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Physico-mechanical properties of flexible polyether foam: Comparative Effects of fillers

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Abstract
This work studied the effects of fillers on the density, compression set, Elongation at break, Tensile strength, porosity, indentation force deflection (IFD) and sag factor of flexible polyether foam samples filled with chicken bone, palm kernel shell, foam dust, calcium carbonate and Barium sulphate. The results showed that all the filled foams have higher density than the unfilled foam. The fillers also modified other properties more than the unfilled foam. The results of the physico mechanical properties of the barium sulphate were better than the results of other fillers tested.
Keywords: Physico-mechanical, flexible, polyether foam Comparative Effects, fillers

Introduction
Polyurethane products abound everywhere, it is found in every area of human endeavored: offices, transportation, market places, under the carpets and household seats and even in the electronics packaging. This usefulness prompts the increases in the prizes of polyurethane products consistently over the years. This in turn necessitated the incorporation of a variety of fillers into foam samples. Fillers denote any materials that are added to polymer formulation to lower its cost or to improve its properties Arnold, (1994). The use of fillers to modify properties of composition can be dated back to at least middle of 19th Century in Roman era when artisans used ground marble, calcium carbonate ($CaCO_3$) in lime plaster, frescoes and pozzolanic mortar, paper and paper coating (Blumberg et al., (1978). The higher the degree of the surface area of the filler, the higher its stiffening ability on the polymer. Fillers can be classified in many different ways ranging from their shapes to specific characteristics: Extender fillers and functional fillers are classes based on performance. Extender fillers primarily occupy space and are used to reduce formulation cost while functional fillers have definite and required function apart from lowering the formulation cost. Based on types, fillers are classified as particulate fillers, rubbery fillers, resins, fibrous filler and cork. The particulate fillers are divided into inert fillers and reinforcing fillers. Inert fillers in addition to reduction of cost improve the properties of the foam samples.

Reinforcing fillers are used majorly for reinforcement. Classification based on morphology groups fillers into crystalline and amorphous fillers. Amorphous fillers can be in form of fibres, flakes, solid spheres and hollow sphere while the crystalline types can be in form of platelets polyhydrous and irregular masses. With respect to compositions, we have inorganic and organic fillers. Organic ones are cellulose, fatty acids, liquid, polyalkanes, polyamines, and polyesters. (Fyszkowska and Jurzyk, 2008). It is difficult to produce a stable suspension with inorganic fillers such as $CaCO_3$ and for this reason, organic fillers are usually preferred. Inorganic fillers have been used in flexible slab stock foams to achieve increased density and load bearing to reduce cost (Morton-Jones, 1989). The effects of various agricultural wastes as fillers in flexible polyether foam have been studied, such waste include: natural proteineous material (Onuegbu et al., 2009), animal waste (goat femur) (Onuegbu et al., 2010a), palm kernel shell (Onuegbu et al., 2010b), *Irvengia gabonensis* shell (Onuegbu et al., 2010c), chicken bone powder (Onuegbu et al., 2010d), cow and chicken bone (Onuegbu et al., 2010e), etc.

Chemicals used for the production of flexible polyether foam are: toluene diisocyanate, polyol, amine, stannous octoate, silicon oil and additives such as colourants, fillers, flame retardants, water and auxiliary blowing agents are also used. (Billmeyer, 1984) flexible polyether foams of different types have been produced using these chemicals. Such foams are used in various fields of life such as bedding, upholstery, laminated clothing and packaging. It also has good acoustic properties due to its structure (Katchy, 2000).

This study is to provide additional information on the effects of chicken bone, foam dust, barium sulphate, calcium carbonate and palm kernel shell powder on some properties of flexible polyether foam samples.

Experimental

Materials and methods

Calcium carbonate and foam dust were collected from Vita foam Nigeria Plc, Jos, Plateau State, Nigeria. Chicken bone was sourced from Thrillers fast food, Awka, Anambra State. Palm kernel shell was obtained from Nsukka in Enugu State while barium sulphate was sourced from BDH England.

Preparation of materials

The palm kernel shell and chicken bones were each washed with hot water and detergent to remove the oil and marrow respectively. They were then dried to remove the water content. The moisture free samples were ground and sieved to pass through sieve mesh seizes of 70µ and 50µ. The 50µ was used for the experiment.

Foam formulation

The foam formulations in Table 1 were used to produce the foam samples.

