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A Study on the Effect of Coconut and Palm Kernel Shells on Density, Porosity Index and Tensile Properties of Flexible Polyether Foam

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ABSTRACT

This work studies the effectiveness of local raw materials (coconut and palm kernel shells) as fillers in flexible polyether foam. Varying loads of the materials, such as 5%, 10%, 15% and 20% were incorporated into the foam recipes. The following properties, density, porosity index and tensile properties of the foam samples produced were compared with standard (10% $CaCO_3$) foam sample. The results showed that the densities of the samples increase with increase in filler load, the samples filled with palm kernel shell showed the best results. In all the 15% and 20% foam samples showed better properties than the commercial filler used as standard. The porosity index of the foam samples filled with the novel fillers decreased when compared with the standard. The tensile properties such as breaking force, elongation at break and tensile strength vary with increase in filler load.

Keyword: *Density, porosity, tensile strength, filler, foam.*

1. INTRODUCTION

Nowadays, there is clear evidence that polyurethane products are important part of everyday life. Polyurethane foams have so many diverse applications [1]. Rigid foams are widely used in applications such as building, insulation, appliances, transportation, furniture, etc, while flexible foams are used in applications which include production of mattresses, cushions, general upholstery interlining and packaging [2]. The foam can either be closed or open cell foams. In closed cell foams, the foam cells are isolated from each other while the open cell foams are made up of broken cell walls.

The prices of flexible polyether foams are becoming increasingly high due to the high cost of raw materials [3]. The raw materials are mostly liquid reagents and chemicals obtained from petrochemicals and agro-products. The raw materials needed for the production of flexible polyether foam include polyol poly isocyanate, blowing agents, catalysts surfactants and additive such as fillers [4].

Flexible polyether foams are classified as low density, medium density and high density [5]. The price of foam depends mainly on its density. As a result of the high cost of raw material, there is a need to source for cheaper, a readily available and eco-friendly material that can be used as filler. Filler, as used in plastic and 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 [6]. The use of filler to modify properties of composition can be traced at least as far back as in the middle of the 19^{th} century in Roman era when artisans used ground marble, calcium carbonate ($CaCO_3$) in lime plaster, frescoes and pozzolanic mortar, paper and paper coating [7]. Fillers that are organic origin are wood floor, cotton, paper pulp, carbon black, etc while that of inorganic origin include asbestos powdered mica, silica, clays, talc, lead oxide, and metal of iron, lead, aluminum in powdered form [6]. The percentage of fillers varies with the nature of plastic formed and properties required and can be as high as 50% of the total mixture. Fillers capable of enhancing properties of a polymer are a reinforcing fillers [8]. The used of precipitated calcium carbonate is very reinforcing but expensive hence the need to source filler from eco-friendly waste substances. A lot of innovative fillers ranging from cattle bone [3] plant shells to fibrous substances [9, 10] have been studied.

This research is aimed at investigating the effect of coconut and palm kernel shells on density, porosity index and tensile strength of flexible polyether foam.

2. EXPERIMENTAL

a. Materials and Methods

The raw materials used for the production of foam were obtained from Winco Foam Nigeria LTD, Awka, Anambra State, while the coconut and palm kernel shells were obtained from Uburu in Oha Ozara Local Government area of Ebonyi State, Nigeria.

b. Preparation Of Materials

The two shells were dried to constant weights at 107^{o}C for 24hrs in an electric oven. They were crushed with hammer, and then milled with electric milling machine and stored in polyethylene bags.

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3. CHARACTERIZATIONS OF THE BONE SAMPLES

a. Sieve Analysis

The particle size distributions of coconut and Palm kernel shells were determined by the Gilson Automatic Sieve Tester, SS-15 model attached to the following mesh sizes, 320µm, 180 µm, 87µm and 63µm

b. Specific Gravity

The specific gravity was measured by the air comparison pyconometer technique using ASTM D2840 Standard method.

3. FOAM FORMULATION

The formulation in Table 1 is used for the preparation of foam.

Table 1: Foam Formulation

Material	Pph(%)	$CaCO_3$(g)	PS_1(g)	PS_2(g)	PS_3(g)	PS_4(g)
Polyol	100	500	500	500	500	500
TDi	54	270	270	270	270	270
Water	4	20	20	20	20	20
Amine	0.14	0.7	0.7	0.7	0.7	0.7
Silicone	0.8	4	4	4	4	4
Stannous octoate	0.15	0.75	0.75	0.75	0.75	0.75
Methylene chloride	3.6	17.5	17.5	17.5	17.5	17.5
Coconut shell/Palm kernel shell	varied	50	25	10	75	100

Note: Pph = Part per hundred, PS = Plant shell

4. PREPARATION OF FLEXIBLE POLYETHER FOAM

The polyol, toluene diisocyanate and fillers with particle size of were accurately weighed into separate beakers using triple beam balance. The other raw materials required in small quantities were measured with syringes. The measurement of raw materials were based on part per hundred of polyol [4]. The mixing of the raw materials was as described in a number of articles [5, 11]. The formulations of various foam samples are shown in Table 1. The mixture was then poured into mould made of Kraft sheet lined with silicone paper. The foam samples were allowed to solidify for 10minutes, removed and kept at temperature of 25^{o}C for 72hrs before testing.

