STUDY ON DIFFERENT PROPERTIES OF LOW DENSITY POLYETHYLENE COMPOSITES REINFORCED WITH PINEAPPLE LEAF FIBER

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Abstract: *Pineapple leaf fiber (PALF) is one of the abundantly available agro wastes materials in Bangladesh. PALF reinforced low density polyethylene (LDPE) based composites were fabricated by compression molding with randomly oriented fiber loading 10-60% interval of 10%. In this study the influence of the addition of fiber contents on the mechanical properties such as tensile strength (TS) and tensile modulus (TM), Elongation at break (EB%), bending strength (BS) and bending modulus (BM), impact strength (IS). Based on the fiber loading 50/50% composite yielded better mechanical and other properties compared to the others. Impact strength increases with the increases of fiber loading in composite till 50% then it decrease in case of more fiber loading. To improve the compatibility between fiber and matrix, 50/50% PALF-LDPE composites were irradiated with gamma rays (Co-60) of doses varied from 2.5kGy to 10kGywhere, composites irradiated with 7.5kGy dose delivered the best results.*

Keywords: *Composite, PALF, LDPE, Mechanical properties, gamma radiation*

INTRODUCTION

The word 'composite' means a substance which are the engineered materials made from two or more constituent materials, with significantly different physical and chemical properties and which remain distinct and separated at the microscopic level within the finished structure. These are becoming more and more important because of its increased utility. Considerable growth has been seen in the production and use of composites made from natural fiber in the construction and automotive industry, but application in other sectors has been limited. The unconventional fibers and other bio-renewable resources offer an almost limitless supply of renewable and potentially sustainable raw materials for the production of composites. Also the introduction of new fibers, with different bio-resins and additives may well result in an expansion in their use into more diverse, and technically demanding application areas [1]. In the development of modern technology, Fiber Reinforced Polymer (FRP) composites play a vital role in day to day life due to its low cost, processing advantage of lower density and possessing good mechanical behavior over traditional reinforcement materials [2]. Renewable natural fibers such as oil palm, flax, and pineapple leaf can be used to acquire high performance polymer materials. The renewable natural fiber as reinforcement for polymer is a sustainable choice to the environment [3]. Composites materials are becoming very important in our daily life because of its growing utility. A composite poses the properties which could not be attained by either of the constituent materials alone. These are used in furniture, aerospace, aircraft, boats, automobiles, bridges, towers and light poles, pipelines, buildings, turbine blades, roads, sports equipments and many other products. Various experiments are being made to upgrade the qualities of composites so that these may be further strong, lightweight, prolonged and economical to manufacture.

Composites are comprised of a hard material with discontinuous reinforcement that is embedded in a weaker, continuous matrix. The reinforcement provides strength and rigidity, in order to help to support the structural load [4]. The regulatory assessment and monitoring procedures as per the National/International guidelines are required to be reviewed wherever needed. They must be updated periodically depending upon the composition, intended usage conditions in order to promote clean processing, applications, biodegradation, recycling and reprocessing [5].

Natural fiber-reinforced (NFR) composites have many advantages as they are lightweight, biodegradable, renewable, economic, environmental friendly, and have reasonable strength and stiffness. In addition, comparing to glass fiber reinforced composites; the NFR composites reduce dermal and respiratory irritation during handling as well as reduce tool wear [6]. The disadvantages of natural fiber composites are lower durability than for synthetic fiber composites, but can be improved considerably with treatment, high moisture absorption, which results in swelling and lower strength in particular impact strength compared to synthetic fiber composites [7].

The composites are developed by using hand lay-up technique with heat compress machine. The developed composites are used to conduct the mechanical tests like tensile test, flexural test and bending test. The water up take percentage and density of these composites also has been measured. The obtained values of mechanical properties of each volume ratio is tabulated and compared. The optimum volume ratio for which the composite show better mechanical properties is concluded. Then the best ratio of PALF and LDPE composites were radiated by gamma ray and further the mentioned properties had been evaluated. In order to achieve the aim, the following objectives have been identified:

- To fabricate biodegradable, environment friendly, and low cost PALF-LDPE composites.
- To evaluate various properties, such as tensile, bending strength, impact strength of the composites.
- To evaluate the best effect of pine apple leaf fiber volume fraction on the above mentioned properties of the composites.
- Then the best ratio of PALF and LDPE is identified and radiated for better cohesion between fiber and polymer.
- Further the mentioned properties are evaluated to identify the increasing percentage of values.

