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Comparative Study of Physical And Elastic Properties of Jute And Glass Fiber Reinforced LDPE Composites

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ABSTRACT:- Jute fiber reinforced low density polyethylene (LDPE) composites and glass fiber reinforced LDPE composites were prepared at variable proportions using compression molding technique at 120 °C. Few physical and mechanical properties such as bulk density, water absorption%, tensile strength, elongation at break (Eb%), Young's modulus, flexural stress and strain and tangent modulus of both composites were studied and compared. Throughout the study, it was revealed that glass composites had better mechanical stability as compared to LDPE jute composites.

Key Words:- Reinforced, composites, thermal stability, low density polyethylene (LDPE).

INTRODUCTION

Now a day, it is well established fact that technological development depends on the advancement in the field of materials. Many of our modern technology require materials with unusual combinations of properties that cannot be meet by conventional metal alloys, ceramics, and polymeric materials. This is actually true for materials that are needed for aerospace, underwater, and transportation applications. For example, aircraft engineers are increasingly searching for structural materials that have low densities, high mechanical strength, abrasion and impact resistant, and are not easily corroded. Generally, stronger materials are denser. At the same time, increasing the strength or stiffness generally results in a decrease in impact strength [1-2]. Composites are formed by two materials: one is called the reinforcing material in the form of fibers, sheets, or particles, and are embedded in the other material called the matrix phase. Reinforcing material and the matrix material can be metal, ceramic, or polymer. Generally, reinforcing materials are stronger with low densities while the matrix is usually a ductile or tough material. A perfectly designed and fabricated composite combines the strength of the reinforcement with the toughness of the matrix in order to achieve desirable properties that are not available in a single component of the composite. Composites are widely used in the brake-shoes, pads, tires and the diesel piston aircraft [3]. The structural components of diesel piston aircraft are 100% composites [4].

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Polymeric technology is one of the most active and promising fields that covers natural polymers such as cellulose, wool, silk, jute, palm fiber etc which are of outmost importance for living systems. The science of macromolecules is divided into two classes: biological and a non-biological materials. Non-biological are the synthetic materials used for plastics, fibers and elastomers with a few naturally occurring polymers such as rubber, wool, and cellulose [5]. In the present era of polymeric science is the most promising and comprehensive field. Development of new polymer is a continuous process for a specific application under certain environmental conditions. The bombardment of the invention of different polymer field has been found to be increased day by day. Biodegradable polymeric materials are enjoying considerable popularity, especially from the standpoint of environmental protection [6]. Fiber reinforced composites are widely used because of their some extraordinary properties such as good processability, relatively good resistance, high stiffness, ease of installation to environmental agent etc. Synthetic fiber reinforced thermo plastic composites are dominating the composite market due to their better durability and moisture resistance properties. Among all the reinforcement materials, glass fiber attracted much attention owing to their improved physical, elastic and mechanical properties, good corrosion resistance, and sound absorption and insulation properties. A well known glass fiber is E-glass which has good insulation properties. Glass fibers are normally used as mats, insulator, reinforcement, sound absorption, heat resistant fabrics, corrosion resistant fabrics and high strength fabrics [7-8]. In recent time, investigations on natural fiber reinforced composites have been performed due to their practical applications [9]. A large abundance of natural fibers like jute, coir, sisal, flax, pineapple leaf fiber, hemp, banana and so forth has enhanced the interest of researchers because of increasing environmental consciousness [10]. Among them, materials with aspect ratio's >1000 are promising as reinforcement materials to use in thermoplastic and thermostat composites due to their low density and excellent mechanical properties [11]. Among all natural fibers, jute is the most useful, inexpensive and commercially available fibers. In the literature it has been documented that the jute fibers can be used as reinforcement in thermoplastics e.g., polyethylene, polyvinyl chloride and polypropylene and thermosets like unsaturated polyester and epoxy resin [12]. Presence of

