

Effect of fillers on the density, rising time, creaming time, ignition time, flame duration and thermal conductivity of flexible polyether foam

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Abstract

This work studied the effects of fillers on the density, rising time, creaming time, ignition time, flame duration and thermal conductivity of flexible polyester 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 densities than the unfilled foam. Foam sample F₂ has the highest density of 21.6kg/m³. The unfilled foam has the lowest density of 20.10kg/m³, while F₁, F₃, F₄, and F₅ have densities of 20.72kg/m³, 20.90kg/m³, 20.51kg/m³ and 20.75kg/m³ respectively.. The fillers also enhanced other properties in the foam sample more than the unfilled foam. Barium sulphate was found to be the best filler from the properties tested.

INTRODUCTION

Fillers denote any materials that are added to polymer formulation to lower cost or to improve its properties. It can also be defined as a finely divided solid material which is added to liquid, semisolid and solid composition to modify the properties of the composite and to reduce cost of the product. The filler can constitute a major or minor part of a composite. In fact, it can occupy as much as 50% of the composite but researches have shown that the optimum filler load for good quality of the product is from 10% to 15% filler load (Arnold, 1994). Fillers can be classified based on the shapes, sizes or characteristics. We have particulate fillers, rubbery fillers, resins, fibrous fillers and cork. The particulate filler is divided into inert fillers and re-enforcing fillers. Inert fillers reduce cost as well as improve the properties of foam samples. Based on performance, fillers can be classify as extender fillers which are those that primarily occupy space and functional fillers are those that have definite function apart from lowering production cost. Fillers are also classified based on morphology and this includes amorphous and crystalline fillers. There are also inorganic fillers which are classifications based on composition (Fyszkowska and Jurzyk, 2008). The organic fillers have advantage of being easier to produce a stable suspension than the inorganic fillers. (Morton-Jones, 1989).

The use of fillers began as far back as middle of 19th century and since then it has been in use till date (Blumberg et al., 1978). Suffice it to say that it has been in use in several composites and polyurethane foam has not been an exception. The use of fillers in polyurethane is due to increase in cost of chemicals used in its production. The increase in cost of polyurethane foam

itself is due to increase in its usefulness in almost every area of human endeavour. It is found in offices, in electronic packaging, in the carpet underlay, in the car we drive, in some of our hospital equipment and many other fields of life. It also has good acoustic properties due to its structure (Katchy, 2000). Polyurethane itself is divided into polyether and polyester foam. Polyether foam has the rigid and flexible forms. The chemicals used in the production of flexible polyether foam include toluene diisocyanate, polyol, amine, stannous octoate, silicone oil and additives such as colourants, flame retardants, water and auxiliary blowing agents (Billmeyer, 1984).

The aim of this work is to study the effects of foam dust, calcium carbonate, barium sulphates, palm kernel shell powder and chicken bone on the properties of flexible polyether foam.

Experimental

Materials

Raw materials and foam dust, calcium carbonate were collected from Vita foam Nigeria Plc, Jos, Nigeria. Chicken bone was sourced from Trillers Fast Food in Awka, Anambra State, Nigeria. Palm kernel shell was obtained from Nsukka, Enugu State, Nigeria, while barium sulphate was got from BDH England.

Method

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 at temperature of 105°C to remove the moisture content. The moisture free

samples were ground and sieved to pass through sieve mesh sizes of 70 μ m, 60 μ m and 50 μ m. The 50 μ m was used for the experiment.

Foam Formulation

The foam formulation is shown in Table 1.

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, (F₀) = without filler, (F₁) = calcium carbonate, (F₂) = barium sulphate

(F₃) = Foam dust, (F₄) = Palm Kernel shell, (F₅) = chicken bones

Preparation of Flexible Polyether Foam

Flexible polyether foam samples were produced by batch process as described in a number of articles (Vulleumier, 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, rising time, creaming time, ignition time, flame duration and thermal conductivity of flexible polyether foam (Ajiwe et al., 2007).

Results and Discussion

The result of density, Fig. 1, showed F_2 to have the highest density of 21.6kg/m^3 . 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 , 20.90kg/m^3 , 20.51kg/m^3 and 20.75kg/m^3 respectively. This implies that foam produce with barium sulphate as a filler has the highest density than the calcium carbonate used in industries whiil yielded better density than all other fillers and palm kernel shell was the least when you talk of density.

