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Research Article

Appraisal of mechanical properties of different particle sizes of palm kernel shell, coconut shell and mixed palm kernel-coconut shells particles epoxy-filled composites

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Abstract

This study presents the appraisal of indentation hardness and flexural modulus of composites prepared by mixing particles of palm kernel shell (PKS), coconut shell (CNS) and mixtures of palm kernel-coconut shell (MPKCNS) of different sizes (35.5 µm, 75 µm and 106 µm) with epoxy and hardener for various applications. The Rockwell hardness tester results showed that PKS particles epoxy filled composites of 35.5 µm had the highest hardness number of 77 while the MPKCNS particles epoxy filled composites of 106 µm had the least hardness number of 43. The CNS particles epoxy filled composites of 35.5 µm and 75 µm had relatively higher flex moduli of 428.66 MPa and 425.55 MPa respectively. The particle size of 106 µm had relatively higher flexure extension than 35.5 µm and 75 µm. The Scanning Electron Microscope (SEM) analysis revealed proper adhesion of the shell particles and epoxy resins with little or no pores in the composites. The PKS particles epoxy filled composites of 35.5 µm can be employed to enhance the mechanical properties of the composites for engineering applications.

Keywords: Palm kernel shell, Coconut shell, SEM, Rheomixer

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1. INTRODUCTION

In recent years, many studies have been dedicated to utilize lignocellulose fillers such as coconut shell, wood, pineapple leaf, palm kernel shell, etc. as fillers in order to replace synthetic fillers through utilization of natural fillers or reinforcement in thermoplastic and thermoset polymer composites in an attempt to minimize the cost, increase productivity and enhance mechanical properties of product. It has been used for different applications[1-12]. Thermoplastic material such as Polypropylene is characterized with high toughness; high resistance to chemical attack, electrical insulation, low coefficient of friction and easy formability but its low strength and low heat resistance have limited its use in many engineering applications[13].

There have been little developments in the use of natural fiber or particulates as reinforcement materials for polymeric composite. The advancement in bio composite technology has tremendously increases the processing and production of natural fibers composites[14]. Though findings have shown that natural fillers reinforced polymeric materials provide materials engineers with a new group of materials that offer exceptional combinations of mechanical properties that make them equivalent to steel applications[15]. A good reinforcement material is known to be stable in a given working temperature and non-reactive too[16]. Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix). Reinforcement provides strength and rigidity, helping to support structural load. In recent years, due to growing environmental awareness, agro-fillers (agro-based waste) have been increasingly used as reinforcing fillers in thermoplastic composite materials[17].

Natural fibers or particulates, as reinforcement, have recently attracted the attention of researchers because of their advantages over other established materials. They are environmentally friendly, fully biodegradable, abundantly available, renewable and cheap, and have low density. Natural fibers or particulates composites are used in place of glass mostly in nonstructural applications. A number of automotive components previously made with glass fiber composites are now being manufactured using environmental friendly composites. This may be attributed to low-weight ratio of the composites. The disposable component of harvested agricultural product (palm kernel) is becoming increasingly problematic in Nigeria, littering the rural and urban areas of the country, and constituting a serious threat to environmental health of the nation.

In this work, effect of different type of particles and their sizes on the hardness and flexural modulus of palm kernel shells, coconut shells and mixtures of palm kernel and coconut shells particles epoxy filled composites were studied.

2. MATERIALS AND METHOD

The palm kernel shells and coconut shells were obtained from Akure farm, Ondo State and pulverized into different particle sizes (35.5 µm, 75 µm and 106 µm) respectively with the grounding machine and sieve. The pulverized palm kernel and coconut particles were mixed separately in different beakers with 12 mls of epoxy and 3 mls of hardener (ratio 4:1) and stirred thoroughly using a two-roll Rheomixer device and a rotor speed of 60 rpm for 5 minutes and put in the compression mold for 48 hrs. The percentage of the palm kernel, coconut and the palm kernel-coconut shell particles in the matrix was not varied. The samples were removed from the compression mold and characterized with Rockwell hardness tester on scale B with a 1.56 mm steel ball. The Scanning Electron Microscope (SEM) was employed to study the surface morphology of the composites.

The universal testing machine for three-point flex test was used to determine the flexural modulus and extensions of each sample. Figures 1 and 2 show pulverized particles and fabricated composites respectively.

