International Journal of Physical Science, Volume 2, Number 4, 2010

THE EFFECTS OF PALM KERNEL SHELL POWDER AS FILLER IN FLEXIBLE POLYETHER FOAM

T.U. Onuegbu, J.N. Obi and C. Ejikeme
Department of Pure and Industrial Chemistry,
Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

ABSTRACT

Palm kernel shell as filler has been incorporated in flexible polyether foam to modify the properties and lower the cost of production of the foam. Varying loads of the palm kernel shell such as 5%, 10%, 15% and 20% were mixed with the foam recipes and the foam samples produced were compared with standard, 10% $CaCO_3$ filler used in the industries. The Physico-mechanical analyses such as density, flammability, compression set, compressive strength, tensile strength, elongation-at-break and porosity index tests were carried out. Results showed that the variations in the properties of the foam samples produced leads to the variations in the qualities of the samples. However, 20% filler load gives the best foam samples since the density and compression set are the major parameters that determine the quality of good foams. These foam samples have been recommended for commercialization.

Keyword: Palm, Kernel, Shell, Filler, Foam

INTRODUCTION

Most polymers cannot be successfully processed or used in their pure form unless they have been incorporated with other ingredients referred to as additives. Filler as an additive used in plastics or rubber industries is a finely divided solid material which is added to the liquid, semi-liquid or solid composition to modify the physical properties of the composition and to reduce cost [1]. Fillers can be organic or inorganic [2]. inorganic fillers such as barium sulphate and calcium carbonate have been used in flexible slab stock foams to achieve increased density and load bearing to reduce cost [3]. Fillers used in foam formulation can be inorganic in nature, but it is difficult to produce a stable suspension with inorganic fillers and for this reason, organic fillers such as wood flour, cotton, paper pulp, carbon black etc are usually preferred [4]. Recently, varieties of local raw materials such as coconut fibres, coconut shells, animal bones, hoofs etc. have been used as fillers to modify the properties of foams produced [6-8]. In this research work, palm kernel shell is used as filler in the production of flexible polyurethane foams. Flexible polyether foams are used to produce mattresses, cushions and general upholstery, while polyester foams are used for cloth interling and packaging[9].

Experimental

Materials

The chemicals used were obtained from Winco Foam Nigeria LTD, Awka, Anambra State, palm kernel shell was got from Abakiliki, Ebonyi State, while the standard filler, calcium carbonate was purchased from Onitsha Market, Anambra State, Nigeria.

Method

Preparation of palm kernel shell

The palm kernel shell was washed with detergent and warm water in order to remove the oil that adhered to it. Fibres were removed as much as possible. It was then ground into fine powder using electric milling machine and stored in polythene bag.

Characterisation of the palm kernel shell

The palm kernel shell was characterized by the following methods:

a). The specific gravity was measured by the air comparison pycnometer method according to ASTM D2840 standard method.

b). Size distribution was determined by the sieve method using U.S.A Standard Testing Sieve (ASTM E.11 Specification). Mesh sizes were 150µm, 75µm and 63µm.

c). Solubility of the palm kernel shell was determined by mixing 0.5g of the shell with 10cm^3 of various organic and inorganic solvents to determine its swelling and solubility behavior d). Metallic ion content was assayed by means AAS, AA.220FS Buck Scientific Model, Air Acetylene flame type at a flame temperature of 2600k and flame height of 6mm. The determination was performed by digesting 0.2g of the palm kernel shell with 5cm^3 of each of the following: hydrogen fluoride, perchloric acid and trioxonitrate (V) acid in the ratio of 1:1:1 for 20 minutes. The solution was diluted to 250cm3 with deionized water and then analyzed.

e). Anion content was obtained by the usual chemical analysis.

