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Mechanical Properties of Palm Kernel Shell Ash Reinforced Composite

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ABSTRACT

The mechanical properties of the Palm kernel Shell (PKS), a by-product of the palm fruit were investigated at different particulate filler loading using unsaturated polyester resin (UPE) as the matrix. The particulate PKS were ground and sieved through a 300µm mesh sized sieve and loaded wit h hand lay up technique at 2%, 4%, 6%, 8% and 10% using the 0% filler loading as the control. The effect of the varying particulate loading on the mechanical properties such as flexural modulus and strength, tensile modulus and strength, stress/strain behaviour and water absorption rate were further investigated. The result showed an increase in the tensile and flexural properties as the filler loading increased but better properties were observed at the 8% filler loading. The water absorption test was carried out for seven days and results showed a significant increase in the water absorption ratio with increase in particulate loading. The 2%, 4% and 6% particulate loading showed a similar trend with the control while the 8% and 10% exhibited a high initial absorption in the first two days followed by a drastic drop in water affinity within the last five days.

Keywords : Mechanical properties; Palm Kernel Shell Ash; Polyester resin; Composites

1 INTRODUCTION

THE use of agro-based by-products as reinforcing agents and fillers in thermoplastics as well as thermoset materials is increasing nowadays due to economic reasons and environmental awareness [4], [9], [10], [15], [18]. As developing nations strive for economic sustainability, effort is geared towards exploiting biomass materials that could have alternative uses to their conventional low valued uses in order to achieve this goal [2]. Palm kernel shell (PKS) is the hard endocarp of palm kernel fruit that surrounds the palm seed [3]. It is obtained as crushed pieces after threshing or crushing to remove the seed which is used in the production of palm kernel oil [3]. It is light and therefore ideal for substitution as aggregate in the production of light weight concrete as well as several other composites [6], [12]. Palm kernel shell is a product of oil palm processing and has been characterized and investigated as reinforcement for resins while it has also been applied for construction purposes due to its attractive properties [1], [13], [17]. Various research have shown the use of polyester resin as a matrix in composite is advantageous in terms of its cost, ease of handling, dimensional stability, durability, good mechanical and electrical properties [4], [7], [14]. It is the least expensive of the resin options providing the most economical way to incorporate resin, filler and reinforcement. Polyester for instance is used in reinforcements of high-energy absorption as well as in sheet molding compound and the toner of laser printers[11]. In the development for better performance of biodegradable composites, a number of researchers have been focused on the utilization of various types of natural fibers such as wood, hemp, ramie, flax, oil palm empty fruit bunch and kenaf treated by irradiation technique namely e-beam, chemical treatment and coupling agent [5]. In Nigeria, oil palm is an important tree because of the value of the crude palm oil, fronds, stems and leaves. Because of the magnitude of this industry, several residues are co-produced with palm oil. These include: the empty fruit bunch (EFB), palm fruit fiber (PFF), palm oil mill effluent (POME) and palm kernel shell (PKS) [4]. Whereas oil palm is chiefly cultivated for palm oil (PO) and palm kernel oil (PKO), the palm kernel shell (PKS) (as residue) has been regarded as 'waste' from palm oil processing. It has been shown that approximately 15 to 18 tonnes of fresh fruit bunches are produced per hectare per year and PKS comprises about 64% of the bunch mass [4]. In the developing world, the PKS is either burned to supply energy at palm oil mills or left in piles to compost and compared with the large amount of oil that the country produces; this PKS will also be produced in large quantities. The PKS for this research was used as particulate filler for polyester resin and different particulate volume fraction were introduced in the resins to obtain varying specimens to be tested.

2 EXPERIMENTAL PROCEEDURE

2.1 Materials

The PKS was obtained from an oil palm mill located in Akpabuyo LGA of Cross River State, Nigeria. The polyester resin and the methyl ethyl ketone peroxide on the other hand were obtained from Lagos in Nigeria.

2.2 Sample Preparation

The cracked palm kernel shell asobtained from the mill was thoroughly washed in clean water with small quantity of detergent to remove residual oil on the shells. The washed PKS was dried in an oven at 80°C for 24 hrs to remove moisture

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and then burnt. The burnt PKS was pulverized and sieved to a preferable particulate size of 300µm as reported by Shehu [19]. Various weight percentage of 2, 4, 6, 8, 10 was introduced in the matrix while methyl ethyl ketone peroxide was used in 15% of the overall volume of the polyester and palm kernel shell powder. The composites were produced by mixing the polyester with the methyl ethyl ketone peroxide before the addition of the palm kernel shell ash (PKSA). The different mixtures were then poured into a rectangular mold and after setting, were cut into small sizes for the different mechanical tests to be carried out.