METHODOLOGY

Tensile tests were conducted according to ASTM D638-01 using a Universal Test Machine (Model: H50KS-0404, HOUNSFIELD Series S, UK).In the present study impact strength of composites was conducted on notched mood according to ASTM D256 standard using a Universal Impact Tester (Hung Ta Instrument Co. Ltd. Taiwan), model-HT-8041B IZOD. The nominal energy of the pendulum was 150 kg-cm, lifting angle (α) was 150°, force torque (WR) was 80.811kg-cm. First of all, the specimen was clamped into the pendulum impact test fixture with the notched side facing the striking edge of the pendulum. Then the pendulum was released and allowed to strike through the specimen. It has been observed that gamma treated PALF/LDPE composites showed the best mechanical properties, such as tensile properties, bending properties and impact strength than untreated composites. The PALF/LDPE composite field incorporated can easily be explored for better commercial decoration, structural and other associated applications. Due to the use of low-cost gamma treatment as a modification technique and good balance of mechanical properties, this type of composite can primarily be used for low-cost housing and automotive interior component applications.

RESULTS AND DISCUSSION

The reason for this distinct value is because at the composition of (PALF/LDPE) 50/50, a higher value of composite has resulted a high tensile strength due to the appropriate proportions of reinforced fiber and matrix polymer where bonding between these happened properly. Hence, it has held that the PALF firm and this affected their mechanical properties.

The introduction of 50wt-% fiber content in the LDPE matrix increased the tensile modulus by more than two times compared to the 10% fiber loading, which is attributed to the higher modulus of the PALF and LDPE ratio.

The increase in strength of the composites indicates an increase in the rigidity of PALF related to the restriction of the mobility in LDPE matrix due to the presence of fiber content. The high values of strength observed in these experiments may be due to the fair distribution of the PALF in the LDPE matrix resulting in fiber reinforced–LDPE matrix interaction.

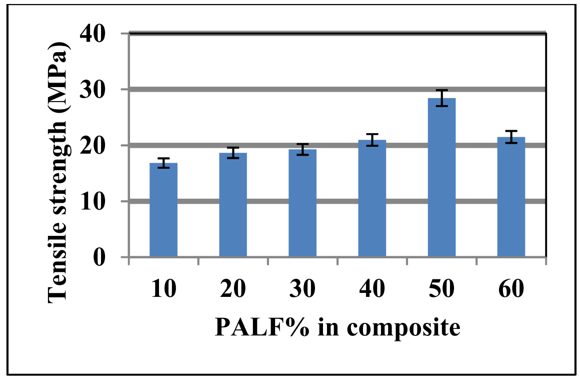

Figure 1: Tensile strength (MPa) of PALF/LDPE composites varying fiber loading

It can be clearly seen from the figure that values of BS composites were increased with the increase of PALF up to 50%. The maximum value of BS were found to be 78.42MPa for 50% PALF reinforced composite and further increasing of fiber content decreased the values.

Bending Modulus (BM) is another mechanical property of composites. It was measured as a function of PALF loading percentage in composite.

Izod impact strength of the PALF-LDPE shows increase in impact strength with filler loading, because of the increase of reinforcement fiber content in the composites. From the figure it was observed that values of IS of PALF/LDPE composites claimed linearly with the increase of fiber content up to 50% in composite.

