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Preparation and Characterization of Polyurethane Foam Based on Different Fillers

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Abstract: Polyurethane (PU or PUR) is a polymer composed of units of organic material connected with each other by urethane (carbamate) links. Most polyurethanes are thermosetting polymers not melting during heating, and thermoplastic polyurethanes are also available. In this article, the target is to find the best additive to add on polyurethane that has a high percentage due to the raw material, which is the polyurethane foam that is so expensive to save much money and have the best characteristics. The results obtained that the best additive is sand with particle size 600 micron. The addition of 8.48% of sand to the toluene diisocyanate and triethylenediamine made the polyurethane better in the compression resistance. It changed the 0% sand load from 0.94 kN to 1.359 kN.

Keywords: polyurethane foam, fillers, polymer.

基于不同填料的聚氨酯泡沫塑料的制备与表征

摘要：聚氨酯（聚氨酯或聚氨酯）是一种由有机材料单元通过聚氨酯（氨基甲酸酯）键相互连接而成的聚合物。大多数聚氨酯是在加热过程中不会熔化的热固性聚合物，也可以使用热塑性聚氨酯。本文的目标是寻找最佳添加剂添加到由于原材料而具有高比例的聚氨酯上，即价格昂贵、节省大量资金并具有最佳特性的聚氨酯泡沫。结果表明，最好的添加剂是粒径为600微米的沙子。在甲苯二异氰酸酯和三乙二胺中加入8.48%的砂，使聚氨酯的抗压性能更好。它将0%沙子载荷从 0.94千牛更改为 1.359千牛。

关键词：聚氨酯泡沫、填料、聚合物。

1. Problem Definition and Objective

Polyurethane is commonly formed by a reaction of polyols with triisocyanate or diisocyanate [16, 33]. Because polyurethanes have two different types of monomers, which polymerize one after the other, they are classified as copolymer alternatives [17, 34, 35]. Both polyols and triisocyanate are used in the production of polyurethane; in general, there are two or more groups per molecule. Polyurethane is used in the manufacturing process of high elasticity foam types, rigid foam insulation panels, microcellular foam seals, and tires [18-20, 52]. The objective of this paper is to review the literature of polyurethane foams and the additives, through sample preparation of polyurethane foam based on different additives, and to study the effect of the additives on polyurethane foam.

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2. Brief Background/Literature Review

Polyurethanes are only one component that can be cured with air moisture and as a result expands while being cured; for an aerosol form in installation, a semi rigid type is used, and insulation and grouting include a more flexible type [21-23, 36, 51]. Flexible types of polyurethane are used in window and door assemblies, heat and sound insulations, and applications of filling [24-26, 37]. Polyurethane reacts quickly with air moisture and expands after the application [27, 38, 39]. It also bonds well to the applied surface, because of its highly adhesive qualities [28, 40, 53].

2.1. How Are Polyurethanes Made?

Polyurethane foams are made from a mixture of two or more streams of liquid. The stream of polyols has surfactants, blowing agents, and catalysts. Two or more components are considered to be a system of polyurethane or a system [29-32]. The isocyanate is mainly assigned to the A side or what is called the iso in North America [1-5]. The mixture of polyols and the other additives are mainly called the B side or the poly [41]. The blend is generally referred to as the resin blend. However, the meanings of the A and B sides are reversed in Europe [42]. The mixture of resin additives includes cross-linkers, flame retardants, chain extenders, fillers, blowing agents, and pigments [43-45, 48-50]. Polyurethane foams can be produced in a wide range of hardnesses and densities through changes in the isocyanate percentages of the additives or even of the polyols [6-10, 46].

2.2. Polyurethane Properties and Characterizations

The properties of polyurethane foam are commercially selected for dressings that are listed in Table 1. Since it is difficult to confirm that the methods of testing are equivalent, the data that have been collected about polyurethane foams will only be used as a guide or index of values in general [11-15, 47].

Table 1 Polyurethane foam properties

Property	Medisponge® SuperSoft™ 60P Series Base Foam and Anti-Microbial Silver Foam	SAQ Standard	MCF03 foam	Product 1012
Thickness (mm)	1.25–6.0	1.5–15	1.5–25	1.5–5
Density (kg/m^3)	90–120	75	75	120
Free swell absorption capacity (g water/g)	Not available	>8	21	17
Retention under 40 mm Hg compression (g water/g)	>10	8	12	8.5
Volume expansion or swelling (%)	60–90	2	Not available	35
Tensile strength (kPa)	85–150	206	100	155
Elongation (%)	150–250	320	250	250

3. Methodology/Approach to the Problem

This research is based on quantitative research methods, involving a thorough review of the literature along with other previous works from different journals that discuss the characterization of polyurethane foam. Physical experiments were also conducted on the mixing of the additives and the polyurethane, these results were then tested using a compression machine, and the loads are recorded. The percentages for the additives in relation to the loads are shown on figures, with comparisons between the results, and the best additive is defined.

3.1. Experimental Work

We had eight samples for each of the additives: wood powder, sand, nano silica, calcium carbonate, and rice straw, so we took eight 250 ml beakers and added different amounts of additives to them. We then measured 20 ml of triethylenediamine and 20 ml of toluene diisocyanate to add to each beaker and stirred this well and very quickly with a spatula, to be able to merge the three components completely. After this, we left it for a few minutes to allow the foaming reaction to take place and let the temperature increase to about 60^{0}C. When the foam had filled the beaker, we removed the foam carefully to cut it into cubes of dimensions measuring 6 x 6. We then weighed it on the scale to be able to calculate the percentage of wood in the polyurethane, as shown in the graph that follows. The final step involved using the tensile machine to evaluate the stress-strain characteristics of the foam that was obtained.