OH groups in the structure of jute fibers make them susceptible toward moisture absorption from the surroundings. This hydrophilic nature lowers the compatibility and wetting behavior with the hydrophilic polymer matrix [13]. Jute fiber is renewable, versatile, non-abrasive, biodegradable, and compatible [14]. Moreover, natural fibers are lighter than glass fibers which revert as fuel reduction when this material is used by the automotive industry. The use of natural fibers also brings social and economical benefits [15]. Most of studies on fiber composites have focused attention on the investigations of polyolefin as a polymeric matrix. Mechanical properties of polyethylene can be altered and improved significantly by using additives [16]. In the present study, our attention has been given on the improvement of physical and elastic properties of jute and glass fiber reinforced composites with increase in wt% of fiber and length of soaking time. Apart from this, a comparison between the physical and elastic properties of jute and glass fiber reinforced composites has been also presented with respect to wt% of fiber and soaking time.

EXPERIMENTAL DETAILS

At the beginning LDPE sheets of jute mat were cut into pieces with dimensions 8 inch × 6.5 inch using a scissor. With the help of Paul-Otto (P/O) Weber Press machine, composites were made with different ratio of LDPE and jute (100:0, 66:34, 56:44, 45:55 and 35:65 weight %). Each layer of LDPE was pre-impregnated with jute fibers and placed one over another as a sandwich-making system. Later on, the sandwiches were placed between two molds. Then the sandwiches were subjected to heat and pressure in a single stoke. This has been accomplished by placing the molds between two steel plates of 450 KN Weber-press. Steel plates were heated at a set temperature of 120º C for 20 minutes under 100 KN pressure. After reaching the set temperature, the holding time was taken about 5 minutes. Pressure was increased up to 100 KN and the heating system was stopped. The system was then allowed to cool by tap water through the outer area of the heating plates of the P/O Weber machine. Composites of jute fiber reinforced low density polyethylene (LDPE) matrix were prepared by compression molding at 120º C and 100 KN pressure. A similar procedure has been followed for the preparation of glass fiber reinforced LDPE composites by compression molding at 120° C and 100KN. Bulk density of both samples was calculated by measuring the mass and volume of the specimens. To study the water absorption properties, specimens were cut with dimensions size 76mm × 25mm, dried in an oven (at a temperature 50° C ± 3° C for 24 hr) and cooled in desiccators and immediately weighted to the nearest 0.001gm. Tensile measurements of the specimens were carried out using an NC machine to determine the tensile strength and the elongation. Bar shaped specimens having dimension was 5 cm × 1.3 cm × 0.06 cm (up to 0.12 cm) with rectangular cross-sections were prepared for flexural measurements. Flexural measurements were performed to a freely supported beam, loaded at mid-span. The loading speed was 1 mm/min and support-span was 38 mm in dimension. A heating rate of 0.1 K/min. to 100.00 K/min, TGA measuring range of ±200 mg (0.2µg), DTA measuring range of ± 100µV (0.06 µV), and Gas flow ≤ 1000m/min have been maintained throughout the measurement process.

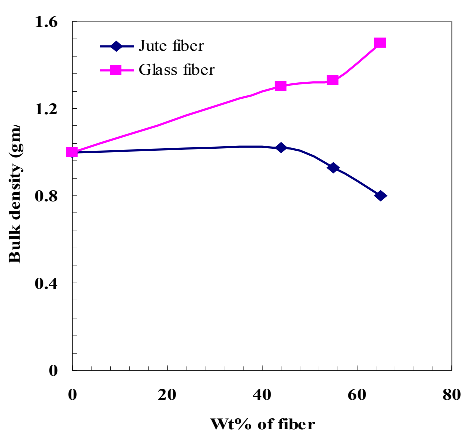

Figure 1: Variation of bulk density of LDPE-glass fiber and LDPE jute composites with wt% of fibers.

RESULTS AND DISCUSSION

Effect of the variation of the wt% of fiber on the bulk density of jute and glass fiber reinforced LDPE composites has been shown in Fig. 1. According to the data, it has been observed that the bulk density of the jute composites decreases due to increases the wt% of the jute fiber. This follows the mixture rule. The bulk density of LDPE-sawdust reinforced composite decreases with the increase of sawdust addition [16]. On the other hand, the bulk density of glass fiber-LDPE composites has been found to be increased with increasing fiber addition. Our results were consistent with the earlier studies [17].

