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Preliminary Studies of the Effect of Coupling Agent on the Properties of Spent Coffee Grounds Polypropylene Bio-Composites

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ABSTRACT:

Lignocellulosic biomass is the most abundant material in the world. Therefore interest in the utilization of agro waste/bio waste as fillers in thermoplastics has increased due to the needs in overcoming the environmental problems caused by their by product. Among the agro waste used, most resent developments are with jute, palm coir, sisal and banana fibers etc as reinforcement. The aim of this present study was to develop a polymer made up of spent coffee grounds reinforced polypropylene composite. Two different grades of polypropylene were taken, one is a copolymer (RepolB650) and other is a homo polymer (RepolHIIO). This paper reports on the effect of coupling agent on the mechanical properties of polypropylene coffee grounds bio composite and extent of degradation of the composites by soil burial method. The coupling agent used for the study was maleic anhydrate grafted polypropylene MAPP (GR 216), these were melt blended using twin screw extruder and then injection molded into standard specimens to study tensile strength, modulus, impact strength and hardness. Results showed that there is an increase in mechanical properties except impact strength with respect to co polymeric composite compared to the homo polymeric composite by the addition of compactibilizer. Fair degradation sites were also found in the SEM analysis.

Key words: Polypropylene, agro waste, coupling agent, bio-composite, thermoplastic composites.

INTRODUCTION:

The use of cheap lingo cellulosic-filled renewable fibers like jute, sisal, coir, and wood etc, in preparing composites with various thermoplastic and thermosetting resins has gained more attraction in the recent years (1-7), especially by using various types of fibers, filler characteristic, type of coupling agent and so forth. Using lingo cellulosic fiber as reinforcement in common thermoplastic matrix would provide versality on the properties of the composite materials. Extensive research has been carried out on the agro waste based plastic composites which have been reported in number of works (8, 9). This is due to their low cost, low density, easy availability, nonabrasive nature, specific properties like decreasing the wear, machines used, absence of residue and toxic product and biodegradable characteristics. Economic gains offered by this technology leading to cost reduction of the materials with required properties are the prime motive for wide acceptance of polymer blends. By combining both the technology (waste and blending) together, better improved composites can be achieved. Despite above advantages, agro dilled composites has not been versatile because of the poor final properties of the composite. This may be due to less thermal stability during processing, poor dispersion characteristics of fiber in the matrix and very low compactability between fiber and matrix (11, 12). However properties can be improved by making some chemical modification on the fiber or by implementing suitable certain surface treatment properties can be improved. Extensive research work has been carried out with different kinds of coupling agent for surface modification of agro fibers in order to increase the adhesiveness with thermoplastic matrix. Few of the recent works MAPP (Maleic anhydride grafted polypropylene) was used as coupling agent (13-16) and the studies revealed that there is improvement in the mechanical properties.

Coffee bean residue is a plentiful, inexpensive material frequently discarded by coffee plants and coffee shops as waste. Since coffee beans and the residue there from are biodegradable, and because the products of this invention contain large amounts of coffee bean residue, these new products are biodegradable and therefore they are environmentally desirable. Coffee generates $15 billion dollars in annual revenue, making it the 2nd largest raw material economy in the world, behind petroleum. Roughly one-half of all coffee beans remain as waste after processing. This provides million of tons of coffee waste, which is a virtually unlimited supply of raw material for use in accordance with this invention. (17)

US department of agriculture (USDA) recently reported that according to Indian coffee board, domestic coffee consumption is increasing 5-6% annually. It also had reported that there were 94, 400 tones consumption in India in 2008, 73% consumed in urban area and remaining 27% in rural areas, mainly in southern India. India is Asia’s biggest coffee exporter, sends 70% of its production to over sea’s market. Production for the current year is estimated to be 3.08 lakh tones.

