Effect of Concentration of Coconut Shell Ash on the Tensile Properties of Epoxy Composites.

P.E. Imoisili*; C.M. Ibegbulam; and T.I. Adejugbe

Engineering Materials Development Institute, Akure, Nigeria.

E-mail: patrickehis2002@yahoo.com*

ABSTRACT

Particulate filled polymer composites are becoming attractive because of their low cost and wide applications. To determine the possibility of using agricultural waste materials as reinforcing fillers in thermosetting polymer composite, the effects of coconut shell ash (CSA) concentration on the tensile properties of polyester composite was investigated. Five filler concentrations (viz. 5 to 25 weight %) were fabricated, test results shows that tensile strength, elastic modulus, and micro-Hardness of the composite increases with increase in filler concentration, while percentage elongation and load at break decreases with increase in filler concentration. Thus CSA can be use as reinforcing filler in epoxy composite.

(Keywords: coconut shell ash, CSA, epoxy composite, reinforcing filler, tensile properties)

INTRODUCTION

Epoxy resins are one of the most important classes of thermosetting polymer which are widely used as matrices for fiber-reinforced composite materials and as structural adhesive (Shangjin *et al.,* 2007and Zhikai *et al.,* 1987). Epoxy are amorphous, highly cross-linked polymer and this structure result in the materials possessing various desirable properties such as high tensile strength and modulus, uncomplicated processing, good thermal and chemical resistance, and dimensional stability (Zhikai *et al.,* 1987) one of the successful method of improving the toughness of epoxy resin is to incorporate a second phase of dispersed rubbery particle into the cross-link polymer (Drake *et al.,* 1982, Riffle *et al.,* 1983, and Yorkitis, 1994). Because the addition of rubbery materials to epoxy resin has been shown to lower their glass transition temperature (Tg) and thermal and oxidative stability, high performance thermoplastics have been employed to toughen epoxy resin in recent years (Shangjin *et al.,* 2007 and Zhikai *et al.,* 1987). Using natural filler to reinforce the composite materials offers the following benefit in comparison with mineral filler (Herrara-Franco *et al.,* 1997 and Maulida *et al.,* 2000), strong and rigid, light weight, environmental friendly, economical, renewable, and abundant resource. However, they have the disadvantage of degradation by moisture, poor surface adhesion to hydrophobic polymers, non-uniform filler sizes, not suitable for high temperature application among others (Belmares *et al.,* 1983).

Research is proceeding to develop composites using various recycled wastes (Son JI *et al.,* 2001), especially in developing composites using most environmentally friendly agro-wastes as reinforcing fillers and thermosetting polymers as matrixes. Recent investigations of polymer-based composite materials have opened new routes for polymer formulations and have allowed the manufacture of new products with optimal properties for special applications (Karnani *et al.,* 1997 and George *et al.,* 2001).

In most cases, these composites improve the product design and reduce the material and energy consumption. A number of natural occurring fillers and fiber in composite have been studied in the past. These include wood fillers (Gattenholm *et al*., 1993) wheat straw, almond husk, ash rice husk (Ismail *et al.,* 2001 and Saroja Devi *et al.,* 1998), pineapple leaf (Mishra *et al*., 2002), coconut fruit fibers(Sergio *et al.,* 2005). Wood-based fillers derive from oil palm wood flour (Fuad *et al*., 1998), etc. These fillers introduce some advantages compared to traditional inorganic fillers, including their renewable nature, low density, nonabrasive properties, reasonable strength, and stiffness (NeusAnglès *et al.,* 1999).

Luo and Netravali (Luo *et al.,* 1999) studied the tensile and flexural properties of pineapple fiber. Belmeres *et al*., (Belmeres *et al.,* 1983) studied sisal, henequen, and palm fiber, and found that they have similar physical, chemical, and tensile properties, epoxy composite reinforced with the use of cotton fiber along with glass fiber (Khalid *et al*., 1998).

Coconut Shell Ash (CSA) is a potential candidate for the development of new composites because of their high strength and modulus properties. These composites made from CSA can be used for a broad range of applications such as furniture, house hold appliances, construction, etc. The objective of this present investigation, is to study the effect of CSA concentration on the tensile properties of epoxy composite.

