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Effect of Gamma Radiation on the Properties of Jute Reinforced Polyester Matrix Composites

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Abstract

The interest in fiber-reinforced polymer composites is growing rapidly due to its high performance in terms of mechanical properties, significant processing advantages, excellent chemical resistance, low cost, and low density. In the present work, hessian jute cloth, were used to prepare jute-polyester composites by hand lay-up and heat press molding techniques. The Jute fabrics were also treated with irradiated under gamma radiation (The source strength 50 kCi Cobalt-60) of various doses (2 kGy to 9 kGy). It was found that by using gamma radiation, the mechanical properties of these composites were improved and at 5 kGy doses all the composite structures shows the best mechanical properties. The increase in tensile properties of jute with increasing gamma radiation dose may be due to the intercross-linking between the neighboring cellulose molecules, which resulted in the strength of natural fibre. It was observed that tensile properties increase with gamma pretreatment up to a certain limit and then decrease due to the two opposing phenomena, namely, photocross-linking and photodegradation that took place simultaneously under gamma radiation.

Keywords: Gamma radiation; Composites; Jute; Polyester; Natural fibre

Introduction

Composites are combinations of materials differing in composition, where the individual constituents retain their separate identities. These separate constituents act together to give the necessary mechanical strength or stiffness to the composite part. Composite material is a material composed of two or more distinct phases (matrix phase and dispersed phase). In recent years, a rapid growth occurred in the consumption of fiber reinforced polymer composites, yielding a unique combination of high performance, great versatility and processing advantages at favorable costs [1] by permutation and combination of various fibers and polymers, a wide range of composites, having unique properties for versatile applications as alternatives to conventional materials like metals, woods etc. have been prepared [2].

Theoretical Background

The jute fabric reinforced polyester composites in corrugated form "Jutin" is an ideal material for roofing and wall cladding. Although the main application of these sheets in Bangladesh is the covering of industrial building, they are equally suitable for roofing residential houses, commercial building, bungalows and go down's sheds since for their good mechanical properties. Weave structure other than the plain may improve the mechanical properties of these composites as weave structure affect the mechanical properties of woven fabric [3]. So in the present work gamma treated (Plain, $\frac{3}{1}$ t will) jute fabrics have been used as reinforcing material for jute-polyester composites. Thus the present study may be a novel work on the mechanical properties of jute-polyester composites.

Materials and Method

Materials used as reinforcement

Grey jute yarn of 5/2 lbs/Spyndle was collected from the local market of Tangail, Bangladesh and used to manufacture jute fabric based on $\frac{3}{1}$ t will and plain weaves.

Matrix

Polyester resin

Manufacturer: Polymer Company Limited, Singapore

Supplier: Nasim Plastic Industries Ltd. 6/1 North South Road, Dhaka

Initiator: Methyl ethyl ketone peroxide (MEKP) is organic peroxide, a high explosive similar to aceton peroxide. The UPAC name of MEKP is 2-Hydroperoxy-2-((2-Hydroperoxy-2-yl)peroxy)butane.

Instrument used for the experimental works

Universal Testing Machine with related accessories, Impact Strength testing machine, Electronic balance, Slide Calipers, Measuring scale, Grinding Machine, Scissors, Beaker, Mylot Paper, Pipette.

Gamma radiation treatment

The Jute fabrics were treated with gamma radiation using Cobalt-60 gamma source (50 kCi) in the Institute of Food and Radiation Biology, Atomic Energy Research Establishment, at different doses (2 kGy to 9 kGy).

Testing method

Tensile Tests (ASTM Designation: D638-03), Bending Test (According to ISO 14125 methods), Impact Tests (According to the ASTM D-256).

Results and Discussion

It should be noted that $\frac{3}{1}$ t will and plain weaves are used for

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fabricating jute polyester reinforced composites to analysis the gamma radiation on jute-polyester composites as this two fabric structures shows the better and lowest mechanical properties respectively in jute-polyester composites. Accordingly the sample IDs have been assigned by considering the jute fabric structures. For example, sample ID, JPC (3/1), denotes the jute polyester composites having $\frac{3}{1}$t will jute gamma treated fabric as reinforcement, similarly JPC (P) denote the jute gamma treated polyester composites having plain weave jute fabric as reinforcing materials respectively.