2.3 Tensile Test

The tensile test was carried out according to ASTM D5083 standards with a universal testing machine equipped with a load capacity of 10kN. Five specimens of 120mm (length) X 25mm (Width) X 5mm (thickness) were cut out using a cutter and the tensile strength and modulus of the samples were measured.

2.4 Water Absorption Test

Water absorption test was carried out according to ASTM D570 standard. The edges of the sample were sealed with polyester resin and exposed to moisture. The samples were then dried at 80ºC for 24 hrs. The weights of the samples were taken with the aid of a weighing balance and the results recorded. The various samples were immersed in distilled water until the water content reached saturation after which they were removed and dried with a cloth at different intervals while measurements were taken at these intervals. The change in weight of the samples for seven days was noted and the water absorption rate was calculated using the following formula;

Where
$W_n = Weight\ after\ immersion$
$W_d = Original\ dry\ weight$
$W_a = Water\ absorption\ rate$

2.5 Flexural Test

A three flexure bending test was carried out using a 200 series electromechanical test machines. The test samples were placed horizontally upon two points and a force of 15kN was applied to the top of the sample through a single point while the flexural measurements were taken.

3 RESULT AND DISCUSSION

Tensile Strength Test: Fig 1 shows the effect of filler loading on the tensile property of the samples. The results obtained from the test showed an increasing tensile strength property with the addition of the PKSA. The tensile strength at yield was highest with the 8% filler loading, and was least when no filler was added to the matrix.

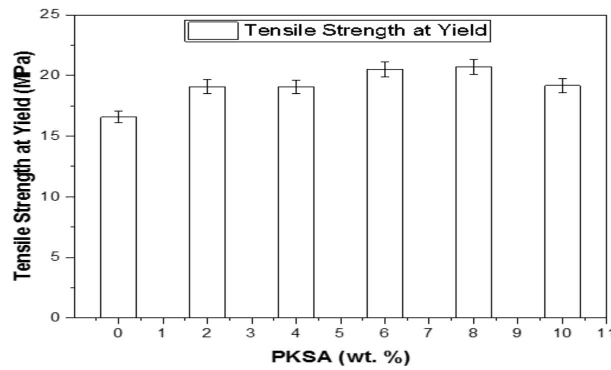

Figure 1: Effect of filler loading on the tensile strength of PKSA reinforced polyester resin composite

Tensile Modulus Test: The tensile modulus test as shown in Fig 2 also showed an increasing pattern with the addition of fillers with 10% fraction of fillers being the one with the greatest tensile modulus of approximately 3GPa while a great spike in the tensile modulus was obtained at 8% filler loading

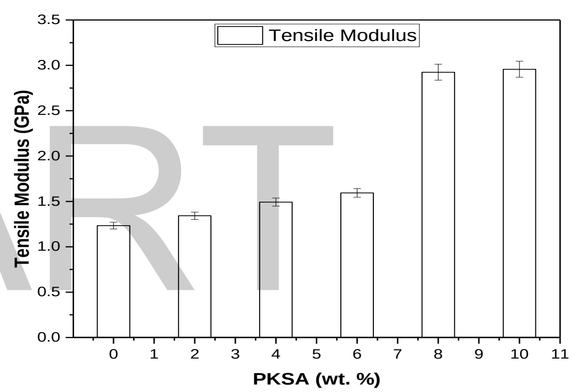

Figure 2: Effect of filler loading on the tensile modulus of PKSA reinforced polyester resin

Water Absorption Test: Figure 3 shows the rate of water absorption of the samples over a period of seven days. The water absorption test showed an increase in the rate of water being absorbed with the introduction of the filler reinforcements. For the 0%, 2% and 4% filler loading, there was a gradual increase in the amount of water being absorbed over the period while the 8% showed a great absorption within the first two days followed by a decline in the absorption rate within the remaining 5 days. The water absorption test shows the hydrophilic nature of the fibre and thus for application purposes, care has to be taken if the samples will be exposed to water.

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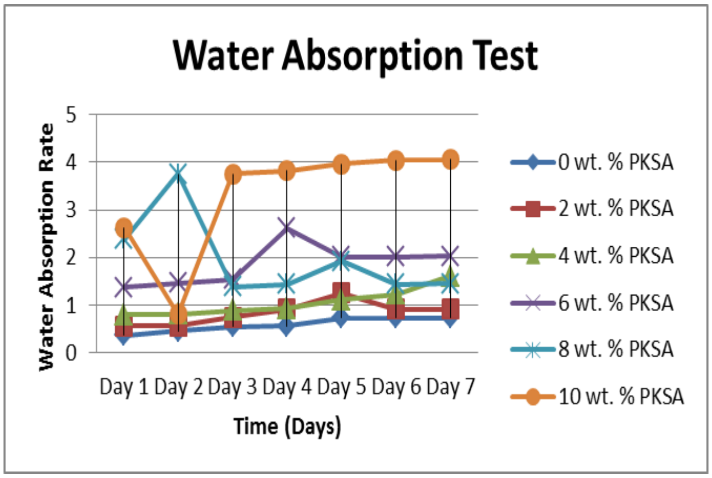

Figure 3: Effect of filler loading on the water absorp-tion capacity of the specimen

Flexural Strength: The flexural strength of the different filler loading exhibited an increase from the plain matrix and after the 4% concentration, there was a drop and then an increase at the 8% filler loading followed again by a drop in the loading percentage.

