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The Effect of Chemical Treatments on the Mechanical and Physical Properties of Bagasse Filler Reinforced Low Density Polyethylene Composite

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ABSTRACT : *The effect of chemical treatments on the mechanical and physical properties of Bagasse filler (Sugar cane fiber) reinforced low density polyethylene composite (LDPEC) was investigated by determining the mechanical and physical properties of the composite. The Bagasse filler was ground and sieved to 100 µm size and the low density polyethylene matrix prepared as a composite material. The filler was chemically treated using alkali (ATBF), acetylation (ACTBF), and stearic acid (SATBF). Composite sheets/samples were prepared from both the chemical treated filler along with the non-treated (NTBF) with the fiber loaded in the order of 10, 20, 30, 40 and 50% weight fractions. These samples were then subjected to mechanical (flexural, tensile, impact) and water absorption tests. The results indicate that for chemically treated Bagasse filler composite, the flexural strength increased for 10 to 30% fiber and then nosedived for 50% fiber loading. The tensile strength was affected by fiber loading as it was increased from 10 to 40%, and the impact strength increased from 10 to 50% without nose diving. The water absorption indicates a nosedive for 10%. The chemically treated Bagasse filler exhibited better mechanical properties while the water absorption reduced. This holds good promise for application of the treated composite.*

KEYWORDS: *Bagasse, Chemical treatments, Composite, Fiber-Matrix, Impact strength, Flexural strength, Polyethylene, Water absorption.*

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I. INTRODUCTION

There are renewed interests in the utilization of natural materials which proffer solution to ecological issues of recyclability and environmental safety materials have become the order of the day in engineering. Composites have become one of the most important engineering materials in various applications. The demands for composites are steadily increasing as they are more preferred compared to other materials such as metals and ceramics.

The increasing demand for biodegradable, sustainable, and environmentally friendly products coupled with better processibility, low density, non abrasive, flexible and cost effective properties has launched the use of natural fibers in Fibers Reinforced polymers (FRP) composite (Valadez et al 1999). Natural fibers like flax, hemp, jute, sisal, Bagasse, banana etc. have been well recognized as good potential reinforcements for engineering fiber composites. The desired properties of natural fibers are lightweight, high specific modulus, non-toxic and ease of processing as well as absorbing CO_2 during growth (Tserki et al 2005).

Though natural fiber-reinforced plastic parts offer many advantages over synthetic fibers such as low cost, low density, competitive specific mechanical properties, CO_2 subtraction, sustainability, recyclability and biodegradability, however several major technical considerations must be addressed to enable it meet the required standards. Such challenges include the homogenization of the fiber's properties, adhesion between fibers and matrix, understanding of the degree of polymerization and crystallinity, as well as moisture repellence. In addition, hydroscopicity is one of natural fiber's undesirable properties which can be attributed to the chemical constituents (John et al 2008). Their structural compositions (cellulose, hemicelluloses, lignin, pectin and waxy substances) allow moisture absorption from the environment leading to poor bonding with the matrix materials. The incompatibility between fibers and polymer matrices, tendency to form aggregates during processing, and poor resistance to moisture limit the use of natural fibers as reinforcements in polymers (Beroti

et al 2009). Studies on the use of natural fibers have shown remarkable improvement in mechanical, physical and thermal properties by the use of chemical treatments or coupling agent (Luz et al 2008).

II. MATERIALS AND METHODS

The materials used for the experiment include Low density polyethylene as the main compound, Sugar cane fibers (Bagasse) as fillers (obtained as waste in streets of Felele in Lokoja, Kogi State, Nigeria), Sodium hydroxide as Alkali solution/treatment, Acetic acid and anhydrides for acetylating treatments, and Stearic acid for stearic treatments.

As a standard procedure, the sugar cane fiber (Bagasse) was soaked in water for 48 hours for ease of separation of dirt that might be stuck to the Bagasse. This was washed, oven dried, grinded and sieved to 100 µm size for preparation of test samples.