Figure 1: Sample of pulverized particles

Figure 2: Fabricated samples

3. RESULTS AND DISCUSSION

Indentation hardness test is most valuable and widely employed mechanical test for evaluating the properties of certain materials. The hardness of a certain material is often considered resistance to permanent indentation. The essence of the hardness test is to determine the material suitability for some specific applications. Figure 3 shows the indentation hardness of PKS; CNS and MPKCNS particles epoxy filled composites of different particle sizes. The palm kernel epoxy filled composites of 35.5 μm had the highest hardness number of 77 followed by the coconut and mixtures of palm kernel-coconut epoxy filled composites with hardness number of 73 and 56.5 respectively. The 75 μm composites had hardness numbers of 76.5, 73.5 and 55 for the mixtures of palm kernel-coconut, coconut and palm kernel shell particles epoxy filled composites respectively. The 106 μm composites had hardness numbers of 75, 66 and 43 for the palm kernel, coconut and the mixtures of palm kernel-coconut shell particles epoxy filled composites. The natural characteristics of the particles, particles sizes, uniform distributions and mixing of the particles and resins plays a major role in determining the hardness of the particles epoxy filled composites.

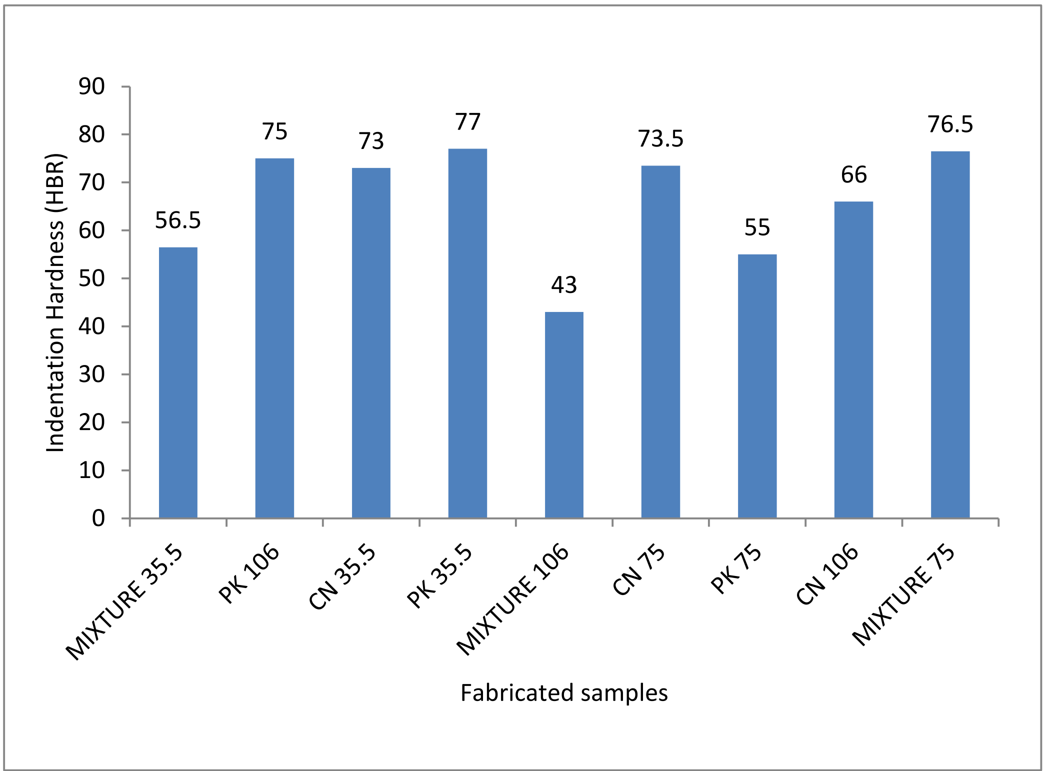

Figure 3: Indentation hardness of the fabricated samples

Table 1 shows the maximum load (N), maximum stress (MPa) and flexural modulus (MPa) for each of the fabricated composites in the specimen label. Flexural modulus or bending modulus is an intensive property computed as the ratio of stress to strain in flexural deformation. It determines the material tendency to resist bending. From the results shown in Table 1, coconut shell particles epoxy filled composites of 35.5 μm and 75 μm had relatively higher flex moduli of 428.66 MPa and 425.55 MPa respectively. Higher flex modulus means that the materials would resist bending.

