is to determine an effective treatment to eliminate lack of adhesion between matrix and fibre.

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