This factor has prompted me to investigate the performance of spent coffee grounds as filler in polypropylene composites. In this study, polypropylene was used as matrix and lignocellulosic material (spent coffee grounds) as a reinforcing filler to prepare polypropylene coffee grounds (PPCG) composites. The present study reveals the effect of treatment of the coupling agent, MAPP (GR 216) on the properties of PPCG bio composites.

SCOPE OF THE WORK:

The present work is aimed at the following objectives.

- To use spent coffee grounds (CG) as bio fillers at different composition in polypropylene to make bio composite (CGPP).
- To determine its effect of coupling agent (GR 216) on the properties of polypropylene bio-composites.
- To study the extent of degradation between CGPP and CGPP subjected to biodegradation by SEM analysis.

EXPERIMENTAL

Materials:

Two grades of polypropylene were used one, is co-polymer grade (RepolB650) and other was homo polymer grade (Repol HIIO) both were supplied by Reliance Company having melt flow index of 65g/10min (230°C/2.16 Kg) and a density of 0.9g/cm^3 and melt flow index of 11g/10min (230°C/2.16 Kg) and a density of 0.9g/cm^3 respectively. The reinforcing filler used were spent coffee grounds obtained from cafeteria of Dr.M.G.R Educational and Research University. MAPP (Amplify GR 216) was supplied from Bhimrajka implex Ltd, melt flow index of 1.23g/10min and a density of 0.87g/cm^3.

Preparation of composites:

The CG were washed thoroughly with water to remove the adhered contaminants, and dried in an air oven at 100°C for 24 hours. The dried coffee ground were then sieved to obtain uniform size of ≤75µm, Polypropylene[both co-polymer and homo polymer were used] is mixed with 15% constant composition of coffee grounds and with various weight ratios of compactiblizer (1%, 3%, 5%). The compounding of polypropylene, MAPP, Coffee Grounds was carried out using twin-screw compounder at 180°C for 20 minutes at a roller speed of 50 rpm. The Composition of bio composites are given in Table 1&2. The extrudates was cooled and passed through a pelletizer and cut into granules and dried. The blended samples were placed between a two-piece molding set and hot pressed followed by cooling for 3 minutes under pressure equipped with chiller facilities. The pressure for heating and cooling was maintained to 150 kg/ cm^2. Molded sheets of 1 and 3 mm thickness were prepared for tensile and impact testing respectively.

Mechanical properties:

Tensile Test

The tensile test specimens were prepared by hand injection molding machine as per ASTM D 638-04 and tested in Universal Testing Machine with a load of 1kN at 50mm / min crosshead speed. Tests were performed until tensile failure occurred. Five replicated specimens were presented as an average of tested specimen.

Impact Test

The impact strength test was developed to overcome the deficiency of flexural impact tests. The impact tests were conducted according to ASTM D235 standard. The Izod method was carried out using notched samples by impact Pendulum Tester (Model Ceast CEUM-636), using 4 joule hammer. Five replicate specimens were presented as an average of tested specimens.

Soil Degradation Test

Composite samples were buried in soil for different periods of time. After certain period, samples were withdrawn carefully, washed with distilled water and dried at 105°C for 6 h and kept at room temperature for 24 h and then the mechanical properties were measured. The soil used in this study was non-calcareous soil. The used soil had a pH of 5.5. The moisture content and sand content was 3.7 &6.6% respectively (18).

RESULTS AND DISCUSSION:

Fillers play an important role in determining the mechanical properties of cellulose filled-thermoplastic composites. The most crucial factor that affects the mechanical properties of the fiber-reinforced materials is the fiber-matrix interfacial adhesion, which in turn is determined by nature of fiber and polymer components, the fiber aspect ratio, the processing parameters and the treatment of fiber (15, 16). Due moisture absorption and because of the presence of other polar groups in the fiber, the adhesion between the fiber and the matrix becomes weak, resulting in de bonding. Therefore in order to enhance the mechanical properties of the composites, by making suitable chemical modification the moisture absorbing nature is reduced, by adding certain compactiblizers or coupling agents. For our study we had used MAPP (Maleic anhydride grafted polypropylene)