MATERIALS AND METHODS

Materials

Coconut shells were procured from a local farm in southern Nigeria; they were burned at 400 ^{0}C in a furnace. In order to reduce the particle size, the ash was ground and sieved with BS/ISO 3310 into particle size of 53 µm. A commercially available epoxy resin 3554A and hardeners were procured from a local supplier in Lagos Nigeria. The weight ratio of resin to hardener was 100:50.

Composite Preparation

Epoxy and hardener were mixed in a container and the coconut shell ash was added and stirred well for 5-7 minutes. After being thoroughly mixed, the mixture was poured onto the cavity of an aluminum mold, previously coated with a mould releasing agent. The dimensions and shape of the cavities were made according to the size and shape of the sample as per ASTM Standard D638-03 and allowed to cure at room temperature. Composites with amounts of CSA ranging from 5, 10, 15, 20, and 25 wt. % were manufactured.

Tensile and Micro-hardness Test

Tensile properties were evaluated using a Universal Instron Testing Machine model 3369, in accordance with ASTM Test Method D638-03, and micro hardness was analyzed using a leco Micro Hardness Tester model LM-700AT, in accordance with ASTM E384

RESULTS AND DISCUSSION

Tensile Properties

The variation of tensile strength as a function of coconut shell ash in wt%, are shown in Figure 1.

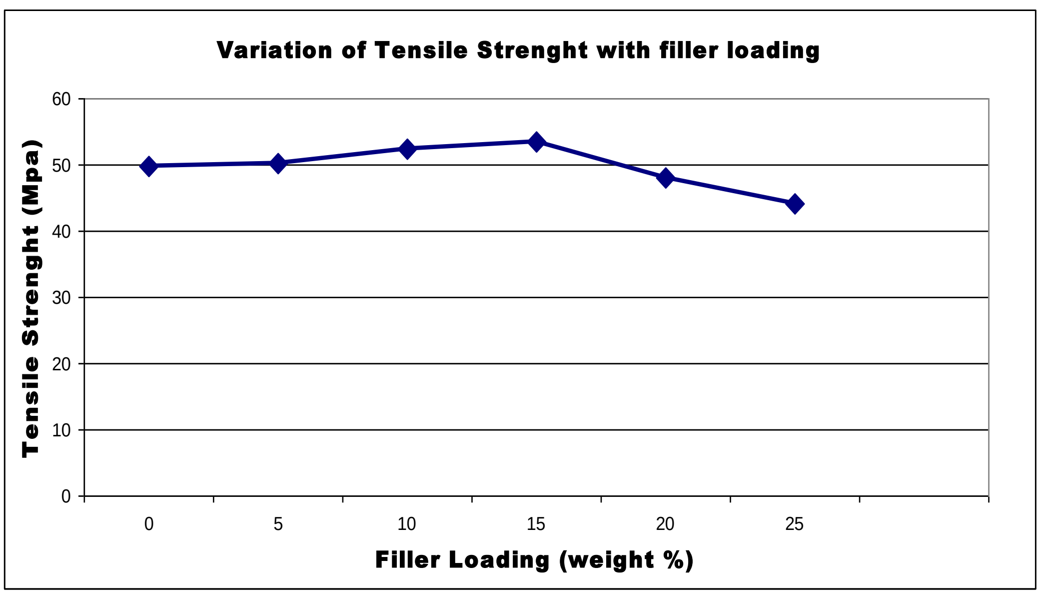

Figure 1: Variation of the Tensile Strength with Filler Concentration.

The increase in filler content, result in the increase in tensile strength of the composite, this is due to the fact that coconut ash filler particle strength the interface of resin matrix and filler mineral. The maximum tensile strength was achieved at 15% filler loading compared to other filler concentration, were it was discovered that as the filler loading increase above 15% the tensile strength decreases gradually.