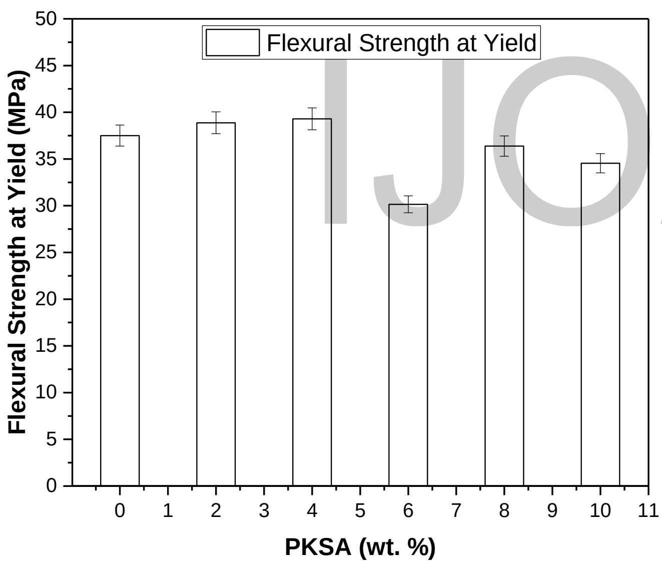

Figure 4: Effect of particulate loading on the flexural strength of the composite

Flexural Modulus: Similar to the tensile modulus, the flexural modulus showed a gradual increase with an increase in the filler loading as shown in Figure 5.

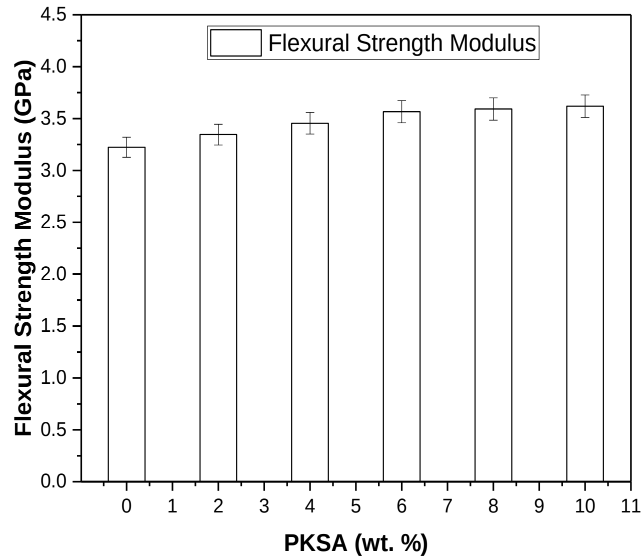

Figure 5: Effect of filler concentration on the flexural modulus of the composite

Stress/Strain Curve: The stress stain curve obtained showed that an increase in the filler loading decrease the tensile properties of the matrix but increased the ultimate yield strength of the composite. Thus giving a composite with a higher yield strength and a lower ductility.

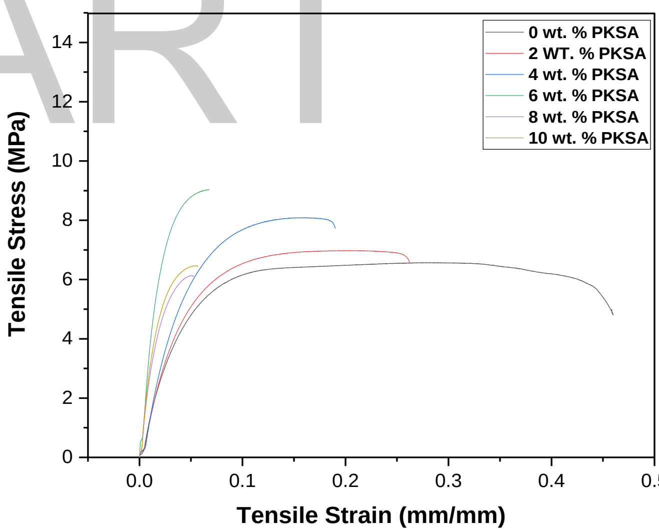

Figure 6: Stress/Strain curve of the different samples

5 CONCLUSION

The tensile properties, yield strength and flexural properties were increased with an increase in the filler loading but showed a higher affinity to water with an increase in the filler loading percentage. The presence of the PKS filler in the matrix of the polyester resin shows desirable properties that can further be worked on to improve the consistency of these properties. Furthermore, morphology and thermal properties of this samples will be investigated to further understand the

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behavior of these samples.