Formulation of Foam Samples

The formulations in Table 1 were used for the production of flexible polyether foam:

Table 1: **Formulation of Foam Samples**

Raw Material	Pph	$CaCO_3$(g)	PKS_1(g)	PKS_2(g)	PKS_3(g)	PKS_4(g)
Polyol	100	200	200	200	200	200
TDI(Index 108)	54.3	109	109	109	109	109
Water	4	8	8	8	8	8
DMEA	0.4	0.60	0.60	0.60	0.60	0.60
Silicone	0.8	1.6	1.6	1.6	1.6	1.6
Stannous	0.3	0.60	0.60	0.60	0.60	0.60
Methylene chloride	3.6	7.2	7.2	7.2	7.2	7.2
Filler	Varied/ percentage	20 (10%)	10 (5%)	20 (10%)	30 (15%)	40 (20%)

Production of Flexible Polyurethane Foam

Polyol, toluene diisocyanate and palm kernel shell were weighed into separate containers using triple beam balance. Other materials required in small quantities were measured using syringes so as to get accurate measurement. The measurement of raw materials was based on part per hundred of polyol[5]. The mixing of the raw material was as described in a number of articles [10, 11]. The mixture was then poured into a mould lined with silicone paper for easy removal. The foam samples were removed and kept at a temperature of 25°C for 48hours before testing.

Characterization of the foam samples

The following physicomechanical properties of various foam samples were determined using standard methods: d ensity, elongation-at-break, tensile strength [12], flammability, compression set (resilience), porosity index and compressive strength [13, 14].

RESULTS AND DISCUSSION

From the results of the analyses, it is clear that palm kernel shell (PKS) powder is essentially of low density, 0.025g/cm^3 and the fillers particle size distributions obtained are 150µm, 75µm and 63µm. Studies have shown that most fillers become increasingly reinforcing as the particle sizes diminish. The solubility test carried out on the sample showed that they were insoluble in all the solvent namely; both hot and cold water, ethanol, propanone, hexane and concentrated/ dilute hydrochloric acid. This means that the filler may enhance the chemical resistance of the polyurethane foam filled with it to common chemicals. The results of the chemical analyses of the PKS powder shown in Table 2 indicate that calcium salts predominate in concentration while Fe^{2+}, K^+, Zn^{2+} and Na^+ occurred in significant amount among the cations analyzed. Among the presence of acid radicals tested the sulphate(SO_4^{2-}) and nitrate(NO_3^-) radicals are equal in concentration and predominate the phosphate ion (PO_4^{3-}).

Table 2: Chemical Compositions of the PKS Powder

Cations	K^+	Cu^{2+}	Ca^{2+}	Zn^{2+}	Fe^{2+}	Pb^{2+}	Na^+	Mg^{2+}
% composition	0.357	0.000	0.607	0.027	0.500	0.000	0.223	0.000
Anions	SO_4^{2-}	NO_3^-	PO_4^{3-}					
% composition	0.150	0.150	0.500					

In addition to these inorganic substances, the filler also contains organic species particularly cellulose. It is expected that there would be a chemical interaction between the chemical species of the filler and polymer. In order to verify further about the interaction between the foam and the filler, the surface chemistry of the filler was analyzed. The pH value of the filler is 5.20 which is weakly acidic. Measurement of the pH of aqueous slurry which depends on the concentrations of both weak and strong acid groups and the volatiles at 950°C is the convectional method for assessing surface chemistry of a material. In plastics, surface chemistry determines the degree of interaction between the filler and the polymer.
The results of physicomechanical analyses of the foam samples are shown in Table 3

Table 3: The results of physicomechanical analyses of the foam samples

Test	$CaCO_3$	PKS_1	PKS_2	PKS_3	PKS_4
Density (kg/m^3)	19.1	18.1	19.1	20.7	23.9
Flammability (sec)	28	30.4	39	49	100
Compression set (%)	7.0	1.0	3.5	5.0	10.0
Tensile Strength N/cm^3	5.15	10.69	6.13	4.63	4.63
Elongation at break(%)	90	104	76	87	80
Compression strength (%)	0.0152	0.0123	0.0187	0.0171	0.0213
Porosity index	10.17	10.83	10.38	9.63	9.67

The density of the polyether foam filled with this material at different percentages increases when compared with the commercial filler, $CaCO_3$ This suggests that the filler has reinforcing effect. The higher the filler load the higher the density, flammability and compression set. It is observed that the elongation at break, tensile strength, porosity and compression strength vary with increasing filler load. The tensile strength is higher at 5% and 10% filler load than of $CaCO_3$, then from 15% to 20% the tensile strength starts to decrease. The results in the Table also show that at 5% filler load, the porosity increases. The 10% and 20% filler load have the highest crushing force followed by 15% filler load when compared to 10%$CaCO_3$ which is the standard.