The test sample was soaked at room temperature by immersing in a 5% Sodium hydroxide (NaOH) solution alkali, acetylated and stearic acid solutions respectively for 5 hours. The filler was then washed and neutralize with dilute HCl acid and washed with distilled water to ensure a final ph of 7. These filler was further dried at room temperature for 24 hours followed by oven drying at 100 ^{0}C for 8 hours to remove all moisture. The fillers were then kept in air tight containers and coded alkali treated bagasse filler (ATBF), acetylated treated bagasse filler (ACTBF), and stearic acid treated bagasse fillers (SATBF) for further experimentation.

Hand lay-up method was used with wooden mould of dimensions 400 x 400 x 10 mm to cast the composite sheets. Twenty (20) samples were produced by varying the fillers/fiber and loading them in the order of 10, 20, 30, 40 and 50 % by weight for each of the treatments, along with the untreated bagasse filler coded NTBF. A calculated amount of low density polyethylene was melted and thoroughly mixed with the bagasse filler by gently stirring to avoid the formation of air bubbles and entrapment, as well as ensuring ease of removal of the composite sheets. The samples were then tested for flexural, tensile and impact strengths, as well as for water absorption.

The Universal testing machine in accordance with ASTM – D790, a 3-point bending fixture utilizing centre loading on a simple supported beam with a bar of rectangular cross-section resting on two supports was loaded by means of a loading nose, set mid-way between the supports to measure the flexural strength of the samples (100 x 30 x 7 mm). The flexural inter laminar shear strength (ILSS) of the composite which is the maximum shear stress a material can withstand before it ruptures was determined using equation 1.

$$\sigma_f = \frac{3Pl}{2bt^2} \quad (1)$$

where, σ_f = ILSS, P = load, b = width and t = thickness of the specimen under test and l = span length.
These procedures were repeated for the entire produced composites to determine the flexural strength, while flexural modulus (E) was determined using equation 2.

$$E = \frac{Pl^3}{4bt^3\gamma} \quad (2)$$

where, γ = deflection, l = span length, P = load, b = width, t = thickness.

A Mosanto tensometer was used in accordance with ASTM D638 the samples were clamped (one after the other) at both ends of the machine and a tensile load applied at a constant rate of elongation until fracture occurs. The maximum tensile stress was determined using equation 3.

$$\sigma_t = \frac{F}{A} \quad (3)$$

where σ_t = maximum tensile stress, F = applied load, and A = cross sectional area of the sample.

The tensile strain was calculated using equation 4.

$$E = \frac{l_2 - l_1}{l_1} \quad (4)$$

where l_1 = gauge length and l_2 length after test.

The impact test was done using the Charpy impact testing machine with the capacity of 15 J in accordance with ASTM standard D-256. The samples were clamped unto the machine and subjected to impact energy of 15 J with a pendulum of 25 kg tricking the sample at the rate of 3.21 m/s. The impact energy was recorded, and impact strength calculated using equation 5.

$$\text{Impact strenght (Is)} = \frac{k\ (kJ)}{A\ (m^2)} \quad (5)$$

where k = Impact energy (kJ), A = cross-sectional area = width x thickness (m^2).

The water absorption test was performed in accordance with ASTM standard D570, both the chemically treated and untreated Bagasse filler reinforced polyethylene composites samples were oven dried at 50 °C for 24 hours to remove moisture, and were the weighed. The same samples were soaked in water for 72

hours and properly dried with absorbent paper and then weighed immediately. The percentage water absorption was calculated using equation 6.

$$\text{Percentage water absorption} = \frac{M_A}{M_B} \quad (6)$$

where M_A = mass of sample before soaking and M_B = mass of sample after soaking in water.

III. RESULTS AND DISCUSSION

The results of mechanical properties are presented in Figs. 1-3. The flexural strengths of the produced composites using different treatment methods are presented in Fig. 1. It was observed that the flexural strength was affected by fiber loading and methods of treatment. The flexural strength increases from 10-30 % then nosedived to 50% fiber loading for all the treatments and the untreated (NTBF). These agree with Wang et.al (2000) who suggested that fiber treatments have better increments for flexural strengths for fiber composites.

