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EFFECT OF COUPLING AGENT ON MECHANICAL PROPERTIES AND PHOTODEGRADABILITY OF HDPE-JUTE FIBRE COMPOSITES

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ABSTRACT

Jute fibre reinforced HDPE composites of different weight percent of fibre loading.were prepared by melt mixing fillowed by compression moulding. Coupling agent (MAPE) treatment were done to improve the interfacial adhesion between the fibre and HDPE matrix. The fibres were treated with different concentration of MAPE and impregnated for different time period. The composites were exposed to UV radiation for different time period. Mechanical strength were recorded as a function of fibre loading, coupling agent concentration, time of impregnation and time of UV exposure. Mechanical strength of the Jute-HDPE composites increased linearly with the increase in the fibre loading and coupling agent concentration. The extent of photodegradation increased with increasing exposure time period.

Key words: HDPE, Jute, MAPE, Mechanical strength.

INTRODUCTION

The use of agro-based lignocellclosic natural fibres such as jute,sisal,coir etc. in preparing composites with various thermoplastic resins is gaining much momentum in recent years[1,2]. A number of studies on wood fibre-polymer composites (WFPC) have been reported in last two decades[3]. Polyethylene (PE) is one of the four most popular thermoplastic in the world. An extensive research has been carried out on jute plastic composites[4,5]. This is due to their low cost, non-abrasive nature, low density, high specific properties and biodegradability characteristic. Despite many advantages, the use of jute fibres in the preparation of thermoplastic composites has not been extensive due to inherent high moisture, absorption capacity.,.poor wettability and poor adhesion characteristics towards many commercial synthetic resins resulting in poor strength. However by the use of suitable coupling agent for surface modification,of the fibres, the properties can be improved substantially. More efforts have been made to improve interfacial bonding between polar wood fibre and nonpolar polyethylene matrix[6-10].

In the present study we have recorded the mechanical strength of jute fibre-HDPE composites as a function of fibre loading, coupling agent concentration and impregnation time. The composites were also exposed to UV radiation for different time periods to investigate the mechanical degradation.

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EXPERIMENTAL

Materials

High density polyethylene (160A80) having density of 0.960 gm/cc and melt flow index of 8, obtained from M/s Gas Authority of India Ltd. (GAIL), India, was used as the base polymer matrix. Jute fibreshaving an average fibre diameter of 50 um, obtained from Indian Jute Industries research Association (IJIRA), India was used as reinforcing agent

Coupling agent treatment

Maleic anhydride grafted polyethylene was used as coupling agent for surface modification of the fibres. The untreated fibres of 6 mm length were immersed in hot MAPE solution (in toluene) at 100^{o}C at different concentration (0.3, 0.5, 1, 2%) to obtain the MAPE modified fibres.

Preparation of composite Samples

The untreated fibres at different weight percent of fibre loading (10%, 15%, 30% and 45%) and MAPE treated fibres (at 30% loading) were melt mixed with HDPE separately in Torque Rheocord-9000(Haake Germany). The mixing was carried out at an optimized temperature of 190^{o}C. for a period of 10 minutes, at a rotor speed of 25 rpm. These premixes were brought to room temperature and compression moulded using 100 T Press (Delta Malikson Pressman, India) at 170 c. to produce sheets of 3 ± 0.1 mm thickness.

Tensile testing

Specimens of virgin HDPE, untreated and MAPE treated composites having dimensions 165 x 13 x 3 mm were subjected to tensile test using Universal tensile machine (UTM) LR-100K. A crooshead speed of 100 mm/min was used for carrying out the test.

UV exposure

The untreated and MAPE treated composites along with virgin HDPE specimen were exposed to UV source of mercury operating at 200 Watt having diameter 25 cm. at a wavelength 280 nm for different time period at relative humidity 50 ± 5%, chamber temperature 40 ± 2. The irradiated samples were subjected to mechanical testing to evaluate the effect of MAPE on UV exposure.

RESULTS AND DISCUSSION

Effect of fibre loading on mechanical properties

The mechanical properties of the virgin HDPE matrix and the untreated jute fibre reinforced HDPE composites as a function of fibre loading is presented in Table 1. It was observed that the mechanical strength of the of the untreated Jute-HDPE composites increased linearly with the increase in the fibre loading from 10 to 30% Nearly 31% increase in tensile strength was obtained with 30% jute filled composite as compared to the virgin matrix. This behavior is primarily attributed to the reinforcing effect of the fiber”s leading to a uniform stress distribution from the continuous polymer matrix to the dispersed fibre phase. However, beyond 30% of the fibre loading there was a notable reduction in the mechanical strength of untreated composite. The tensile strength decreased to 24% as the fibre loading increased from 30 to 45%. This decrease in the mechanical properties at high fibre loading is an indication of poor fibre-matrix adhesion, which promoted micro-crack formation at the interface as well as non-uniform stress transfer due to fibre agglomeration within the matrix[11].