Table 1: Results of flexural modulus of the composites

S/N	Specimen (µm)	Maximum load (N)	Maximum stress (MPa)	Flexural modulus (MPa)
1	CN 35.5	25.79	3.29	428.66
2	CN 75	21.04	2.68	425.55
3	CN 106	17.13	2.19	88.13
4	PK 35.5	24.37	3.11	260.31
5	PK 75	30.49	3.89	109.35
6	PK 106	8.42	1.07	55.23
7	MIXTURE 35.5	24.84	3.17	208.05
8	MIXTURE 75	19.15	2.44	153.80
9	MIXTURE 106	7.41	0.95	81.69

Figure 4 shows the plot of flexure load (N) against the flexure extension (mm) for the PKS particle epoxy filled composite for 35.5 µm, 75 µm and 106 µm.

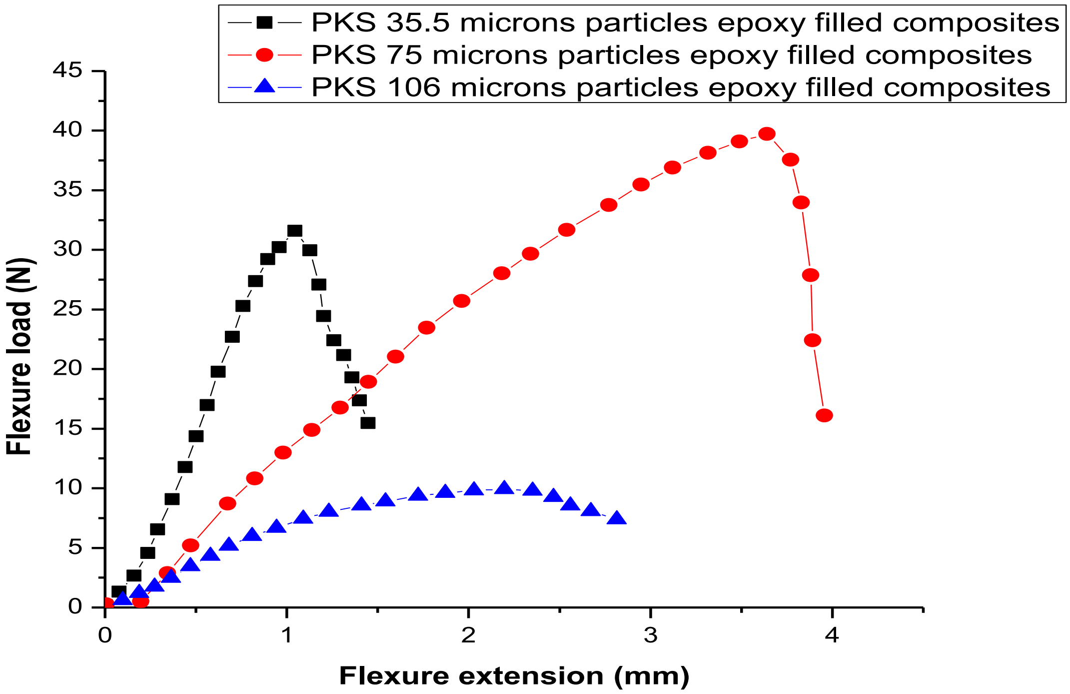

Figure 4: Flexure load (N) against flexure extension (mm) of PKS particles epoxy filled composite

Different loads were applied to determine the flexure extension (mm) of the samples under testing. This involves placing a sample to be tested between two points or supports and initiating a load using a third point. The essence of doing this is to find out what load will make the sample break. The PKS 35.5 µm, 75 µm and PKS 106 µm had maximum extensions of 1 mm, 3.5 mm and 2.5 mm under the applications of maximum loads of 32.5 N, 40 N and 9 N respectively. The application of small flexure load of about 9 N gave maximum extension of about 2.5 mm for the PKS 106 µm before the sample breaks. The application of the same load 9 N for the PKS 35.5 µm and PKS 75 µm only yielded about 0.4 mm and 0.7 mm respectively. This shows that PKS 106 µm particles epoxy filled composites had relatively higher flexure extension than PKS 35.5 µm and 75 µm particles epoxy filled composites under the same flexure load.