Table 1: foam formulation

Materials	Pphp*	F_0 (g)	F_1(g)	F_2(g)	F_3(g)	F_4(g)	F_5(g)
Polyol	100	550	500	500	500	500	500
Filler	10	0	50	50	50	50	50
TDI (index=110)	53	303	265	265	265	265	265
Silicone	0.9	5	4.5	4.5	4.5	4.5	4.5
Amine	0.2	1.1	1	1	1	1	1
Tin	0.15	0.83	0.75	0.75	0.75	0.75	0.75
Water	4.3	23.7	21.5	21.5	21.5	21.5	21.5
Glycerine	1.0	5.5	5	5	5	5	5

Note: **Pphp= parts per hundred of Polyol*, (F_0) = without filler, (F_1) = calcium carbonate, (F_2) = barium sulphate, (F_3) = Foam dust, (F_4) = Palm Kernel shell, (F_5) = chicken bones

Preparation of Flexible Polyether Foam

Flexible polyether foam samples were produced by batch process as described in a number of articles (Vuilleumier, 1993). Foam sample without filler was used as control while chicken bone powder, palm kernel shell powder, foam dust, Calcium Carbonate and Barium Sulphate were incorporated in foam samples at 10% load each.

Characterization of Foam Sample

The following physico-mechanical properties of foam samples were determined using standard methods: density, compression set, Elongation at break, Tensile strength porosity (Ajiwe et al., 2007; Onuegbu, 2011; Onuegbu et al., 2012), indentation force deflection and support factor of flexible polyether foam.

Results and Discussion

The results of density (Fig. 1) showed F_2 to have the highest density of 21.6kg. The unfilled foam has the lowest density of 20.10kg/m^3. F_1, $F_{3,}$ F_4 and F_5 have densities of 20.72kg/m^3, 20.51kg/m^3 and 20.75 kg/m^3 respectively. This implies that barium sulphate yields much higher density foam than the calcium carbonate commonly used in industries. The calcium carbonate yielded better density than all other fillers and palm kernel shell was the least when you talk of density.

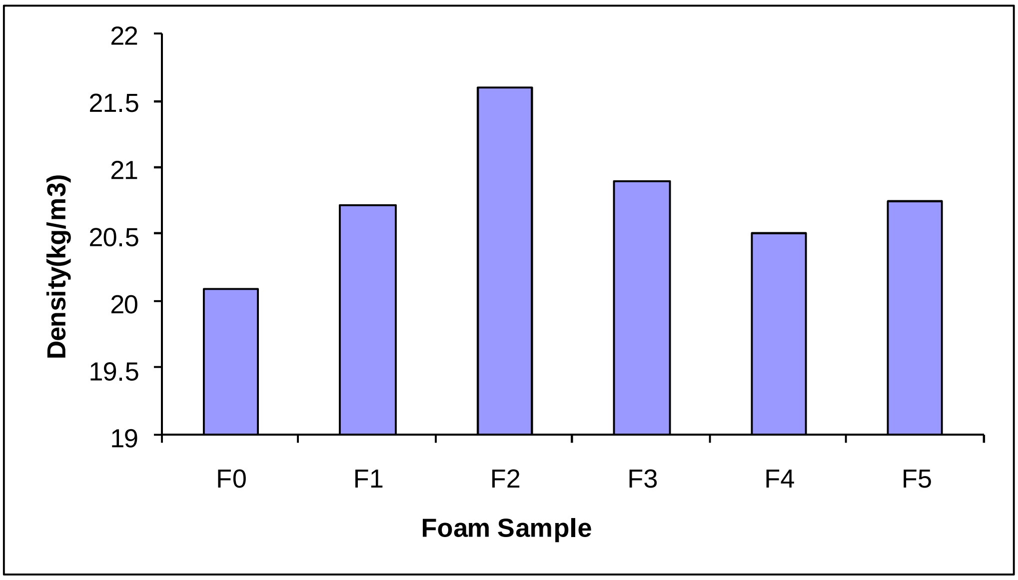

Fig.1: Densities of various Foam Samples.

The F_0 recorded the lowest value (6.14%) for compression set test which implies that fillers reduce the tendency of the foam to return to its original size after compressions. The F_2 foam has the lowest compression set of all the filled foams with a value of 7.13% followed by F_3, F_4, F_5 and F_1 respectively. The foam sample, F_2 even though with higher density than F_3, F_4, F_1 and F_5 foams has lower ability to return to its original size when compressed. It is then obvious that the density of a foam sample cannot be directly proportional to the compression.