Table 1: Effect of fibre loading on mechanical properties

Fibre Wt. %	Tensile strength (MPa)
0	20.82
10	22.47
15	24.68
30	26.24
45	22.14

Effect of concentration of MAPE on mechanical strength

The efficiency of MAPE as coupling agent is reviewed by varying its concentration. The mechanical properties of the composites treated at various concentration of MAPE is represented in table 2. From the table it is evident that with the increase in the MAPE concentration from 0.3 to 1%, there was a consistent increase in the mechanical strength of the composites. This increase in mechanical properties is primarily attributed to the formation of ester linkages between the anhydride groups of MAPE and hydroxyl groups of the jute fibres. Further, the long PE chains of MAPE become compatible with the virgin matrix, lower's the surface energies of the fibre's, thereby increasing its wettability and dispersion within the matrix[12]. This phenomenon is probably due to increase in interfacial adhesion between the fibres and the matrix[13]. The composites prepared at 1% MAPE concentration exhibited optimum strength. However with further increase in MAPE concentration from 1 to 2%, there was a marginal decrease in mechanical properties. This behavior may be attributed to the migration of excess MAPE around the fibre's, causing self entanglement among themselves rather than polymer matrix resulting in slippage[13].

Table 2: Effect of concentration of MAPE on mechanical strength

Conc. of Mape %	Tensile strength (MPa)
0.3	32.00
0.5	36.35
1.0	40.14
2.0	37.10

Effect of time period of impregnation of the fibres in MAPE

The treatment time period of impregnation of the fibre's in MAPE was varied from 3, 5, to 10 minutes. An optimized jute loading of 30% and MAPE concentration of 1% was maintained for the evaluation of the mechanical strength as a function of treatment time period. Table 3.

Table 3: Effect of time period of impregnation of the fibres in MAPE

Time of impregnation (in min.)	Tensile strength (MPa)
3	35.20
5	39.14
10	25.85

Demonstrate that there is an increase of 11% in tensile strength, as the treatment time period increased from 3 to 5 minute. However, with further increase in treatment time from 5 to 10 minutes, there was a significant deterioration in the overall properties of the composite. This may be due to loss of strength of jute fibre's owing to their chain scission at high temperature for a longer time period of 10 minutes.

Effect of UV-radiation on mechanical properties

The degradation behavior of virgin HDPE along with the untreated and MAPE treated composites (at 30% fibre loading) by UV radiation was studied using mercury lamp having diameter 25 cm. operating at 200 Watt. The samples were irradiated for different time periods of 100, 125, 150 and 200 hours respectively, to evaluate the extent of mechanical degradation. The variation of tensile strength of various composite samples after UV exposure is depicted in Table 4. From the table, it is evident that the extent of degradation increased with increase in exposure time period

Table 4: Effect of UV-radiation on mechanical properties

Sample type	Tensile strength (MPa)			
	Time period of exposure (in hours)			
	100	**125**	**150**	**200**
HDPE (Virgin)	18.63	17.11	15.9	14.65
Untreated	23.77	20.01	18.87	15.25
MAPE treated	37.06	34	31.18	26.20

Differences in both the thermal and moisture expansion coefficient's of fibres and matrix on prolonged exposure have contributed to progressive debonding and therefore weakening of the materials. Debonded fibre-matrix interface is found in both untreated and MAPE treated composites compared to those before aging. The damage is more severe for the samples exposed for a prolonged time period of 200 hours. This may be due to oxidative degradation and chain scission of cellulosic fibres and matrix material that has caused a greater reduction in the tensile strength of the composites. However the extent of degradation is comparatively less in the MAPE treated composites, which may be due to enhanced fibre-matrix adhesion.

CONCULSION

Low cost lignocellulosic fibre jute can be used as an effective reinforcement with a fibre loading of 30% to prepare high performance Jute- HDPE composites. Surface modification of the fibres with MAPE resulted in an improvement in the mechanical properties of Jute – HDPE composites. The composites prepared at 30% Jute loading and 1% MAPE concentration for time period 5 min. impregnation showed better results. Mechanical strength after UVexposure revealed enhanced compatibility of the Jute fibres within the HDPE matrix with MAPE treatment.

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