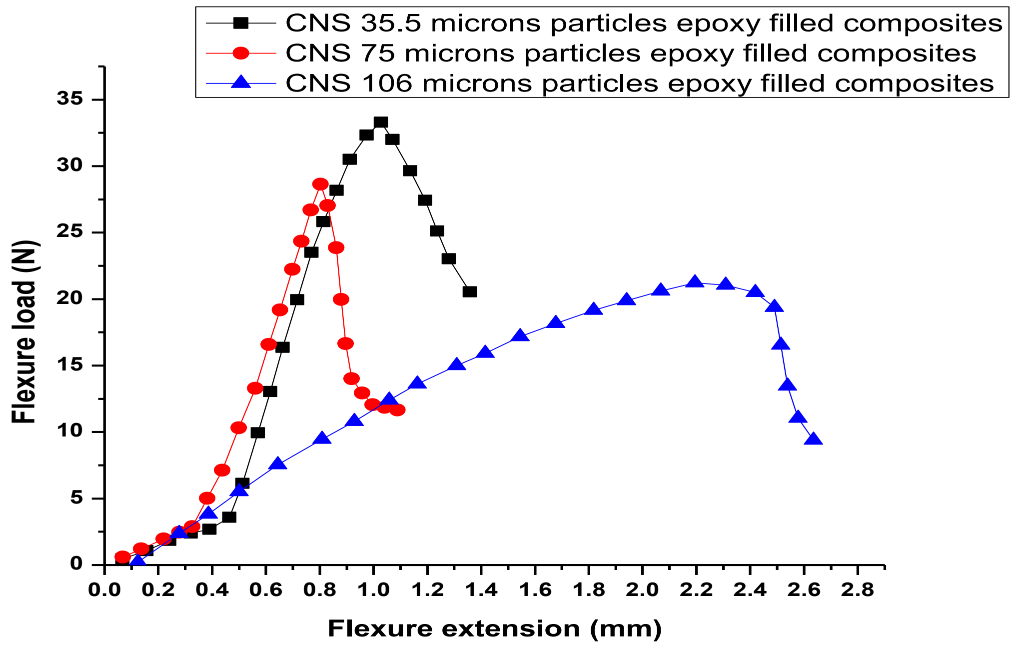

Figure 5: Flexure load (N) against flexure extension (mm) of CNS epoxy filled composite

Figure 5 shows the plots of Flexure load (N) against Flexure extension (mm) of CNS particles epoxy filled composite. Under the same application of flexure load of 20 N, CNS 106 µm particle epoxy filled composite had maximum extension of 2.2 mm while CNS 35.5 µm and 75 µm particles epoxy filled composite had roughly the same maximum extension of 0.6 mm.