Fig 1 shows MAPP treated Co-polymeric and Homo-polymeric Composites (15%CG). It is observed that increase in 1 wt% MAPP in case of HPP shows slight increase, where as it almost same in case of CPP, this may be due to decrease in number of polar groups in case of CPP (Co-Polymer of both ethylene and propylene). This shows that MAPP has slightly improved the resin pickup and wet ability of homo polymer during composite preparation. On the other hand PPCG bio composites did not show any significant increase in the tensile strength compared to control sample i.e., with further increase in concentration of MAPP from 3 to 5% a decrease in tensile strength was observed for both different matrixes. The reason might be MAPP has lower molecular weight compared to matrix which seems to be responsible for plasticizing effect. Whereas in contract to tensile strength both bio-composites shows increase in impact strength, which means the adding of filler content has decreased the stiffness of the composite.

Little difference in the properties obtained between 2% and 3% (by weight) MAPP systems. The drop in tensile strength with the addition of MAPP is probably due to0 polymer morphology. Transcrystallization and changes in the apparent modulus of the bulk matrix can result in changes in the contribution of the matrix to the composite strength (17).

Fig 3& 4 shows the effect of MAPP on the impact strength and hardness respectively of PPCG bio composites. Increase in impact strength was reported with increase in filler content, but homo polymeric matrix shows tremendous increase in value compared to co polymeric matrix, with respect to hardness it shows reverse effect. In case of un-notched impact test determination, energy absorption is through a combination of crack initiation and propagation. The use of additives increases the energy needed to initiate cracks in the system and thereby results in improved un-notched impact strength values with the addition of MAPP (17).

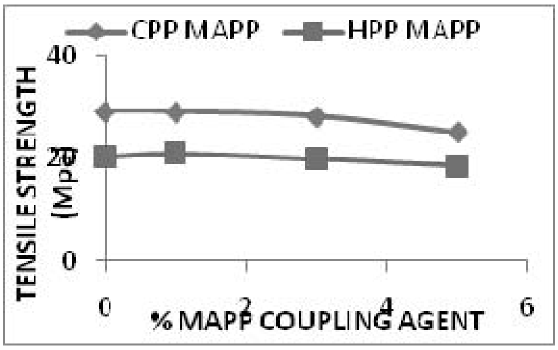

Fig 1: Effect of coupling agent (MAPP) on tensile strength of PPCG (HP&CP) bio composites at 15% filler loading.

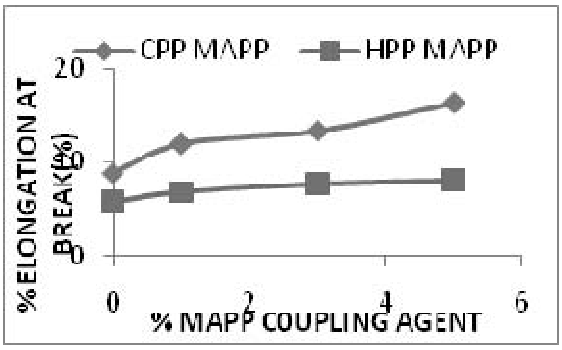

Fig 2: Effect of coupling agent (MAPP) on elongation at break of PPCG (HP&CP) bio composites at 15% filler loading.

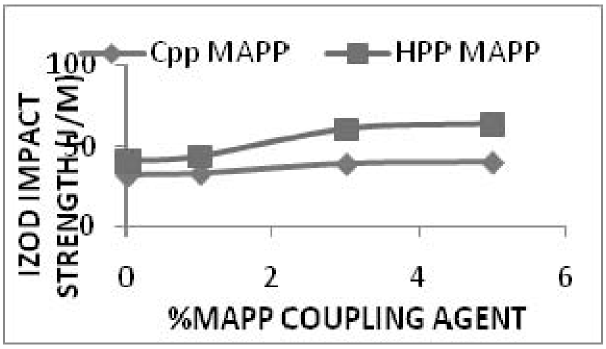

Fig 3: Effect of coupling agent (MAPP) on Impact strength of PPCG (HP&CP) bio composites at 15% filler loading.