Percentage elongation at break decreases as filler loading increases as shown in Figure 2; this is due to the interference of filler in the mobility or deformability of the matrix. This interference is created through the physical interaction and immobilization of the polymer matrix by the presence of mechanical restraints, thereby reducing the elongation at break.

From Figure 3, Maximum load at break of above 2,000N was achieve from coconut ash filler epoxy composite, however it was observed that load at break increases gradually from 5% filler loading, up to 15% filler loading, thereafter, it decreases gradually as filler loading increases. Modulus from Figure 4 shows an increase as the amount of filler concentration increases, this is due to the fact that coconut ash filler strengthen the interface of resin matrix and filler materials.

Micro-Hardness

Figure 5 illustrates the variation of micro hardness, with filler loading, this increase is attributed to the relationship between the interface of filler and matrix in which the filler strengthen the composite material.

CONCLUSION

Successful fabrication of coconut shell Ash (CSA) epoxy composites is possible, incorporation of these fillers modifies the Mechanical properties of the composite. The micro-hardness of the composites is also greatly influenced by the content of fillers, hence, while fabricating a composite of specific requirements, there is a need for the choice of appropriate filler material and for optimizing its content in the composite system.

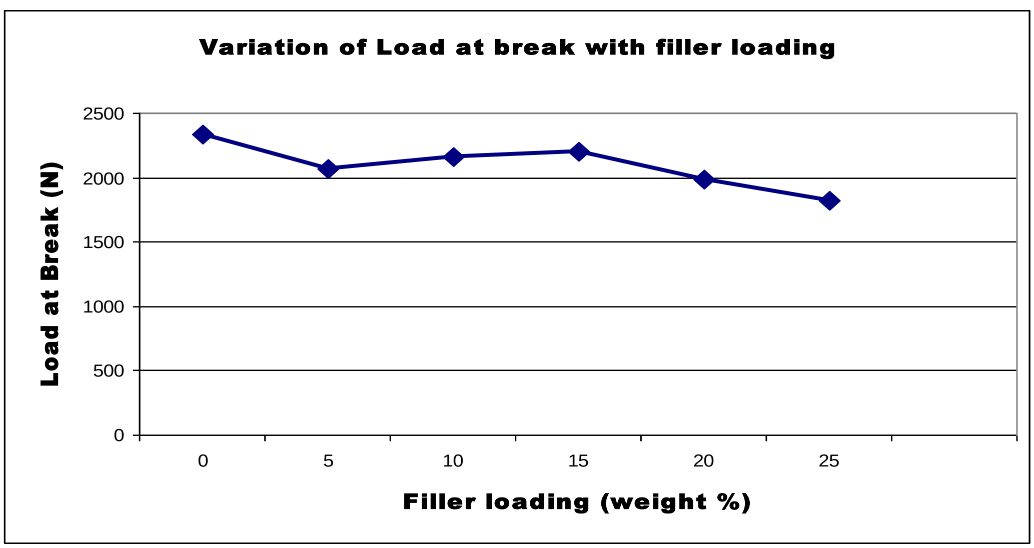

Figure 3: Variation of the Maximum Load with Filler Concentration.