The tensile strength of the produced composites using the different treatment methods as presented in Fig. 2. It was observed that tensile strength was affected by fiber loading and methods of treatment. These agree with Wang et.al (2000) who suggested that fiber treatments have better increments for tensile strengths of fiber composites.

The impact energy, of the produced composites using different treatment methods are presented in Fig. 3. It was observed that the impact energy was affected by fiber loading and methods of treatment. The impact energy increases from 10-20% then nosedived to 50% fiber loading for all the treated and the untreated (NTBF) which agree with Zampaloni et al. (2007) that fiber treatments reduces impact energy of fiber composites.

The water absorption of the produced composites using different treatment methods is presented in Fig. 4. It was observed that the water absorption was affected by fiber loading and methods of treatment. The water absorption increases from 10-50 % there was no nosedive up to 50% fiber loading for the untreated (NTBF). The nosedive of 50% fiber loading plays between 10 and 20% treatments. These agree with Wang et al. (2000) who suggested that fiber treatments have better increments for water absorption of fiber composites.

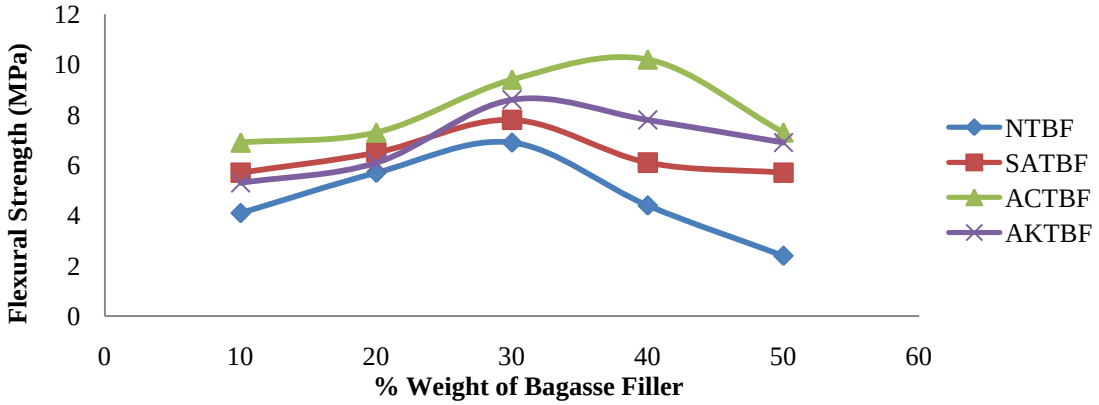

Fig. 1.Variation of Flexural Strength against composition of Bagasse filler in PEC

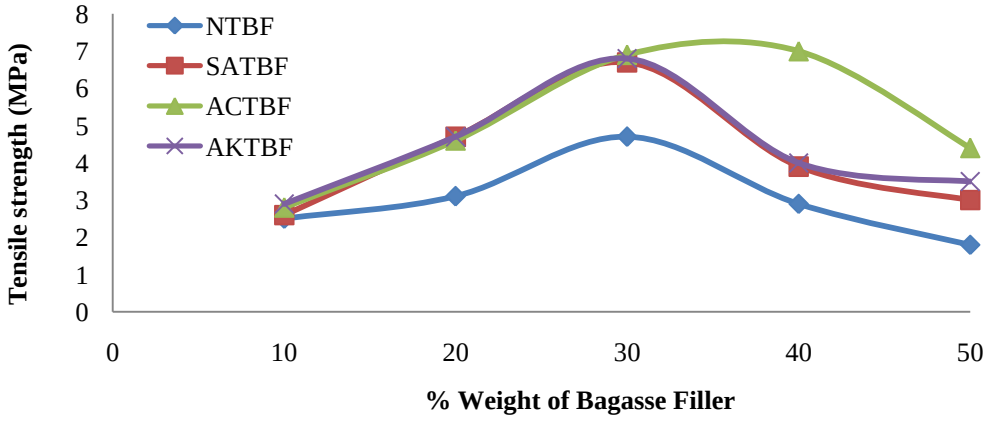

Fig. 2.Variation of Tensile Strength against composition of Bagasse filler in PEC