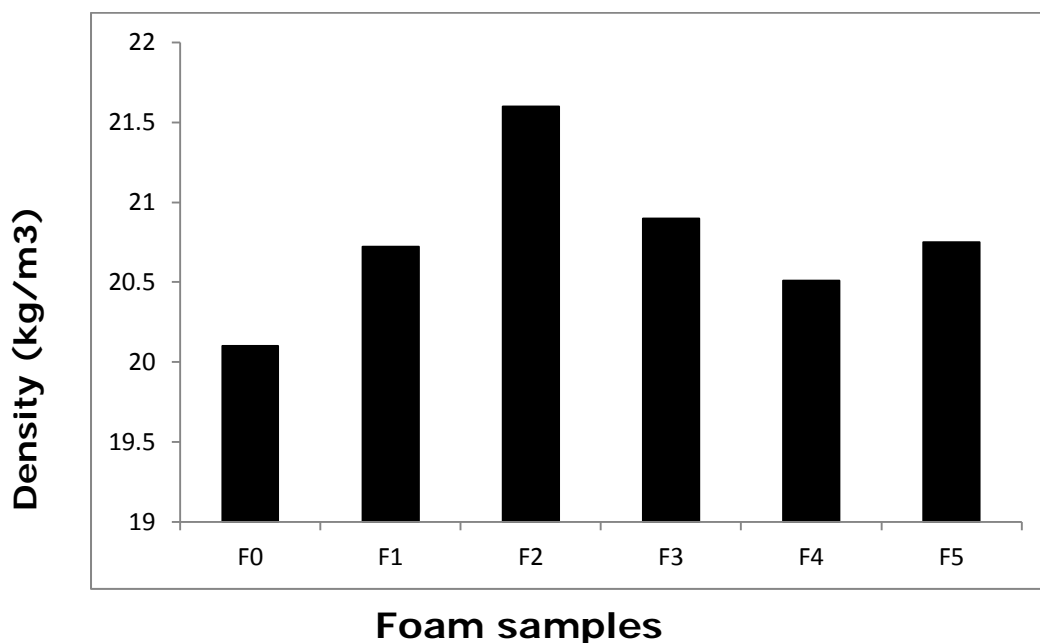


Fig. 1: Density of Foam Samples

From Fig. 2, the rising time is highest with F_3 with a value of hundred followed by F_2 and F_4 with the values of 97secs each. F_0 is has the lowest rising time with a values of 94secs followed by F_5 and F_1 with values of 95secs and 96secs respectively. It is then obvious that fillers increase the rising time of foam samples. This shows that they interfere with the blowing reaction that causes rising. However, metals have lesser tendency to hinder it since chicken bone with the highest concentration of metallic ion has the lowest value of all the filled foam.

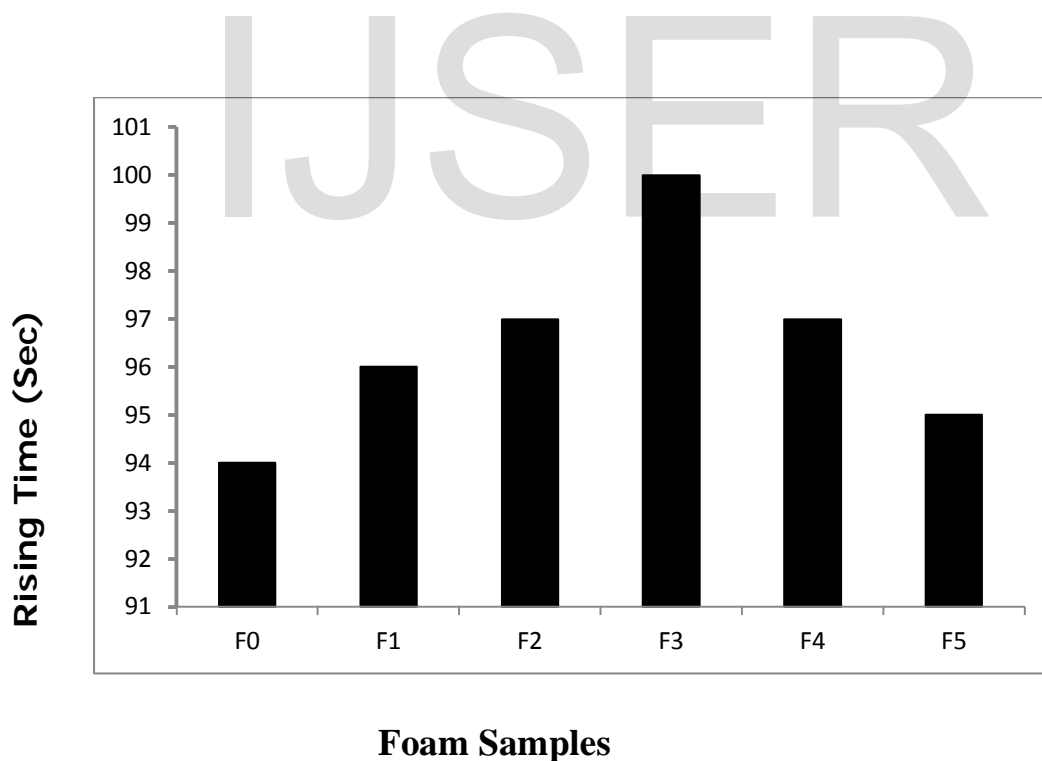


Fig. 2: Rising Time of Foam Samples:

The creaming time (Fig. 3) of the filled foams are higher than that of the unfilled foam except that of F_5 have the same value of 13secs with the filled foam. The difference is in the order $F_3 > F_4 > F_2 = F_1 > F_5 = F_0$. The cream time varies in the same direction with rising time even though with a lower value. Nevertheless, neither the creaming time nor the rising time varies in the direction with density; hence it is irrespective of the density.

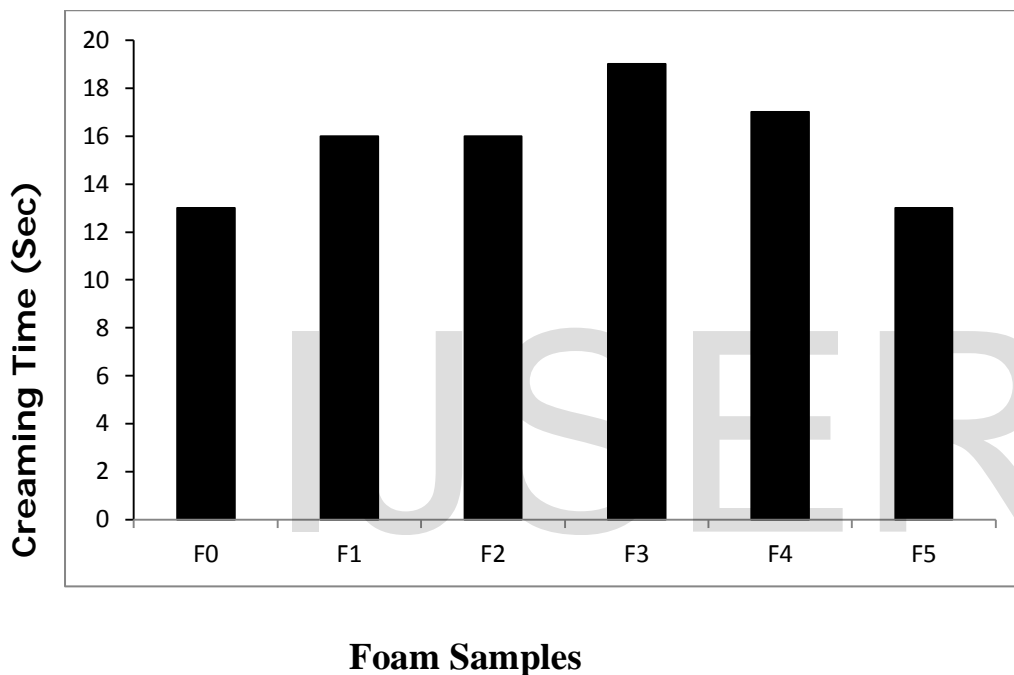


Fig. 3: Creaming Time of Foam Samples

The thermal conductivity (Fig. 4) is highest with F_5 (0.868kw/m.k) followed by F_0 with a value of 0.837kw/m.k. Others are F_1 , F_2 , F_3 and F_4 with values of 0.722kw/m.k, 0.664kw/m.k, 0.548kw/m.k and 0.477kw/m.k respectively. Meanwhile, F_5 conducts more heat than others due to the presence of calcium ions that can transfer heat while F_4 is the least due to lesser concentration of metallic conductors that transmit heat.