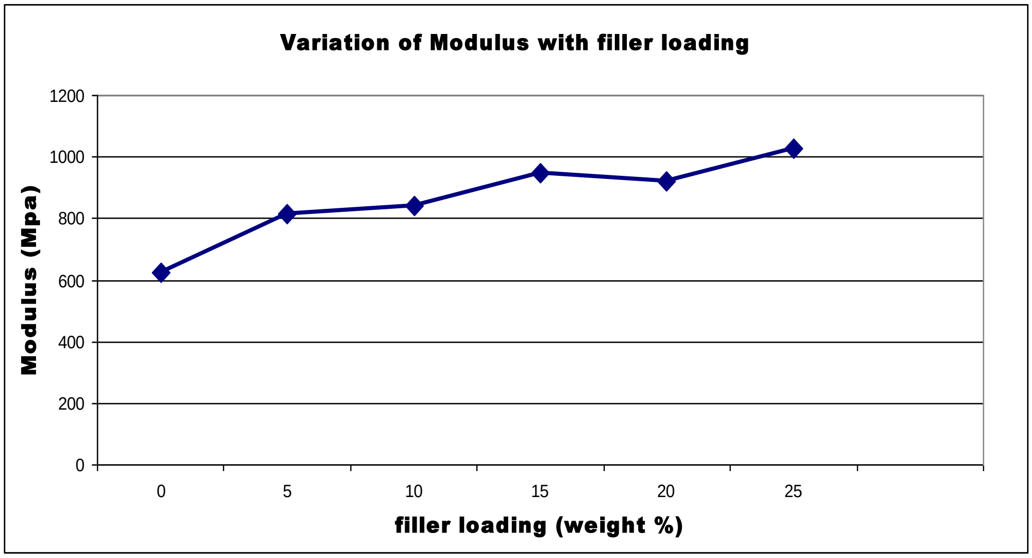

Figure 4: Variation of the Modulus with Filler Concentration.

Figure 5: Variation of Micro-Hardness with Filler Concentration.

REFERENCES

1. Belmares, H., Barrera, A., and Monjaras, M.1983. "New Composite Materials from Natural Hard Fibers. Part 2. Fatigue Studies and a Novel Fatigue Degradation Model". *Industrial Engineering Chemical Product Research and Development*. 22:643–652.

2. Drake, R.S., Egan, D.R., and Murphy, W.T.1982. *Epoxy Resin Chemistry I.* R.S. Bauer (ed.). ACS Symposium Series no. 221. American Chemical Society: Washington, DC.

3. Fuad, M.Y.A., Rahmad, S., and Azlan, M.R.N. 1998. "Filler Content Determination of Bio-Based Thermoplastics Composites by Thermo gravimetric Analysis". *Proceedings of the Fourth International*

Conference on Advances in Materials and Processing Technologies. Kuala Lumpur. 268–275.

4. Gattenholm, P., Berlisson, H., and Mathiasson, A. 1993. "The Effect of Chemical Composition of Interphase, On Dispersion of Cellulosic Fiber in Polymer.I.PVC-Coated Cellulose in Polystyrene". *Journal Applied Polymer Science*. 49(2):197-208.

5. George, J., Sreekala, M.S., and Thomas, S. 2001. "A Review on Interface Modification and Characterization of Natural Fiber Reinforced Plastic Composites". *Polymer Engineering & Science*. 41:1471–1485.

6. Herrara-Franco, P.A., Valadez-Gonzalez, and Cervantes, U.C.M. 1997. "Development and Characterization of a HDPE–Sand–Natural Fiber Composite". *Composites Part B: Engineering*. 28B(3):331–343.

7. Ismail, H., Mega, L., and Abdul-Khalil, H.P.S. 2001 "Effect of a Silane Coupling Agent on the Properties of White Rice Husk Ash Polypropylene/ Natural Rubber Composite". *Polymer International*. 50(5):606-611.

8. Karnani, R., Krishnan, M., and Narayan, R. 1997. "Biofiber-Reinforced Polypropylene Composites". *Polymer Engineering & Science*. 37:476–483.

9. Khalid, A.A., Sahari, B., and Khalid, Y.A. 1998 "Environmental Effects on the Progressive Crushing of Cotton and Glass Fiber/Epoxy Composite Cones". *Proceedings of the Fourth International Conference on Advances in Materials and Processing Technologies*. Kuala Lumpur. 680–689.

10. Luo, S. and Netravali, A.N. 1999. "Mechanical and Thermal Properties of Environmentally Friendly "Green" Composites Made from Pineapple Leaf Fibers and Poly (hydroxybutyrate-co-valerate) Resin". *Polymer Composites*. 20(3):367–378.

11. Maulida, A., Nasir, M., and Khalil, H.P.S.A. 2000. "Hybrid Composites Based on Natural Fiber". *Proceedings of Symposium on Polymeric Materials*. Penang, 1-2 June 2000. USM Press, Penang. 216–219.

12. Mishra, S., Hamzah, H., Murshidi, J.A., Deraman, M. 2002. "Chemical Modification on Lignocellulosic Polymeric Oil Palm Empty Fruit Bunch for Advance Material". *Advances in Polymer Tech*. 20(4): 289-295.