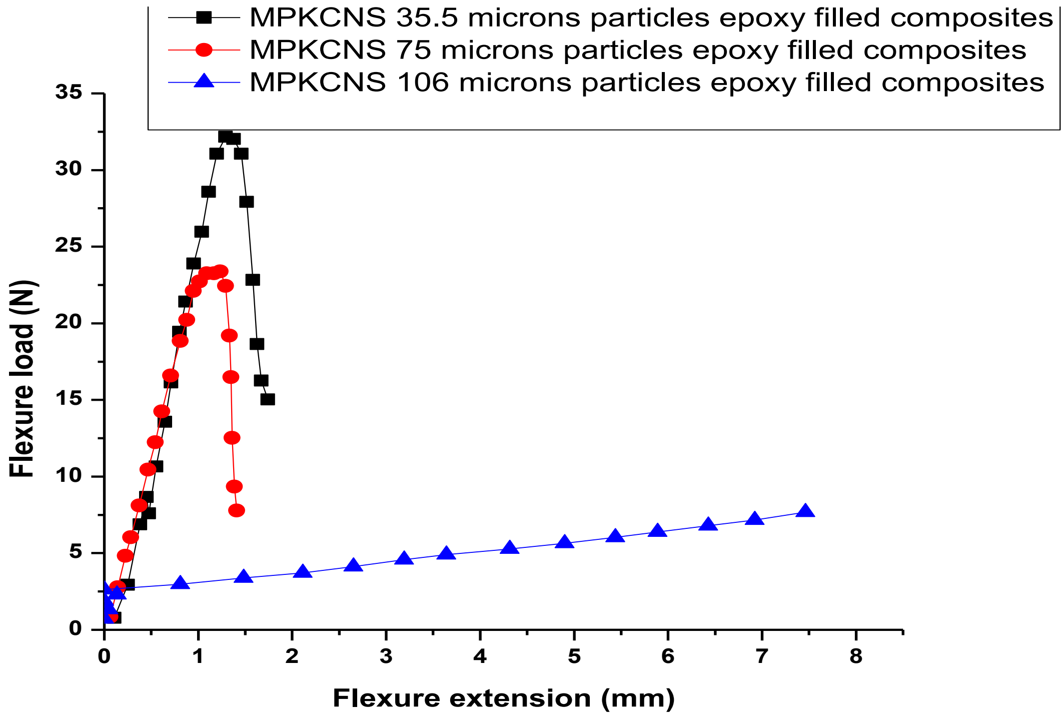

Figure 6: Flexure load (N) against flexure extension (mm) of MPKCNS epoxy filled composite

Figure 6 shows the plots of Flexure load (N) against Flexure extension (mm) of MPKCNS epoxy filled composites for 35.5 µm, 75 µm and 106 µm. The MPKCNS of 106 µm particles epoxy filled composites exhibited maximum flexure extension of 7.5 mm while MPKCNS of 35.5 µm and 75 µm particles epoxy filled composites had roughly the same value of extension of 0.5 mm under the same application of flexure load of 7.5 N.

Generally, the 106 µm size for the PKS, CNS and MPKCNS particles epoxy filled composites had relatively higher extensions than the 35.5 µm and 75 µm.

The scanning electron microscope was employed to obtain information about the surface morphology of the fabricated composites. The post mechanical tests were carried out to observe the distribution of PKS, CNS and MPKCNS particles of different µm in the matrix, resin particles interface, pores, homogeneity and deformation behavior.

Figures 7 to 9 show the SEM image view of the fabricated composites at different particle sizes.

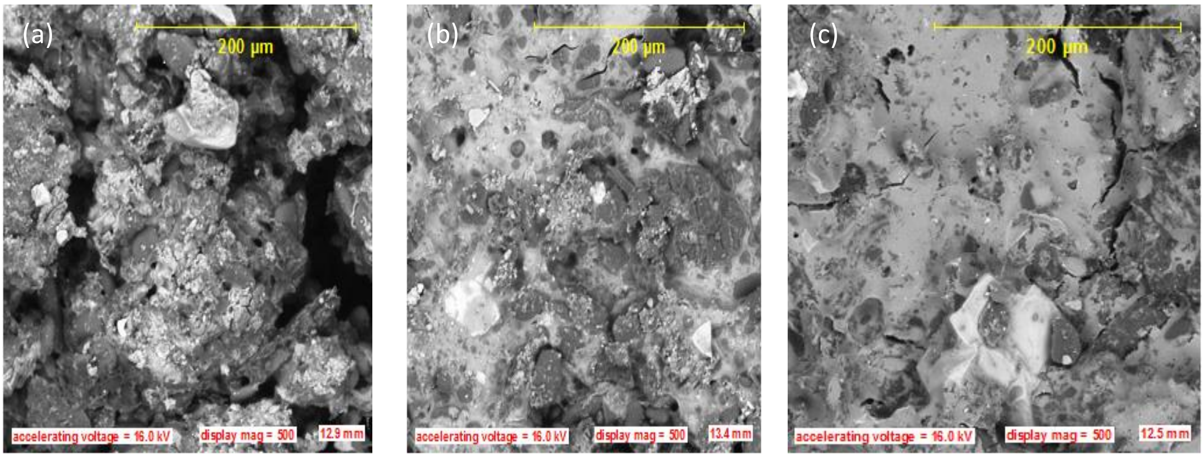

Figure 7: SEM image view of fabricated PKS particles epoxy filled composites: (a) 35.5 µm (b) 75 µm and (c) 106 µm