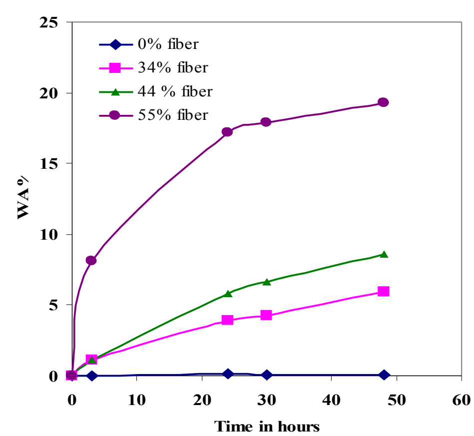

Figure 2: Variation of water absorption of LDPE- glass fiber composites at different wt% of fiber and time.

Fig. 3 shows the effect of soaking time on water absorption of LDPE and LDPE-jute mat composites prepared with different wt% of jute fibers. It reveals that the water absorption is dependent on fiber addition and length of soaking time. According to the diffusion phenomenon, water absorption percentage of all the samples has been found to be increased with time. Water absorption percentage of LDPE glass fibers also increase with the increase in wt% of the fibers on the samples. From 0% to 44% fiber content in the LDPE glass composite, almost no water has been found to be absorbed with time. Since the glass fiber is synthetic, % of water intake increases slowly initially with increases time after that it remain constant. But except, 65% fiber addition % of water absorption increases with socking time. The cellulosic, the lignin and also void spaces that present in the composites might be responsible for the increase of water absorption with soaking time. Moreover, the hydrophilic nature of glass fiber and hydrophobic nature of LDPE might be responsible for this characteristic, while the jute has been found to show hydrophilic behavior. Due to the hydrophilic nature, jute composites can intake higher percentage of water which has been confirmed in a comparative study of water absorption % of jute and glass fibers in Fig. 4. Fig. 4 shows water absorption % increases with increasing fiber addition and soaking time for both composites. For the same wt% of glass and jute composites, water absorption capacity of the jute fiber composites is higher than that of glass. This reflects the fact that jute fibers are hydrophilic in nature.

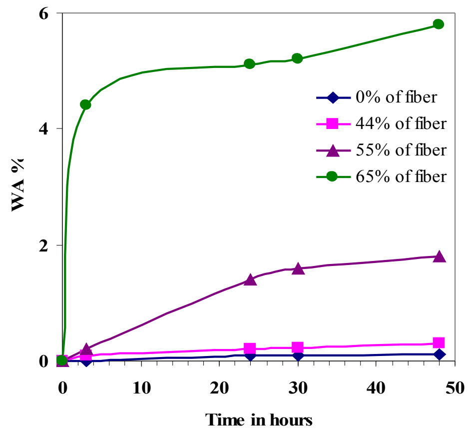

Figure 3: Effect of soaking time on water absorption of LDPE glass fiber composites at different wt% of fiber.

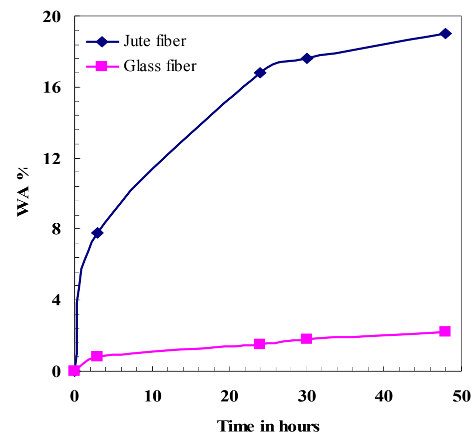

Figure 4: Water absorption of glass fiber LDPE and jute fiber LDPE reinforced composites.