6 REFERENCES

[1] Davoodi M. M, "Conceptual Design of a Polymer Composite Automotive Bumper Energy Absorber," Materials & Design, Vol. 29, No. 7, 2008, pp. 1447-1452. doi:10.1016/j.matdes.2007.07.011

[2] Dit, Mohammad (2007) Palm Kernel Shell (PKS) is More Than Biomass for Alternative Fuel After 2005.

[3] Hussain Z, Zainac Z, Abdullah Z. (2002) 'Briquetting of Palm Fibre and Shell from the Processing of Palm Nuts to Palm Oil. Biomass and Bioenergy 2002; 22, 6:505-509.

[4] Jacob M, Thomas S and Varughese K T, (2004). Natural rubber composites reinforced with sisal/oil palm hybrid fibers: Tensile and cure characteristics, Journal of Applied Polymer Science, 93 (5), 2305-2312, 2004.

[5] Jawaid M, Khalil H P S A, Khanam P N and Bakar A A, (2011) Hybrid Composites Made from Oil Palm Empty Fruit Bunches/Jute Fibres: Water Absorption, Thickness Swelling and Density Behaviours, J. Polym. Env., 19 (1),106-109, 2011

[6] Johnson U., Mahmud H. and Mohd Z. (1998). "Enhancement and Prediction of Modulus of Elasticity of Palm Kernel Shell Concrete," Materials and Design Journal, Vol. 32, No. 4, 2010, pp. 2143-2148.

[7] Joseph S, and Thomas S, (2008). Electrical properties of banana fiber-reinforced phenol formaldehyde composites, J. Appl. Polym. Sci. 109 (1), 256-263, 2008.

[8] Jumaat. A. Alengaram, U. J. (2008): Comparison of Mechanical and Bond Properties of Palm Kernel Shell: Journals: www.academicjournals.org/ijps/pdf.

[9] Larbig H, Scherzer H, Dahlke B. and Poltrock R, "Natural Fiber Reinforced Foams Based on Renewable Re- sources for Automotive Interior Applications," Journal of Cellular Plastics, Vol. 34, No. 4, 1998, pp. 361-379.

[10] Luo S, Netravali A N, Mechanical and thermal properties of environmentally friendly green composites made from pineapple leaf fibers and poly (hydroxybutyrate-co-valerate) resin, Polym.(1999) Compos., 20(3), 367-78, 1999.

[11] Muzzy J.D. (2002) Thermoplastics – Properties, Georgia Institute of Technology, Atlanta, Georgia,USA. www.me.gatech.edu

[12] Nuhu-Koko M. K., The use of Palm kernel shells as aggregates for concrete, Paper presented at 21st Annual Conference of Materials Testing, Control and Research, FMW, Lagos, Nigeria, pp. 20, 1990.

[13] Olumuyiwa, Agunsoye J., Isaac, Talabi S., Adewunmi, Obe A., and Ololade, Adamson I., (2012) Effects of Palm Kernel Shell on the Microstructure and Mechanical Properties of Recycled Polyethylene/Palm Kernel Shell Particulate Composites

[14] Pothana A. L., Zachariah O., and Thomas S. (2006) Dynamic mechanical analysis of banana fiber reinforced polyester composite, Composite Science. Technology, 63 (2), 283-293, 2003.

[15] Prakash T, (2009) Processing and Characterisation of Natural Fiber Reinforced Polymer Composite, National Institute of Technology, Rourkela. www.ethesis.nitrkl.ac.in

[16] Raghupathi, N. (1990) Chapter 7: Long fiber thermoplastic composites, in Composite Materials Technology (eds P.K.Mallick and S. Newman), Hanser Publishers, Munich, pp. 237–264.

[17] Richard S and Maki A. (2011): Thermoplastic Composites – Recyclabilty and Fast Processing top List of Benefits. Issue of Reinforced Plastics Magazine, May 2011. www.reinforcedplastics.com.

[18] Saira T, Munawar M.A and Shafi U. K, (2007): Natural Fiber-Reinforced Polymer Composites. Proceedings of Pakistan Academic of Science, 44(2S) . Pp. 129-144. www.paspk.org

[19] Shehu, U., Aponbiede, O., Ause T,. Obiodunkwe (2013). Effect of particle size on the properties of polyester/palm kernel shell (PKS) particulate composites

[20] Stokes V K, Inzinna L P, Liang E W, Trantina G G and Woods J T, (2000). A phenomenological study of the mechanical properties of long fibre filled injection-molded thermoplastic composites, Polymer composite 21 (5), 696-710.