Tensile strength

Fabric structures have influences the mechanical properties of the composites. Tensile strength (MPa) of the composites was measured as a function of jute fabric structure and the results are shown in Figure 1 and Table 1. The effect of Gamma radiation on the mechanical properties of jute-based composites is shown in Figure 2. The Gamma doses of different intensities were given to jute surface and Gamma radiation of 5 kGy showed the optimum mechanical properties. Mechanical properties, such as tensile strength increases up to 5 kGy showed, which gives 31% increase in tensile strength for $\frac{3}{1}$t will and 37% increase in TS for plain fabric structure composites. The increase of tensile properties of jute with increasing gamma radiation dose may be due to the intercross-linking between the neighboring cellulose molecules, which resulted in the strength of natural fiber. It is observed that tensile properties increase with gamma pretreatment up to a certain limit and then decrease due to the two opposing phenomena, namely, photo cross-linking and photo degradation that take place simultaneously under gamma radiation [3]. At lower doses, free radicals are stabilized by a combination reaction and, 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 and, as a result, tensile properties will decrease after certain gamma doses. An intense radiation results in a loss of tensile strength, and a reduced degree of polymerization is observed [4].

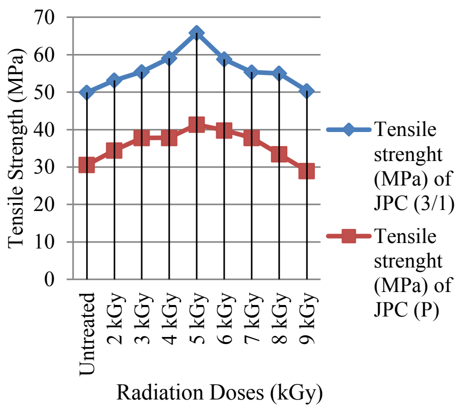

Figure 1: Tensile Strength of various jute reinforced polyester composites.

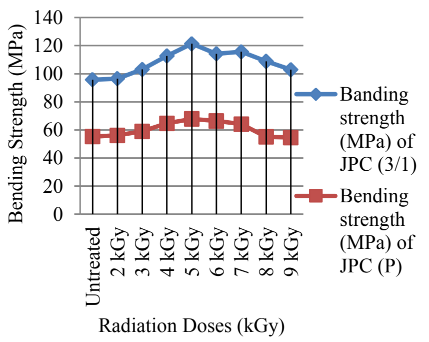

Figure 2: Bending strength of various jute reinforced polyester composites.

Bending strength

Bending strength is another mechanical property of the composites. Bending strength of the composites was measured in MPa and function of jute fabric structure and the results are shown in Figure 2 and Table 2. The effect of gamma radiation on the mechanical properties of jute-based composites is shown in Figure 2. The gamma doses of different intensities were given to jute surface and gamma radiation of 5 kGy showed the optimum mechanical properties. Mechanical properties, such as bending strength increases up to 5 kGy, which gives 26% increase in bending strength for $\frac{3}{1}$t will and 22% increase in bending strength for plain fabric structure composites. The increase of tensile properties of jute with increasing gamma radiation dose may be due to the intercross-linking between the neighboring cellulose molecules, which resulted in the strength of natural fiber. It is observed that tensile properties increase with gamma pretreatment up to a certain limit and then decrease due to the two opposing phenomena, namely, photo cross-linking and photo degradation that take place simultaneously under gamma radiation [3]. At lower doses, free radicals are stabilized by a combination reaction and, 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 and, as a result, tensile properties will decrease after certain gamma doses. An intense radiation results in a loss of tensile strength, and a reduced degree of polymerization is observed [4].

