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The use of Chicken Bone Powder as Filler in Flexible Polyether Foam

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Abstract

The use of chicken bone powder as filler in flexible polyether foam has been studied. Foam recipes were incorporated with 0%, 5%, 10%, 15%, 20% and 25% chicken bone powder and the foam samples formed were analyzed; the results obtained were compared with 10% $CaCO_3$ as used in foam industries. The physico-mechanical properties of the foam samples produced were enhanced, 10% of the chicken bone as filler is comparable with 10% $CaCO_3$. Analysis of the bone gave the following cations in descending order of concentration Ca^{2+}, Mg^{2+}, K^+, Na^+, Zn^{2+}, Mn^{2+} and Cu^{2+} while the concentration of CO_3^{2-} was higher than PO_4^{3-}.

Key words : Chicken, Bone, Filler, Flexible, Foam

Introduction

Filler is a finely divided solid material which is added to liquid, semi-liquid or solid composition to modify the physical properties of the composition and to reduce the cost of the product[1]. The use of fillers to modify the properties of composition can be traced at least as far back as early Roman times, when artisans used ground marble in lime plasters, frescoes and pozzolanic mortar[2]. Fillers may be classified as reinforcing and non-reinforcing. Reinforcing fillers are small in particle size and chemically active while non-reinforcing fillers are added as extenders in polymer to reduce cost.

Bone functions in various ways, such as, protection, shape and support to the body; it helps in movement, blood production, acid-base balance and detoxification[3]. The applications of bone in the ancient times include archaeological dating due to the fluorine content of the bone and decorative arts. Other applications of bone in the modern era include its use as artificial manure, as well as in making buttons and knife handle; the fat content is used in soap and candle making,[4]. Animal charcoal, bone oil and pitch obtained from distillation of bone are used as filtering and clarifying materials[5,6].

The vast applications of foam in virtually all aspects of human activity show the overwhelming importance of foam industries and their growth in synthetic polymer technology. There is a continuing need to improving the texture and at the same time lower the prices of polyurethane foams by the incorporating of a variety of fillers in the foam recipes. In recent publication works, lots of locally available raw materials such as coconut shell powder, coconut fibres, cattle bone (femur) and various nut shells have been used as fillers in flexible polyether foam. The aim of this work is to determine the effect of chicken bone powder as filler on flexible polyether foam.

Experimental

Materials

Fresh chicken bone was collected from Citi exotic(fast food company), No. 39 Afikpo Road, Abakaliki, Ebonyi State, while the raw materials used were obtained from Winco foam Nigeria Ltd, Awka, Anambra State, Nigeria.

Method

Preparation of Chicken bone Powder :

17.45kg of fresh chicken bone was assembled by hand picking. The meat particles attached to the bone were scraped off with the aid of a knife. The bones were cracked open and washed with hot water and detergents to remove the bone marrow. This was followed by rinsing with warm water, and drying in an oven for 24hrs at the temperature of 100°C for complete removal of water content. The bone was reduced to smaller sizes with mortar and pestle. It was then milled with a manually operated corona lever machine, Landers and YCIA S.A model.

Characterization of the filler sample :

The chicken bone was characterized using the following methods:

a). Size distribution was determined using Gilson Automatic Sieve Tester, SS 15 model. The sieve was fitted with Rotan- type timer suitably to give the sieve a vibrating vertical movement. Samples of different mesh sizes; 320μm, 180μm, 87μm and 63μm were assembled on the Gilson Automatic Sieve Tester.

b). The hydrogen ion concentration of the chicken bone was determined using universal indicator paper, 1-14 Q/GHSC 1544-1999 made by SHANGHAI SSS REAGENT CO LTD.

c). Solubility of the bone sample was determined by mixing 0.3g of the bone with 10cm^3 of various inorganic and organic solvents such as hot and cold water, 2M each of dilute hydrochloric and sulphuric acid, butanol, acetone, methanol and ethanol.

d). Specific gravity was measured by the air comparison pycnometer method using ASTM D2840 standard method.

e). Charring temperature: 1.0g of the bone was placed inside a combustion tube

Table 1. Formulation of Foam Samples

Raw Material	Pph	$CaCO_3$ (g)	CB_0 (g)	CB_1 (g)	CB_2 (g)	CB_3 (g)	CB_4 (g)	CB_5 (g)
Polyol	100	200	200	200	200	200	200	200
TDI(Index 108)	54.3	109	109	109	109	109	109	109
Water	4	8	8	8	8	8	8	8
DMEA	0.4	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Silicone	0.8	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Stannous	0.3	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Methylene chloride	3.6	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Filler	Varied/ percentage	20 (10%)	0 (0%)	10 (5%)	20 (10%)	30 (15%)	40 (20%)	50 (25%)

Pph = Part per hundred

attached to a 0-360°C ranged thermometer. The combustion tube was clamped on a heating mantle which was regulated at constant heating point. The char temperature was recorded.

f). Metallic ion content: This was determined using buck Scientific AAS 205 Model, Air acetylene flame type at a flame temperature of 2000K and flame height of 6mm[7-8]. The determination was carried out by digesting 1g of the bone with 3:1 hydrochloric acid and nitric acid (aqua- regia) for 20mins. The solution was diluted to 250cm^3 with de-ionized water and then analyzed.

g). Anion contents were determined by usual qualitative analysis. The foam formulation is shown in Table 1.