CONCLUSION

In conclusion, palm kernel shell can be used in flexible polyether foam. The plant material imparts colour to the foam apart from enhancing some of its physicomechanical properties and so it can be used as colouring agent as well as reinforcing filler. The chemical composition of the filler indicated that it is made up of some inorganic compounds and cellulose. The metallic ions that predominate in the palm kernel shell are Ca^{2+}, Fe^{2+} and K^{+} in descending order. Other metallic ions present are Zn^{2+} and Mg^{2+}, The acidic ions present are SO_4^{2-}, NO_3^- and PO_4^{3-}. These inorganic substances cannot establish strong bond with polymer to guarantee strong filler interaction. The extent of reinforcing was perhaps due to the interaction between the organic phase of the filler and the polymer.

REFERENCES

A. C. Hampel and G. G. Hawley (1973) The Encyclopaedia of Chemistry Van Nostrand Reinhold Company, New York. pp 96 -99.

B.K. Sharma (2006) Industrial Chemistry Including Chemistry of Engineering, Goel Publishing House, Meerut. pp 253-255

C.W. James L.C. Stuart (1978), Thermoplastic Elastomers, Academic Press, New York, p 30.

J. Brydon (1982) Plastic Mterials, Butterworth Scientific, London,pp 125-127.

T. U. Onuegbu, O. Ogunfemitimi and V.I.E. Ajiwe (2007): Local raw Material as Filler in Flexible Polyether Foam. Anachem J. Chem. Soc. Nigeria, Vol 1 (1&2) pp 1-7.

T.U.Onuegbu, C.C. Ezenduka and O. Ogunfeyitimi (2008), Natural Cellulosic Material as Filler in Flexible Polyether Foam Deltachem. Conference Proceedings of 31st Annual international Conferrence of Chem. Soc. Nigeria, pp 23-28.

T.U. Onuegbu, P.N. Ekemezie and N.C. Okoro (2008), Effetct of Filler on production of Flexible polyether Foam. Anachem J. Chem. Soc. Nigeria, Vol 2 (1) pp 262-267.

T.U. Onuegbu, I.O.C. Ekejiuba, P.N. Ekemezie and C.C. Ogbonna(2009).The use of Natural Proteioneous Materials as Filler in Flexible Polyether Foam, J Chem. Soc, Nig. Vol. 34, No.1, pp 193-197.

M.S. Bhatnagar, (2004) A Textbook of polymers, Chemistry and Technology of Polymers, Condensation Polymers Vol. 11, S Chand & Company LTD, New Delhi, p 526.

Ajiwe V.I.E., Ulakpa C.M.and Onuegbu T.U., (2005) Additive Effects on Production of Polyurethane Flexible Foams. World Journ. Of Biotechnology, 6; 957-967.

V.I.E. Ajiwe, T.U. Onuegbu and M.C. Ozumba (2007) Manufacture and Analysis of Co-polymerized Rigid Polyurethane Foam Products. J.Sci Engr Tech. 14(1):7298-7310.

Nigerian Industrial Standard (1979) Method of Measuring tensile Strength and Elongation at break of Flexible Polyurethane Foam NIS 53. Lagos, p 3-8.

L.F. Lawler and R. Schiffanir (1993): Advanced Property Prediction Models for Flexible Slabstock Foam. Proceedings of the Polyurethane World Congress Technomics, Lancaster, p 296.

D.C. Allport and W. James (1973): Block Polymers, Applied Science, Publisher, London pp 57-63.

J.E. Huheey (1983) Inorganic Chemistry, Principles of Structure and reactivity. 3rd edn, Harber and Row Publishers INC., New York, pp 904-909.