Treatment Type	Tensile strength (MPa) of JPC (3/1)	Tensile strength (MPa) of JPC (P)
Untreated	49.94	30.55
2 kGy	53.13	34.44
3 kGy	55.43	37.75
4 kGy	59.07	37.82
5 kGy	65.80	41.30
6 kGy	58.74	39.76
7 kGy	55.31	37.78
8 kGy	54.99	33.45
9 kGy	50.34	29.00

Table 1: Tensile strength of various jute reinforced polyester composites.

Treatment Type	Tensile strength (MPa) of JPC (3/1)	Tensile strength (MPa) of JPC (P)
Untreated	95.80	55.40
2 kGy	96.42	56.12
3 kGy	103.13	58.93
4 kGy	112.59	64.77
5 kGy	121.3	67.81
6 kGy	114.26	66.38
7 kGy	115.54	64.14
8 kGy	108.85	55.12
9 kGy	102.99	54.67

Table 2: Bending strength of various jute reinforced polyester composites.

Impact strength

Impact strength another mechanical property of the composites. Impact strength (Kj/m²) of the composites was measured as a function of jute fabric structure and the results are shown in Figure 3 and Table 3.

The effect of gamma radiation on the mechanical properties of jute-based composites is shown in Figure 3. The gamma doses of different intensities were given to jute surface and gamma radiation of 5 kGy passes showed the optimum mechanical properties. Mechanical properties, such as Impact strength increases up to 5 kGy, which gives 12% increase in impact strength for $\frac{3}{1}$ t will and 26% increase in impact strength for plain fabric structure composites. The increase of tensile properties of jute with increasing gamma radiation dose may be due radiation at an optimum intensity and also increases the impact strength of jute unsaturated polyester composites to the intercross-linking between the neighboring cellulose molecules, which resulted in the strength of natural fiber.

It is observed that impact strength increase with gamma pretreatment up to a certain limit and then decrease due to the two opposing phenomena, namely, photo cross-linking and photo degradation that take place simultaneously under gamma radiation [3]. At lower doses, free radicals are stabilized by a combination reaction and, 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 and, as a result, tensile properties will decrease after certain gamma doses. An intense radiation results in a loss of tens impact strength, and a reduced degree of polymerization is observed [4,5].

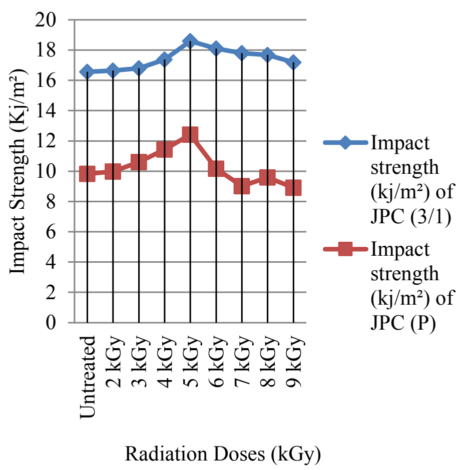

Figure 3: Impact strength of various Jute reinforced polyester composites.

Treatment Type	Impact strength (Kj/m²) of JPC (3/1)	Impact strength (Kj/m²) of JPC (P)
Untreated	16.56	9.82
2 kGy	16.65	9.98
3 kGy	16.80	10.61
4 kGy	17.38	11.43
5 kGy	18.59	12.42
6 kGy	18.10	10.17
7 kGy	17.80	9.01
8 kGy	17.68	9.59
9 kGy	17.19	8.91

Table 3: Impact Strength of various Jute reinforced polyester composites.

Conclusion

- It has been observed that composites fabricated from gamma treated jute fabric showed the best mechanical properties, such as tensile properties and bending properties than untreated jute-based composites. The jute-reinforced composite field incorporated can easily be explored for better commercial structural applications. Due to the use of low-cost gamma treatment as a surface 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. Water uptake behavior of gamma treated jute composites showed a significantly lower trend relative to untreated jute-based composites; higher moisture resistance is developed after gamma radiation treatment. Due to the low cost of gamma treatment, one can easily explore the jute reinforced composite field for diverse application of jute and its products.

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