13. Neus Anglès, M., Salvadó, J., and Dufresne, A. 1999. "Steam-Exploded Residual Softwood-Filled Polypropylene Composites". *Journal of Applied Polymer Science*. 74:1962–1977.

14. Riffle, J.S., Yilgor, I., Banthia, A.K., Tran, C., Wilkes, G.L., and McGrath J.E. 1983. *Epoxy Resin Chemistry*. R.S. Bauer (ed.). ACS Symposium Series no. 201. American Chemical Society. Washington, DC. 21

15. Sergio, N., Monteiro, A., Luiz Augusto, H. Terronesa, Felipe P. D. Lopesa, José Roberto, and M. d'Almeidab. 2005. "Mechanical Strength of Polyester Matrix Composites Reinforced with Coconut Fiber Wastes". *Revista Matéria*. 10(4): 571 – 576.

16. Saroja Devi M., Murugesan, V., Rengaraj, K, and Anand, P. 1998. "Utilization of Flyash as Filler for Unsaturated Polyester Resin". *Journal of Applied Polymer Science*. 69(7):1385-1391.

17. Shangjin, H., Keyu, S., Jie, B., Zengkun, Z., Liang, L., Zongjie, D., and Baolong, Z. 2001. "Studies on the Properties of Epoxy Resins Modified with Chain-Extended Ureas". *Journal of Polymer*. 42:9641–9647.

18. Son, J.I., Kim, H.J., and Lee, P.W. 2001. "Role of Paper Sludge Particle Size and Extrusion Temperature on Performance of Paper Sludge Thermoplastic Polymer Composites". *Journal of Applied Polymer Science*. 82(11):2709–2718.

19. Yorkitis, E.M. 1994. *Rubber-Modified Thermoset Resins*. K. Riew and J. K. Gillham (eds.). Advances in Chemistry Series no.208. American Chemical Society: Washington, DC. 137.

20. Zhikai, Z., Sixun, Z., Jinyu, H., Xingguo, C., Qipeng, G., and Jun, W. 1997. "Phase Behavior and Mechanical Properties of Epoxy Resin Containing Phenolphthalein Poly Ether Ether Ketone". *Journal of Polymer*. 39(5):1075–1080.

ABOUT THE AUTHORS

P.E. Imoisili, is a Senior Technical Officer in the Polymer Composite Unit of the Research and Development Department, Engineering Materials Development Institute, Akure Nigeria. He holds a Post Graduate Diploma (P.G.D.) in industrial Chemistry and a Higher National Diploma in Polymer Technology, and has currently enrolled for an M. Tech. in industrials chemistry with the Federal University of Technology Akure. He is a member of the Institute of Charted Chemist of Nigeria (ICCON), Polymer Institute of Nigeria (PIN), Materials Society of Nigeria (MSN) and an affiliate member of the International Union of Pure and Applied Chemistry (IUPAC). His research interests are in the areas of polymer composite, polymer synthesis, and materials testing.

C.M. Ibegbulam, is a bachelor degree holder in Materials and Metallurgical Engineering and his currently a research officer in Engineering Materials Development Institute, Akure, Ondo State, Nigeria and a member of the Materials Society of Nigeria (MSN). His research interests are in the areas of corrosion science with mathematical modeling; materials/mechanical testing and analysis; and materials and metallurgical engineering.

T.I. Adejugbe, is a bachelor degree holder in Mechanical Engineering and his currently a research officer in Engineering Materials Development Institute, Akure, Ondo State, Nigeria. He is a member of the Materials Society of Nigeria (MSN). His research interests are in engineering designs, advanced manufacturing processes, modeling, and simulation.

SUGGESTED CITATION

Imoisili, P.E., C.M. Ibegbulam, and T.I. Adejugbe. 2012. "Effect of Concentration of Coconut Shell Ash on the Tensile Properties of Epoxy Composites". *Pacific Journal of Science and Technology*. 13(1):463-468.

Pacific Journal of Science and Technology