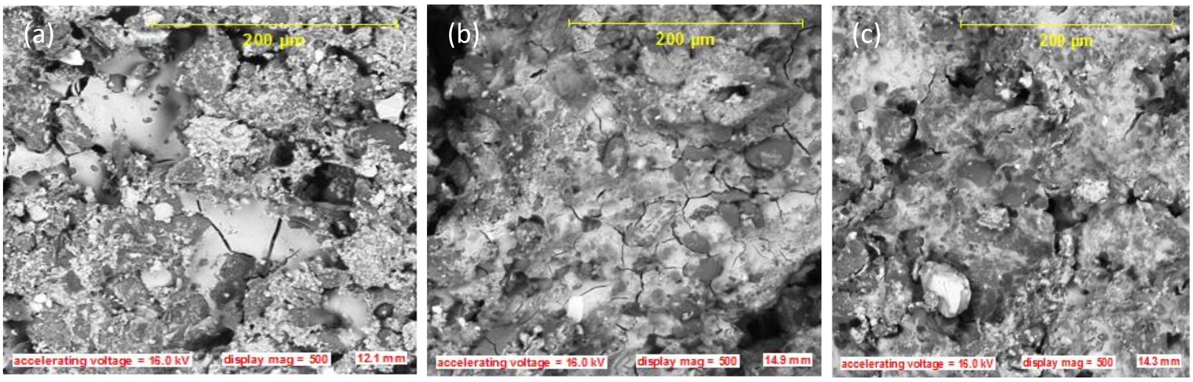

Figure 8: SEM image view of fabricated CNS particles epoxy filled composites: (a) 35.5 µm (b) 75 µm and (c) 106 µm

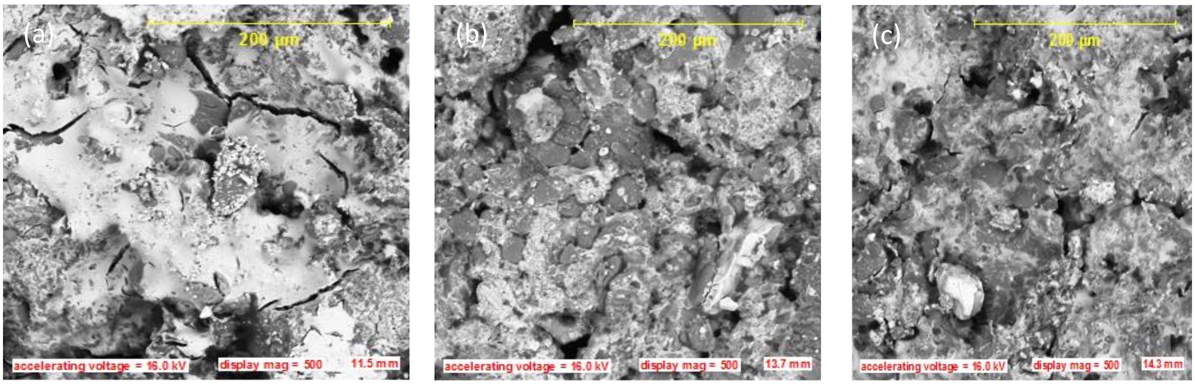

Figure 9: SEM image view of fabricated MPKCNS particles epoxy filled composites: (a) 35.5 µm (b) 75 µm and (c) 106 µm

The images showed proper adhesion of the shell particles and epoxy resins with little or no pores in the composites. The anomaly observed in the hardness of PKS 75 µm particles epoxy filled composite relative to CNS 75 µm and MPKCNS of 75 µm could resulted from the pores within the fabricated composite (PKS 75 µm).

4. CONCLUSION

The PKS, CNS and MPKCNS particles with epoxy and hardener filled composites have been successfully fabricated using different particle sizes. Their hardness, flexural extensions, flexural modulus and microstructures were determined. The results showed that PKS particles epoxy filled composites of 35.5 µm had the relatively highest hardness number while the particle size of 106 µm had relatively higher flexure extension than 35.5 µm and 75 µm. The nature of the particles, particles sizes, uniform mixing, types of epoxy and hardener used in the composites played the major factors for the mechanical properties. The study revealed the uses of different particle sizes for hardness and bending polymer composite productions. The sample with PKS particles of 35.5 µm with higher strength can be employed to improve the hardness property of the recycled polyethylene matrix composite.