5. CHARACTERIZATION OF THE FOAM SAMPLES

The following mechanical properties of the foam samples were determined using standard methods: density, porosity index [11] while tensile strength was measured according to the standard specifications [12].

6. RESULTS AND DISCUSSION

The results of the particle size determination of coconut and palm kernel shell indicated that the mesh sizes are 150µm, 75µm and 63µm while the 63µm was used for the production of the foam samples. The particle size of filler has a dominating effect on tensile strength and other properties. The smaller the particle size the larger the surface area and the more the filler polymer interaction. The finer the particle sizes the higher the tensile strength, modulus and hardness. Coarser particles give weak product than the materials without fillers, but if the particle size is fine there is an enhancement of the mechanical properties. Coarse particles lead to points of weakness in polymer and will therefore fail under stresses. Filler surface area determines the ease of dispersion in the foam recipes, the flow properties and optimum loading of filled polyether foam. This indicates that the particle size of the filler sample is of fine particle grade, which are suitable for use as filler in polymer. Fillers become increasingly reinforcing as their particle size decreases.

The results of the density of flexible polyether foam filled with coconut and palm kernel shells at different percent filler loading are shown in Fig.1. It is

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evident that the densities of the foam samples filled with the two fillers were higher than density of the foam samples filled with the commercial filler ($CaCO_3$). The higher values observed for the palm kernel shell filled foam samples may be due to he fibrous nature of the filler and hence is more reinforcing than the coconut shell filler which is more particulate. Again, the higher the filler load, the higher the density of the foam and the extent of the improvement on the density of the foam by the two fillers are however observed to be gradual within the limits of loading studied.

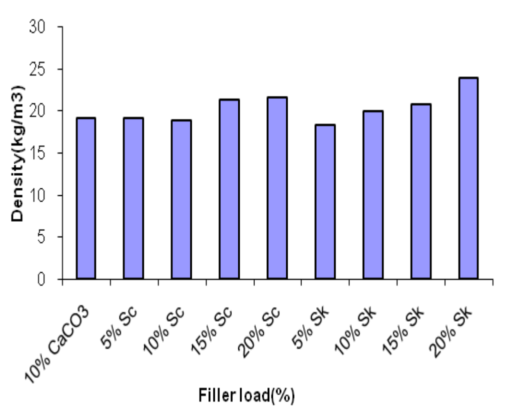

Fig.1: Effects of fillers on density of the foam samples

Fig 1: Effects of Fillers on Density of the Foam Samples

The results in Fig. 2 showed a variation in porosity index as the percentage of filler loads increases. At 10% $CaCO_3$ filler which is used as the standard, the volume of water percolated is 73ml and the porosity index is 10.17 while at 10% coconut and palm kernel shell fillers, the volume percolated are 92ml and 87ml and the porosity index for these are 11.36 and 10.38 respectively.

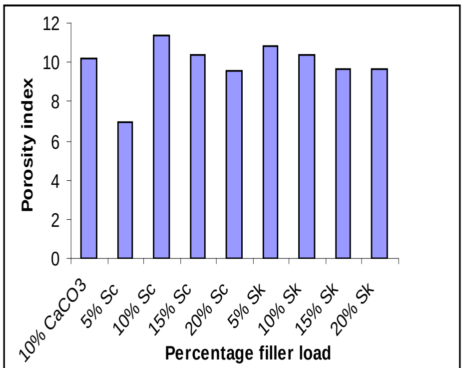

Fig.2: Effects of filler load on porosity index of

Fig 2: Effects of filler load on porosity index of

The results of the effect of filler on the tensile properties of the flexible polyether foam sample are shown of Fig.3. It is observed that in both samples filled with coconut shell and palm kernel shell fillers, the tensile strengths at yield increased at 5% filler load and sharply decreased at 10%, then slightly increased with increase in filler load for coconut shell and sharply decreased in palm kernel shell filler when compared with the standard. The elongation at break increased remarkably with the coconut shell filled samples while for palm kernel shell; there is an increase at 5%, decrease at 10% and remarkable increase with increase in filler load. When compared to the 10% $CaCO_3$ used as standard, 5% filler loads were better as shown in the table.

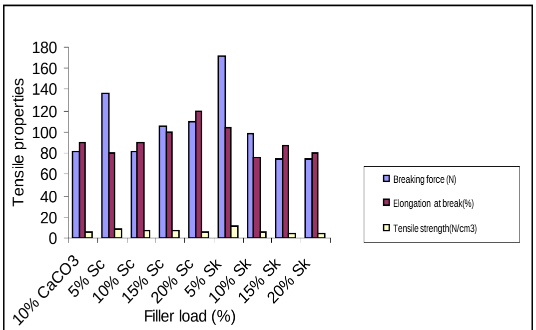

Fig.3: Effects fillers on tensile properties of foam

Fig 3: Effects Files on Tens Properties of Foam

7. CONLUSION

The results of the effects of coconut and palm kernel shells on the flexible polyether foam samples show that the reinforcing effects of these fillers is more with palm kernel shell which produced samples with higher density, porosity index and tensile properties. The particle 63µm was used in the production and the smallness of the particle size provides a larger surface area and hence a large filler- polymer- interaction.

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