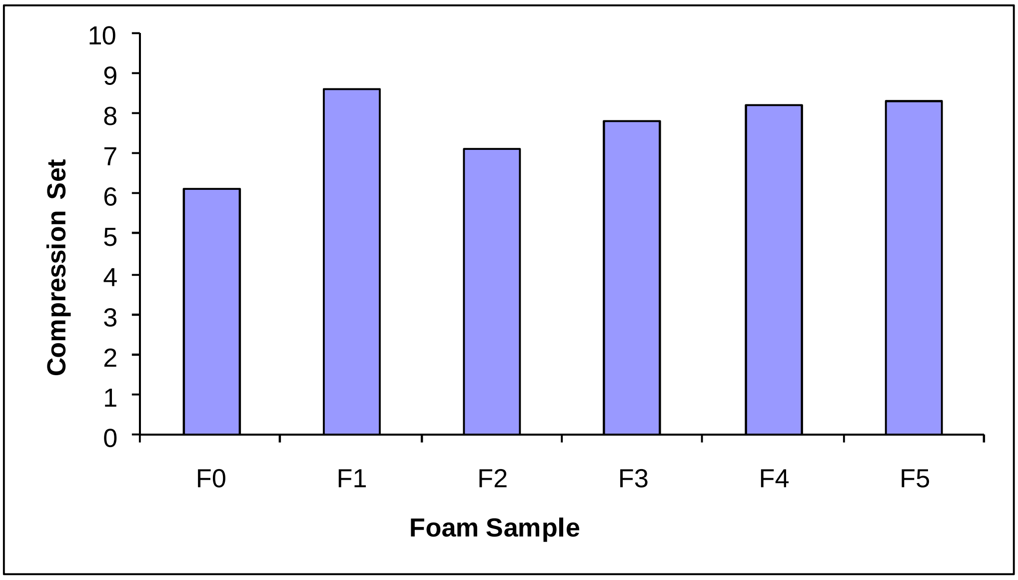

Fig. 2: Compression set of Foam Sample

The elongation at break (Fig. 3) value was highest for F_0 (149.9%). That is, its maximum load carrying capacity is highest. Fillers make foam to tear easier by filling the pores in the foam samples, increasing its stiffness and reducing its elasticity (elongation at break). F_2 still maintained a better value for elongation at break (140.9%) than other samples with the value of 135.4%, 138.7%, 136.67% and 135.38% for F_1, F_3, F_4 and F_5 respectively. Calcium Carbonate as a filler reduces the elongation at break of foam samples than others, though very close to foam sample filled with chicken bone. Foams filled with these two fillers can easily tear compare to others. Foam dust has closer value of elongation at break to the control after barium sulphate, followed by palm kernel shell powder.

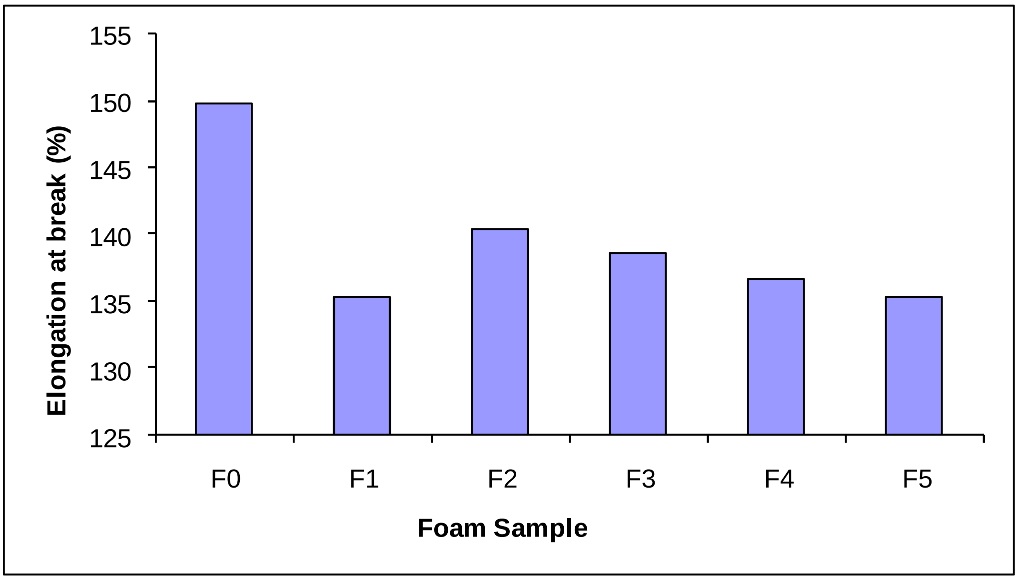

Fig. 3: Elongation at break of foam sample

The tensile strength of the unfilled foam sample shoots far above all the filled foam samples followed by F_2, F_4, F_3, F_5 and F_1 respectively. From that it means that tensile strength increases in the same direction with elongation at break as shown in Fig. 4.