A comparison of tensile strengths of glass and jute fiber LDPE composites is shown in Fig. 5. Fig. 5 shows that the value tensile strength of LDPE is found to be 7.3 MPa. In our study, the maximum value of the tensile strength of glass fiber LDPE composites was 86.24 MPa at 55% fiber content. Beyond this % of fiber content the tensile strength has been noticed to be decreased rapidly. This might be due to the reason that up to 55% of the fiber content, the fibers in the composites are well distributed and the better interfacial bonding between the fiber and matrix.

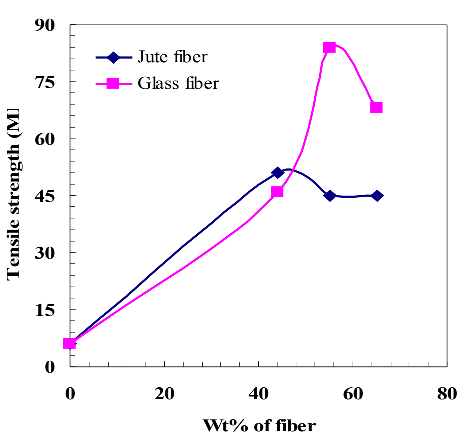

Figure 5: Comparison of tensile strength of glass fiber LDPE and jute fiber LDPE composite with different wt% of fiber.

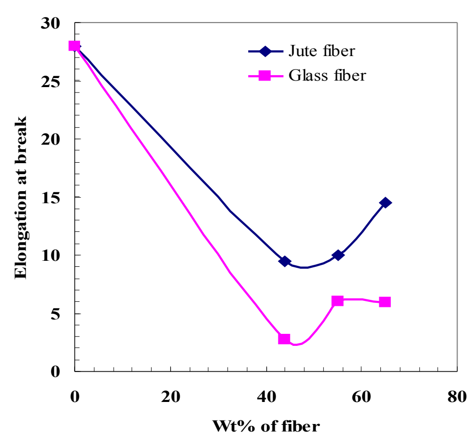

Figure 6: Effect of addition on Eb% of glass fiber LDPE and jute fiber LDPE composites.

The incorporation of fibers into thermoplastics leads to poor dispersion of fibers due to strong inter fiber hydrogen bonding which holds the fibers together. Improper adhesion hinders the considerable increment of tensile strength. It has been also observed that the tensile strength of glass fiber LDPE composites is higher than that of jute composites. Fig. 6 shows the comparison of elongation at break, Eb (%) of jute and glass fiber LDPE composites for various wt% of fiber content. Fig. 6 represents that the value of Eb (%) for LDPE is about 28.83%. It shows that the Eb (%) decreases as the fiber content increases from 0 to 44 wt% in the both composites and then increases slightly for higher percentage of fiber content. The presence of fiber addition restricts the slip resulting in lesser ductility and consequently the % of strain decreases with the increase of fiber addition. It was also found that Eb (%) is higher for Jute LDPE composites than that of glass. Comparison of Young's modulus of LDPE glass and jute reinforced composites of different wt% of fiber has been displayed in Fig. 7. Young's modulus increases with increase of fiber content up to 44% of the fabricated product after that it decreases. This reveals the fact that up to this fiber content, the fiber and the polymer are well distributed. For this reason, the stiffness of the LDPE fiber composites increases with the increase in fiber percentage. The decrement of Young's modulus might be caused by the irregular distribution of the fiber and matrix. According to the data shown in Fig. 7, it is also seen that Young's modulus is higher for glass composites than that of jute.

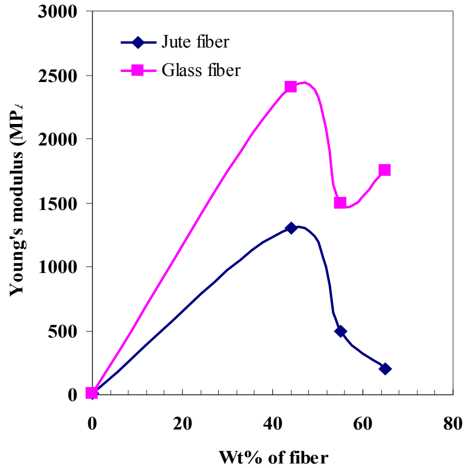

Figure 7: Young痴 modulus of LDPE glass and jute composites at different wt% of fiber.