Preparation of Flexible Polyurethane Foam:

The filler loads used in the production of foam samples varied from 0%, 5%, 10%, 15%, 20% and 25% while the measurements of the raw materials used were constant, 10% calcium carbonate used in industry was used as standard. Flexible polyurethane foam sample was produced by batch process as described in a number of articles[9, 10]. The foam samples were removed and kept at a temperature of 25°C for 48hours before testing.

Characterization of foam samples :

The following physico-mechanical properties of various foam samples were determined using standard methods; density, tensile strength, elongation-at –break[11], porosity, compressive strength, flammability, compression set, thermal conductivity and hardness test[12, 13].

Results and Discussion

The results of the analyses of the filler showed that the particle size distributions are 320μm, 180μm, 87μm and 63μm while 63μm particle size was used. Fillers become increasingly reinforcing as the particle size decreases. The particle size of filler has dominating effect on tensile strength and other properties. The smallness of the particle size provides a larger surface area. The pH value of the bone is 5. The specific gravity is 0.79 and the charring temperature is in the range of 190-200°C which indicated its resistance to thermal degradation. The solubility test carried out on the bone powder showed that it is insoluble in acetone, hot and cold water, slightly soluble in butanol, methanol and ethanol but soluble in dilute hydrochloric and sulphuric acids, concentrated hydrochloric and sulphuric acids. It therefore showed that the chicken bone powder will enhance the chemical resistance of the polyurethane foam to chemical attack. The colour change observed when tested showed that the chicken bone powder will impart colour on any composite into which it is incorporated. The results of the chemical composition of the bone powder are shown in Table 2.

These ions in the sample are centres of adhesion between the polymer and the fillers. The Ca^{2+} serves as the binding agent in the polyurethane foam as well as a hardener. Mg^{2+} also serves as a binding agent, while Na^{+} and K^{+} enhance porosity, Fe^{2+} helps in structure maintenance and rigidity, and Mn^{2+}, Cu^{2+} and Zn^{2+} act as catalysts. PO_4^{3-} will be useful as a buffering agent and as a retardant while the CO_3^{2-} in combination with the calcium, that is, calcium carbonate serves as an extender. The effects of filler on the physico-mechanical properties of the foam samples are shown on Table 3.

The results of the density showed that sample without filler, CBF_0 is airtight and has higher density followed by CBF_1. As the filler load increases the cell sizes of the foam samples increase and thereby affecting density negatively. The 10% filler load has the same compressive strength with 10% calcium carbonate which is used as standard, after which the values steadily decreases. The tensile strength of 0% filler load is low and increases from 5% to 10% and then starts to decrease from 15% to 25%. When compared

Table 2. Chemical composition of bone powder

Cations	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	Fe^{2+}	Zn^{2+}	Mn^{2+}	Cu^{2+}
Concentra-tiong/dm³	78.039	7.304	1.495	7.833	0.385	0.286	0.067	0.007
Anions	PO_4^{3-}	CO_3^{2-}						
Concentra-tiong/dm³	0.00035	0.408						

Table 3. Results of the Physico-mechanical properties of the foam samples

Test	$CaCO_3$	CBF_0	CBF_1	CBF_2	CBF_3	CBF_4	CBF_5
Density(kg/m^3)	25.6	30.6	26.3	22.3	19.0	14.0	12.3
Compressive strength(N/mm^2)	0.010	0.016	0.011	0.016	0.014	0.013	0.012
Tensile strength (N/mm^2)	4.5	9.68	8.93	9.12	7.56	6.93	5.93
Elongation at break (%)	86	62	83	76	59	43	40
Compression set (%)	1.90	6.66	5.04	6.66	8.57	11.42	14.00
Thermal conductivity(°C)	56	36	42	32	28	25	21
Flammability(sec)	13	28	20	35	53	72	75
Porosity Index	15.5	13.5	13.13	11.75	7.98	7.5	5.75
Hardness value	711	226	300	741	572	361	249

Note: CBF means Chicken bone Filler

to 10% $CaCO_3$, 5% and 10% chicken bone compositions have higher elongation-at-break while 0% has the highest elongation-at-break. The elongation-at-break decreases with increase in filler load. The thermal conductivity decreases with increase in filler load probably, because the composite does not have so much mobile ions. From the results of the hardness test, it could be seen that the incorporation of filler into the foam recipes enhances its hardness property. The 0% foam sample has low hardness value while foam with 10% chicken bone has higher value than 10% $CaCO_3$. The porosity index of 5% filler is comparable to that of 10% $CaCO_3$ and from 10% filler load it starts to decrease.

As filler, the bone powder also interacted with the foam recipes. The mode of interaction is complex but definitely includes lock-and-key, mere physical entanglements, some van der Waal's and other dispersion forces, electrostatic or coulombic interaction between cations and the slightly negative charges on the secondary carbon atom. The net results of these interactions would be an intimate union between the filler particles and the binder. This is expected to exert more effect on the physico- mechanical properties of the foam compared with those of unfilled sample.

Conclusion

In conclusion, it could be concluded from the results of the analyses that the chemical constituents of the filler contribute much to the mechanical properties of the polyurethane foam samples. The decreasing order of the concentration of the cations is Ca^{2+}, Mg^{2+}, K^+, Na^+, Fe^{2+}, Zn^{2+} and Cu^{2+} while

CO_3^{2-} predominates over PO_4^{3-} in concentration. The animal bone also impart colour to the polyurethane foam samples. The physico-mechanical properties of the foam samples produced were enhanced, 10% chicken bone as filler is comparable to 10% $CaCO_3$ used in the industry.

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