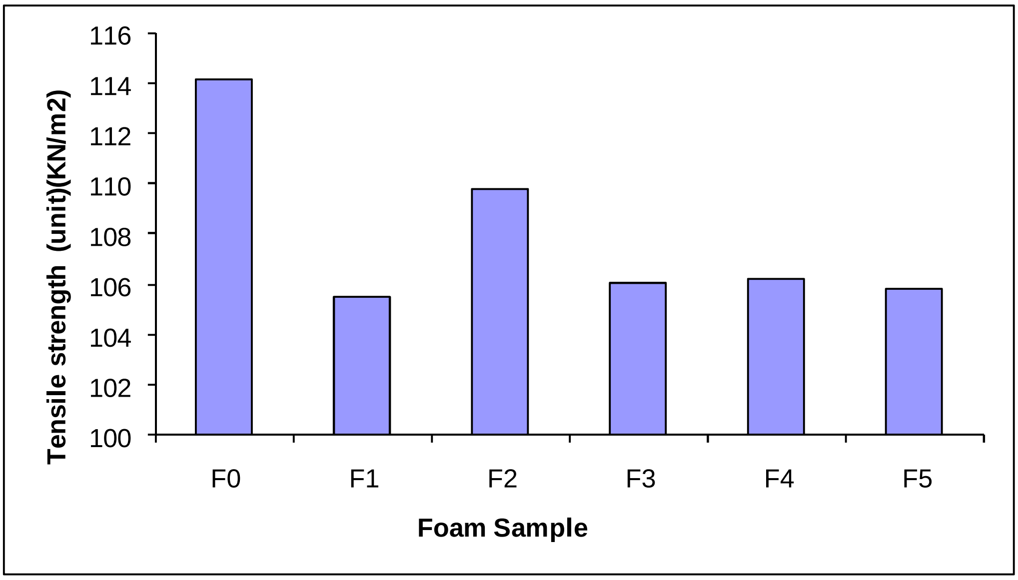

Fig. 4: Tensile strength of foam sample

Porosity is highest also with the unfilled foam with a value of 65 as show in Fig. 5 because fillers occupy the pores in between the foam, reducing the penetration of air. The F_2 and F_3 have equal porosity of 67 while F_1, F_3 and F_4 have porosity of 66, 64 and 65 respectively.

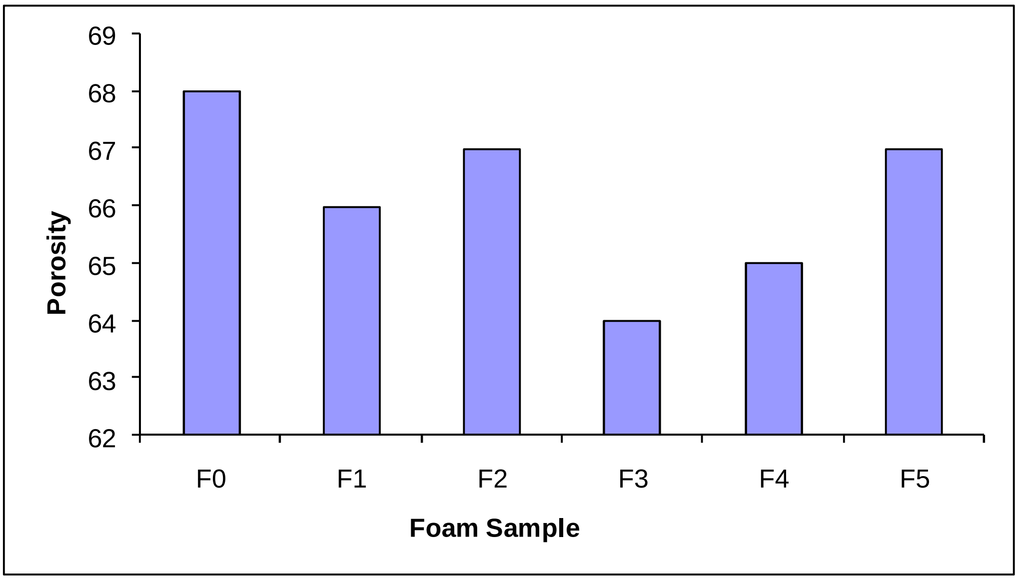

Fig. 5: Porosity of foam Samples

Indentation force deflection at 75/25, 60/40 and 35/65 is least for the F_0 likewise the support factor. It is highest for the F_1 followed by F_4, F_5, F_3 and F_5 respectively.