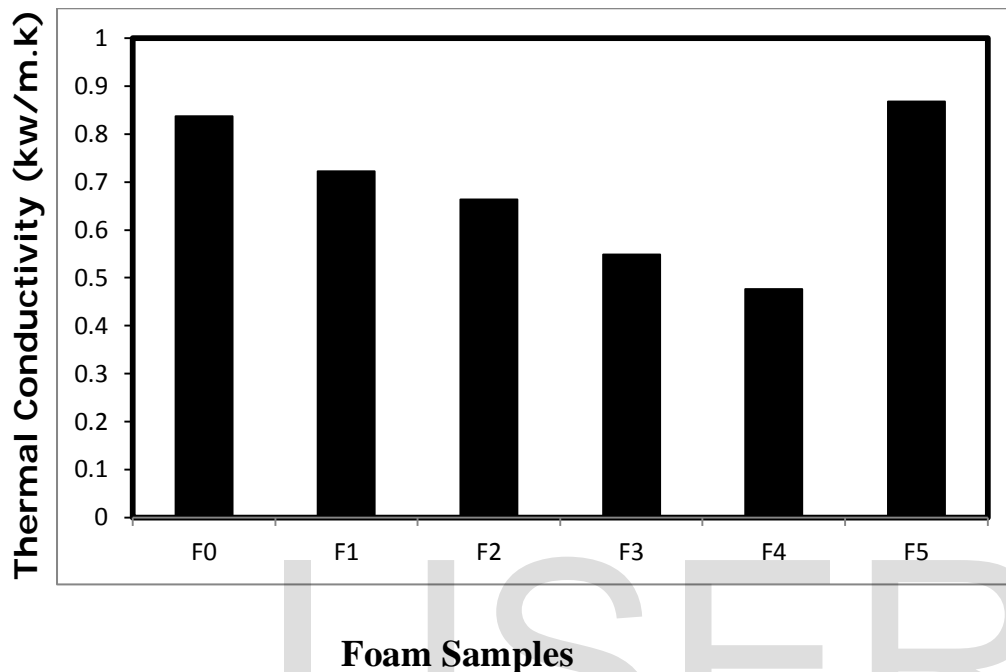
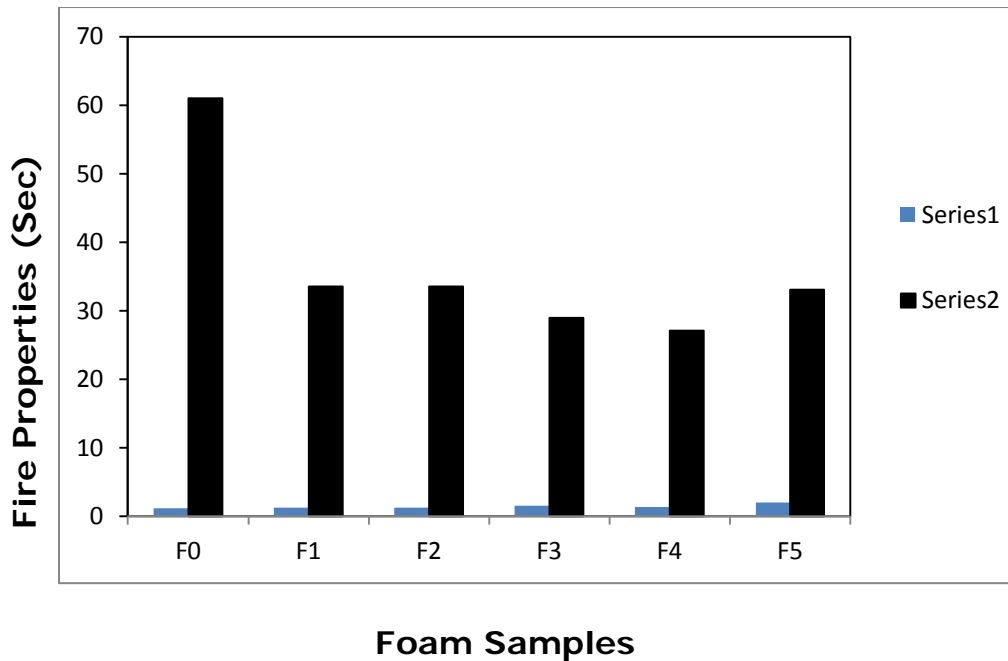


Fig. 4: Thermal Conductivity:

From Fig. 5 the ignition time are 1.20, 1.30, 1.30, 1.55, 1.40 and 2.00 for F_0 , F_1 , F_2 , F_3 , F_4 and F_5 respectively and the flame duration varies in order of 61, 33, 57, 33.57, 28.95, 27.10 and 33.11 for F_0 , F_1 , F_2 , F_3 , F_4 and F_5 respectively. This simply shows that fillers increase the ignition time of foam samples and reduce the flame duration. This is due to the fact that fillers serve as heat sink reducing the block internal temperature thereby making it harder for the foam to ignite and also for the flame to go off if it ignites. The char formation is also higher with filled foam due to the fillers constituting more residues after the ignition.



Series 1= Ignition Time

Series 2 = Flame Duration

Fig. 5: Fire Properties of Foam Sample:

Conclusion:

A number of conclusions are evident from the results of this analysis. All the fillers increase the density of the foam, the rising time and the creaming time. Barium sulphate compared better than other foams in density which is a major factor in foam properties. At 10% filler load, fillers reduce the ignition time and lengthen the flame duration. The higher the concentration of the metallic ion in a filler, the higher the tendency of the filler to conduct heat.

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