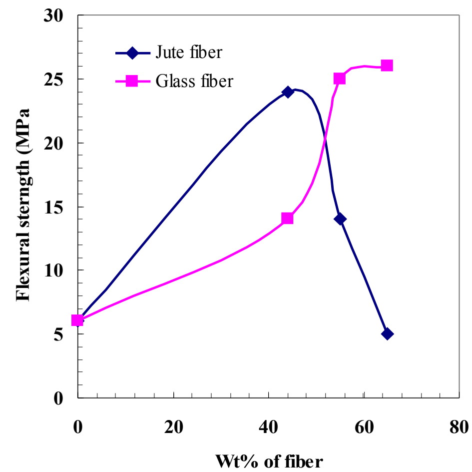

Figure 8: Flexural strength of LDPE glass and jute composites at different wt% of fiber.

Influence of the percentage of fiber on the flexural strength of LDPE glass and Jute composites have been displayed in Fig. 8. For both composites, the flexural strength was found to be 6.31 MPa. It is also found that flexural strength is increased almost linearly with the increase of fiber content in the glass composites. However, in the case of jute composites, flexural strength increases with increasing fiber percentage up to 44% after that it is found to be decreased. We believe that this happens due to the wellness of the distribution of the fiber and matrix in the jute composite. It was also recorded that the flexural strength of glass composite is higher than that of jute composite. Fig. 9 shows the effect of fiber addition on the flexural strain of LDPE glass r and jute fiber composites. For LDPE composites the flexural strain has been obtained was 1.8%. It has been found that the flexural strain of fabricated products increases slowly with the increase of fiber percentage up to a certain limit then remains constant or decreasing slightly. It is apparent that the elongation decreases very slightly with the increase of fiber amount on the LDPE composites. It was also observed that the flexural strain is higher for jute composites than that of glass fiber composites.

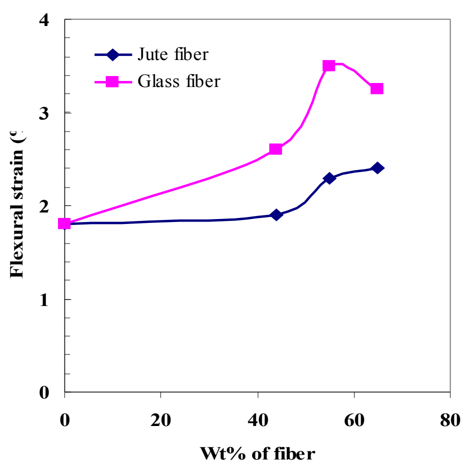

Figure 9: Flexural strain of LDPE glass fiber and LDPE jute composites at different wt% of fiber.

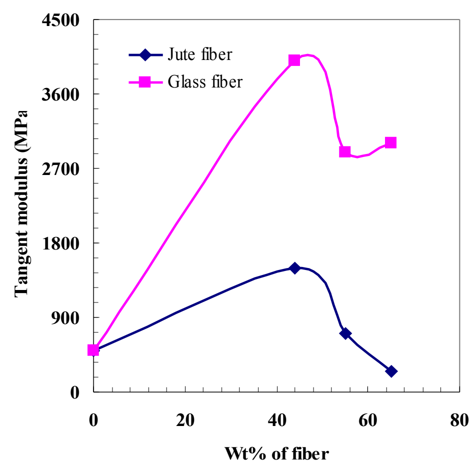

Figure 10: Tangent modulus of LDPE glass fiber and LDPE jute composites at different wt% of fiber.

Tangent modulus of glass and jute based composites have been plotted in Fig. 10. From this graph, it is clearly observed that the tangent modulus increases with fiber content up to 44% then decreases slightly to a lower value. Again this increment of tangent modulus may be related to the regular distribution pattern the fiber and the polymer on the composites. The decrease of tangent modulus might be due to the decrease in wet ability of the matrix to the fibers, where the matrix loses its ability to wet the fibers at high concentration and fibers act alone and the matrix cannot transfer the load between the fibers. Another reason might be due to poor distribution or dispersion of fibers within the matrix which is related to the use of inefficient method of mixing [18].