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REFERENCES

1. Manoj S. and Vikas C. *Mechanical Properties of Epoxy Resin – Fly Ash Composite*, Journal of Minerals & Materials Characterization & Engineering, **9**(3), (2010) 199-210.
2. Shehu U, Aponbiede O. T, Ause E, Obiodunukwe F. *Effect of particle size on the properties of Polyester/Palm Kernel Shell (PKS) Particulate Composites*. J. Mater. Environ. Sci. **5**(2), (2014) 366-373.
3. Romeo S. F and Jen T. *Effect of Reinforcememt Particles Preheating on Mechanical and Microstructural Properties of Amc*, Acta Metallurgica Slovaca, **24**(4), (2018) 337-346.
4. Ameh A. O, Isa M. T and Sanusi .I. *Effect of particle size and concentration on the mechanical properties of polyester/date palm seed particulate composites*, Leonardo Electronic Journal of Practices and Technologies, **26**, (2015) 65-78.
5. Akindapo J. O, Orueri D. U, Garba D. K, Ogabi R. *Production of A Safety Helmet Using Palm Kernel Fiber And Shell Particulat*es, International Journal of Engineering Science Invention, **6**(2), (2017) 44-55.

6. Ipilakyaa T. D, Dagi C. N and Tuleun L. T. *Effects of Filler Content and Particle Size on the Mechanical Properties of Unsaturated Polyester Resin Reinforced with Rice Husk-Coconut Shell Particles*, European Journal of Advances in Engineering and Technology, **4**(8), (2017) 637-643.
7. Mohammed T. I, Ojo O. O. and Kaffo O. P. *Development of Ecofriendly Automobile Brake Pad Using Different Grade Sizes of Palm Kernel Shell Powder*, Current Journal of Applied Science and Technology, **23**(2), (2017) 1-14.
8. Olanipekun E. A, Olusola K. O, Ata O. *A comparative study of concrete properties using coconut shell and palm kernel shell as coarse aggregates*, Building and Environment, **41**, (2006) 297–301
9. Festus A. O, Habeeb A. Q and Oladipupo S. O. *Investigation of the Strength Properties of Palm Kernel Shell Ash Concrete*, Engineering, Technology & Applied Science Research **2**(6), (2012) 315-319.
10. Meteku, B. E. *Production of Activated Carbon from Palm Kernel Shell for Gold Adsorption Using Leachates from Cocoa Husk Ash (Crude Potash) As Activating Agent*, M. Sc thesis submitted to the department of Chemical Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, (2013).
11. Mahmud .D. N. F, Abdollah M. F. B, Masripan N. A. B, Shuhimi F. F, Amiruddin H., and Tamaldin .N. *Bearing Load Capacity of a Palm Kernel Activated Carbon-Epoxy Composite*, 4th Malaysia-Japan Tribology Symposium, Malaysia-Japan International Institute of Technology (MJJIT), Universiti Teknologi Malaysia (UTM), Kuala Lumpur, Malaysia, (2016) 17-18.
12. Reddy B. D, Jyothy S. A and Shaik F. *Experimental Analysis of the Use of Coconut Shell as Coarse Aggregate*, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 10(6), (2014) 6-13.
13. Agunsoye J. O, Bello S. A, Azeez S. O, Yekinni A. A., Adeyemo R. G. *Recycled Polypropylene Reinforced Coconut Shell Composite: Surface Treatment Morphological, Mechanical and Thermal Studies.* International Journal of Composite Materials, **4(**3), (2014) 168-178. DOI: https://doi.org /10.5923/j.cmaterials.20140403.03.
14. Durowaye S. I, Lawal G. I, Akande M. A, Durowaye V. O. *Mechanical Properties of Particulate Coconut Shell and Palm Fruit Polyester Composites*. International Journal of Materials Engineering, **4**(4), (2014) 141-147. DOI:https://doi.org/10.5923/j.ijme.20140404.04.
15. Chee P. E., Talib R. A, Yusof, Y. A, Chin N. L, Ratnam C. T, Khalid M., and Chuah, T. G. *Mechanical and physical properties of oil palm derived Cellulose-ldpe biocomposites as packaging material.* International Journal of Engineering and Technology, **7**(1), (2010) 26-32.
16. Oladele I. O, and Okoro A. M. *The effect of palm kernel shell ash on the mechanical properties of as-cast aluminium alloy matrix composites*, Leonardo Journal of Sciences, (2016) 15-30.
17. Afolabi M, Abubakre O. K, Lawal S. A, Raji A. *Experimental Investigation of Palm Kernel Shell and Cow Bone Reinforced Polymer Composites For Brake Pad Production*, International Journal of Chemistry and Materials Research, 3(2), (2015) 27-40. DOI:https://doi.org/10.18488/*journal*.64/2015.3.2/64.2.27.40.