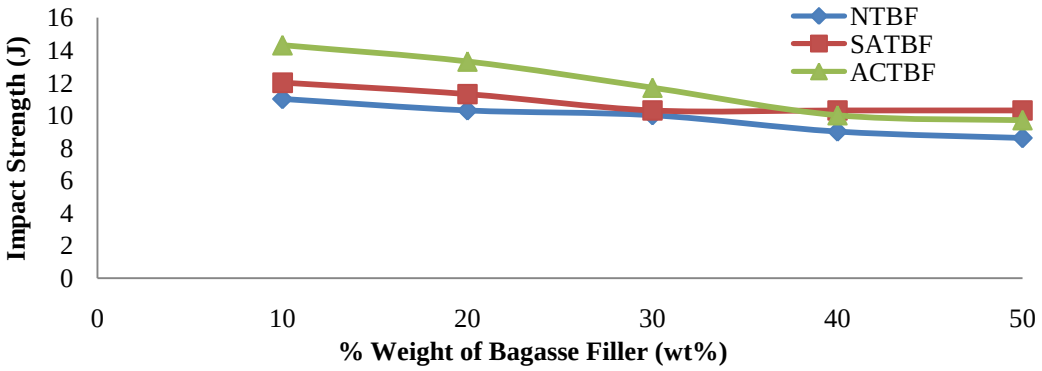

Fig. 3.Variation of Impact Strength against composition of Bagasse filler in PEC

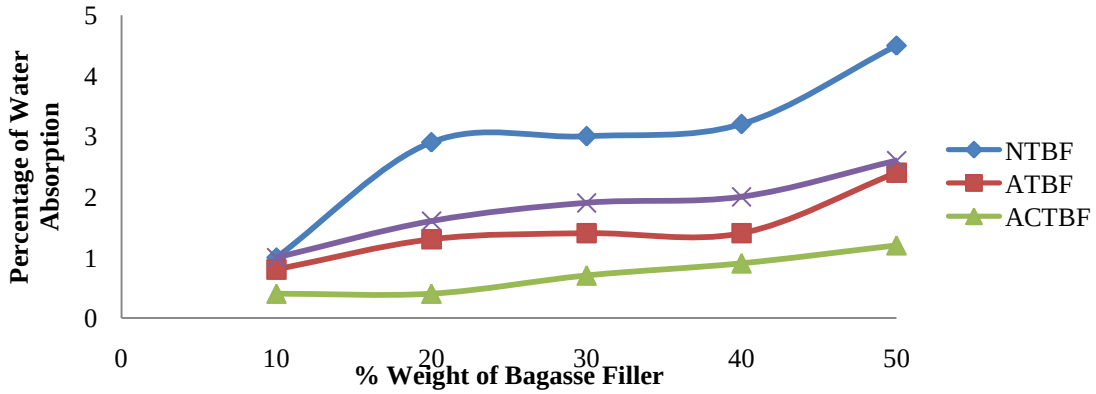

Fig.4.Variation of Water absorption against composition of Bagasse filler in PEC

IV. CONCLUSION

Based on the experimental results/observations, it can be concluded that NTBF do not respond positively to mechanical properties while treated Bagasse filler composite responds positively to mechanical properties with those given acetylated treatments showing better responses. Furthermore, as percentage weight of Bagasse increases, water absorption increases progressively for NTBF while for the treated Bagasse fillers the water absorption increases marginally with ACTBF showing better results. Finally, the variation of the properties against percentage weight of Bagasse indicates that the maximum levels were at 30% after which these properties nosedived or decreased.

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