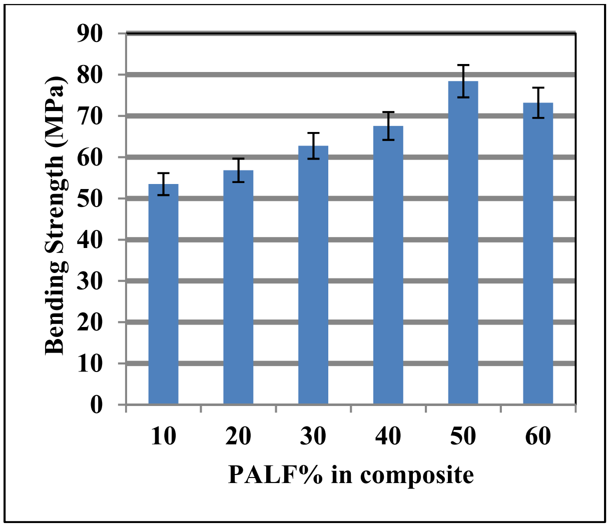

Figure 2: Bending Strength (MPa) of PALF/LDPE composites varying fiber loading

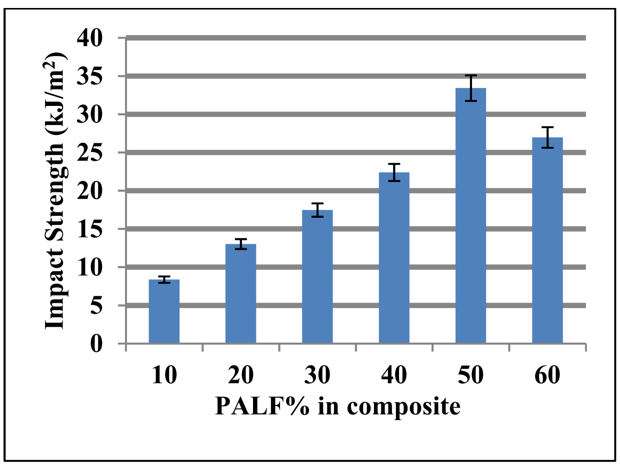

Figure 3: Impact strength (kJ/m^2) of PALF/LDPE composites varying fiber loading

It is observed that mechanical and physical properties of PALF/LDPE composites increased with gamma radiation up to a certain dose and then decreased due to the two opposing phenomena, namely, photo cross-linking and photo degradation that took place simultaneously under g radiation. At lower doses, free radicals are stabilized by a combination reaction as a result photo cross-linking occurs. The higher the number of active sites generated on the polymeric substrate, the greater the grafting efficiency. But at higher radiation, the main chain may be broken down and polymer may degrade into fragments as a result mechanical and physical properties will decrease after certain gamma doses.

Tensile properties of the composites were found to be improved significantly after irradiation. TS, TM, IS, BS, BM and ρ of these composites increased maximum 35.34%, 16.01%, 32.94%, 26.17%, 26.87%and 8.85% respectively at 7.5kGy. But the elongation at break and water uptake percentage have been decreased the maximum 45.63% and 52% respectively in case of 7.5kGy due to radiation.

CONCLUSIONS

Based on the results of tensile strength, hardness and density, it can be concluded that the PALF/LDPE composite with the composition ratio of 50/50 has shown the best mechanical properties comparable to others composition ratios. However, for PALF/LDPE composites with PALF loading of less than 50% and more than 50% not appropriate for composite materials because comparatively it shows the lowers mechanical properties. Furthermore this type (50/50) of composite was irradiated with different doses of gamma ray. From this investigation it was found that tensile, bending and impact strength of composites were increased significantly after application of gamma radiation. In the 7.5 kGy dose showed better mechanical properties compared to the best for above properties. After radiation the tensile strength, tensile modulus, elongation at break, bending strength, bending modulus, impact strength, water absorbency and density of 50/50 PALF/LDPE composites were found 38.49 MPa, 966.22 MPa, 36.17%, 98.94 MPa, 7313.93 MPa, 44.43 kJ/m^2, 9.33%, 1.23 gm/cc respectively in 7.50kGy dose. It revealed that gamma irradiation formed better cross-linking between PALF and LDPE matrix. Finally to summarize, the study has demonstrated the optimum fiber loading for peak performance is at 50 wt%. Fiber matrix interaction is well adhered and compatible with the radiation of gamma ray at this concentration of fiber of 7.5 kGy. PALF is widely accepted in textile sector and already used in our daily life materials but we attribute that further study will enhance the application in various other exiting products.

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