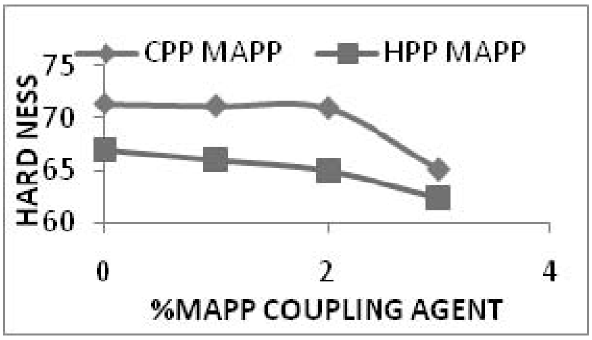

Fig 4: Effect of coupling agent (MAPP) on Hardness of PPCG (HP&CP) bio composites at 15% filler loading.

CONCLUSION:

The results of the present study showed that useful PPCG bio-composites with two different PP matrixes with better compatibility and impact strength were successfully developed. Mechanical properties of co-polymeric composites were found to be higher than homo polymeric composite. Thermodynamic segregation of MAPP towards the inter phase of co polymeric composite (Propylene and Ethylene) can have better covalent bonding to –OH groups on the filler surface. Under tensile load, improved adhesion at the fiber/matrix interface results in a more efficient stress transfer from the matrix to the reinforced fillers. As a result, strength of agro-resource composites can be improved with a small addition of MAPP (17). Further testing should be done with still lower concentration of MAPP and with higher filler loading.

Surface morphology revealed that there is good dispersion and adhesion of filler particle in the polymer matrix. Fig 5 it can be seen that, bonding occurred between –OH groups and CG of PP matrix through MAPP, Presence of voids in Fig 6 shows enhanced degradation had occurred. In conclusion due to shortage of petroleum products and increasing interest in maximizing renewable sources, we can use this modified bio composites for value added cost effective housing and packing materials.

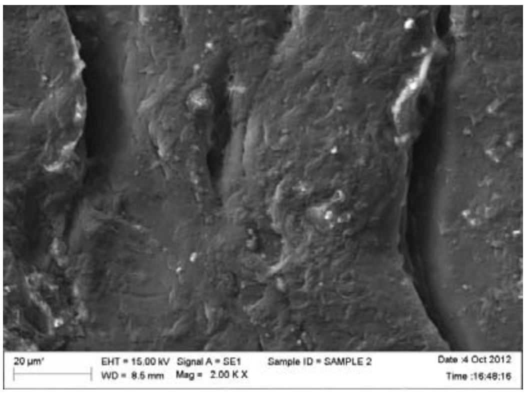

Fig 5: SEM image of CGPP composite

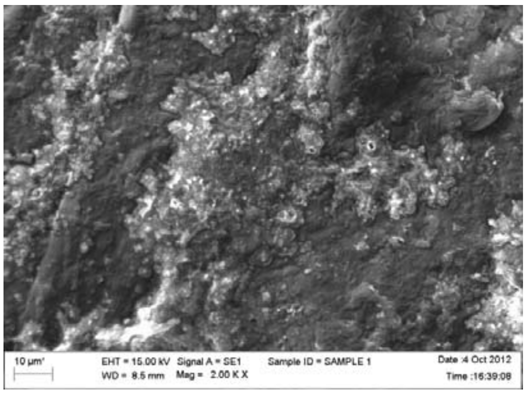

Fig 6: SEM image of biodegraded CGPP composite

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