CONCLUSIONS

Glass fibers possess good physical and mechanical properties than jute which make them suitable for polymer composites. The main disadvantage of glass fiber is non-biodegradability. The bulk density of LDPE without addition of fiber was found 0.99 gm/cc. With the increase of fiber content in the glass composites bulk density has been found to be increased. However, the bulk density of jute composites decreases very slowly. For both composites, water absorption increases with increase of fiber amount and soaking time. However, at the same percentage of fiber, the increase of water absorption of jute composites was found to be more than that of glass composites with time. Tensile strength of glass composites increases up to 55% of the fiber content due to the well distribution of the fibers and the better interfacial bonding between the fiber and matrix. Glass composites have better tensile strength compared to jute composites. Young's modulus is higher for LDPE glass composites than that of jute composites.

REFERENCES

[1] Bledzki, A., Gassan, J., *Prog. Pol. Sci*., **24**, 221 (1999).

[2] Browns, P.B., in the Chemistry of Lignin, Academic Press, New York, USA (1952).

[3] Schaffer, J.P., Saxena, A., Antolovich, S.D., Sanders, T.H. Jr., and S.B. Warner. The Science and Design of Engineering Materials; 2nd Edition, WCB/McGraw-Hill, Chicago, USA (1999).

[4] Bose, B., *BSc Thesis*, Bangladesh University of Engineering & Technology (BUET), Dhaka, Bangladesh (2005).

[5] Uddin, M.K., Khan, M.A., Ali, K.M.I., *J. Apppl. Poly. Sci*., **60**, 887 (1996).

[6] Mucha, M., *Inter. Polymer Sc. Tech*., **26** (6), 97 (1999).

[7] Khan, R.A., Khan, M.A., Zaman, H.U., Pervin, S., Khan, N., Sultana, S., *J. Rein. Plas. Comp*., **29** (7), 1078 (2010).

[8] Cameron, N.M., *Glass Tech*., **9**(1), 14 (1968).

[9] El-Tayeb, N.S.M., *Wear*., **265** (1-2), 223 (2008).

[10] Khan, M.A.; Hossain, M., Ali, K.M.I., *J. Appl. Pol. Sci*., **74**, 900 (1999).

[11] Joseph, K., Mattoso, L.H.C., Toledo, R.D., Thomas, S., de Carvalho, L.H., Pothen, L., Kala, S., and James, B., Nat. Polymer Agro Fibers Based Composites. Frollini E., Leao A.L. & Mattoso L.H.C. Eds., 159, San Carlos, Brazil, Embrapa, USP-IQSC, UNESP., (2000).

[12] Mohanty, A. K., Misra, M., *Poly. Plas. Tech. Engg*., **34** (5), 729 (1995).

[13] Wambua, P., Ivan, J. and Verport, I., *Comp. Sci. Tech*., **63**, 1259 (2003).

[14] Rowell, R.M., Stout, H.P., Hand Book of Fiber Chemistry, Marcel Dekker Inc. 2nd Edition, New York, 10016, USA (1998).

[15] Georgopoulos, S.T., Tarantili, P.A., Avergerinos, E., Adreopoulos, A.G., Koukios, E.G., *Polym. Deg. Stab*., **90**, 303 (2005).

[16] Salma, A., *BSc Thesis*, Department of Chemical Engineering & Polymer Science, Shahjalal University of Science and Technology (SUST), Sylhet, Bangladesh, (2006).

[17] Askeland, D.R., Fulay, P.P., Wright, W.J., The Science and Engineering of Materials, Cengage, Learning India Private Limited, New Delhi, India (2010).

[18] Islam, M. N., Bagom J., Gafur, M.A. and Khan, A.H., *Jahangirnagar Uni. J. Sci*., **30**, 89 (2007).