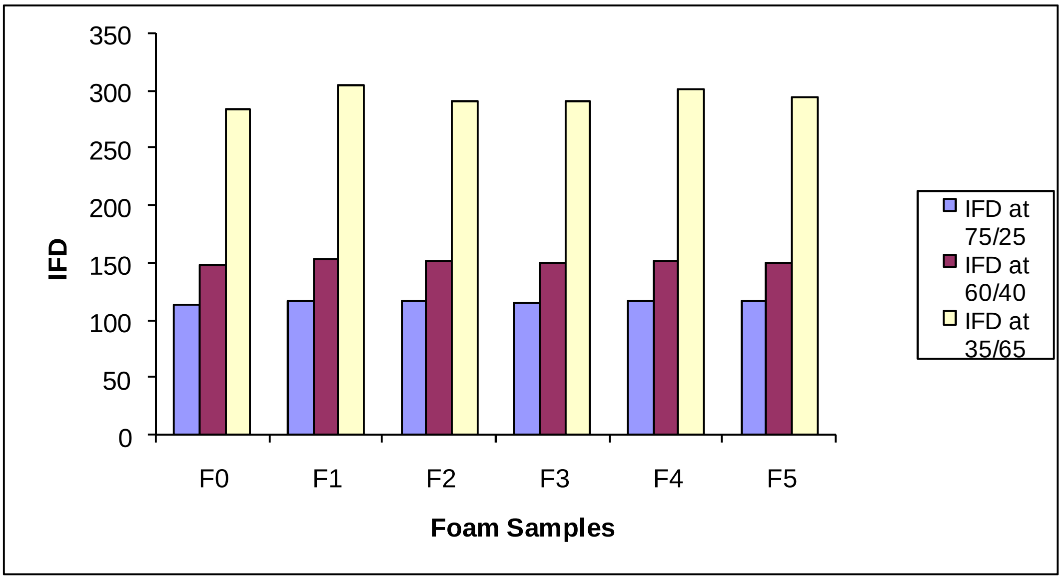

Fig. 6: A graph of IFD at 75/25, 60/40, and 35/65 for all the foam samples

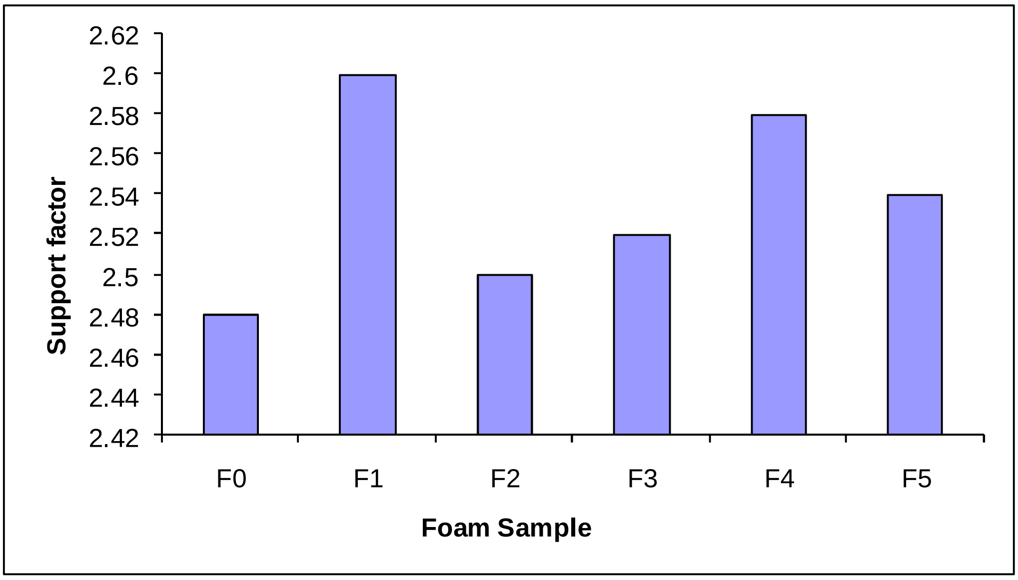

Fig. 7: Support factor of foam sample

CONCLUSION

A number of conclusions are evident from the results of the analysis. All the fillers increase the density of the foam. Barium sulphate as filler produced better property in the foam samples than all the other fillers. In most of the physico-mechanical properties, barium sulphate compared very close to the unfilled foam. At 10% filler load, fillers reduce some properties such as elongation at break, porosity and tensile strength of the foam samples.

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