Fig. 1 PU after the reaction takes place

Fig. 2 After removing it from the beaker

Fig. 3 After cutting with dimension 6 x 6

Fig. 4 In the tensile machine

4. Results and Discussion

4.1. The Wood Sample

From Fig. 5, we can observe that when we include 3.32% wood powder we get the maximum resistance of compression at load 1.095 kN.

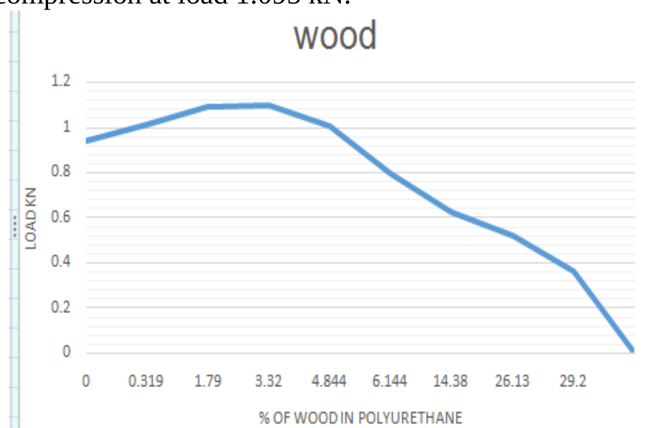

Fig. 5 Load vs. percentage of wood in polyurethane

4.2. For the Sand Sample

As shown in the graph, by adding 8.48% sand we reached the maximum resistance of compression at 1.359 kN.

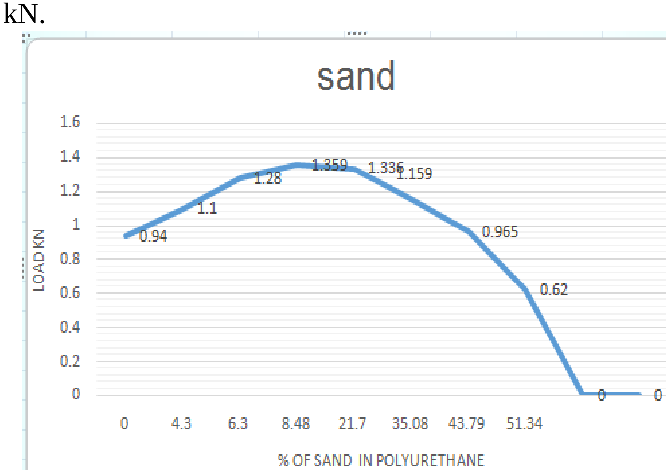

Fig. 6 Load vs. percentage of sand in polyurethane

4.3. For the Calcium Carbonate (Speedage)

As shown in Fig. 7, 1.862% calcium carbonate in polyurethane can be the optimum for resistance to compression with loads equaling 0.99 kN.

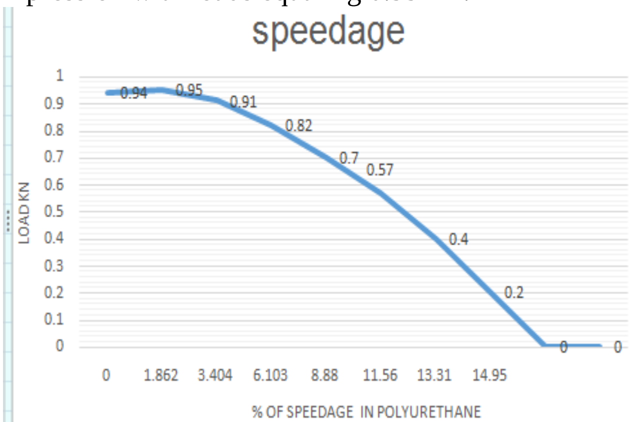

Fig. 7 Load vs. percentage of calcium carbonate in polyurethane

4.4. For Nano Silica

We observed that the addition of nano silica is a disadvantage because it does not enhance the resistance of compression.

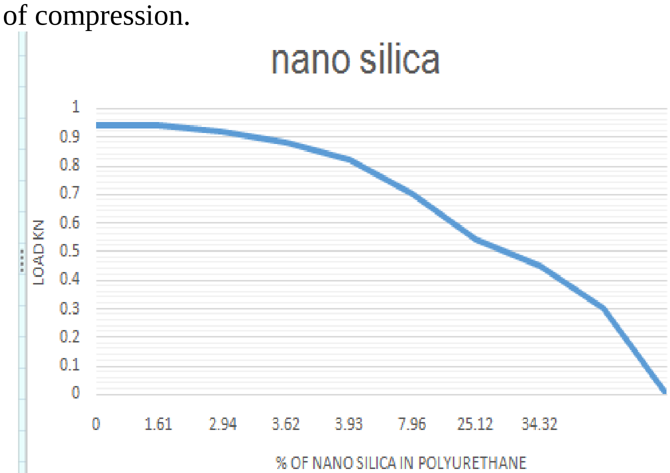

Fig. 8 Load vs. percentage of nano-silica in polyurethane

4.5. For the Powder Rice Straw Sample

As shown in the graph, using 4% sand we reached the maximum resistance of compression at 0.99 kN.

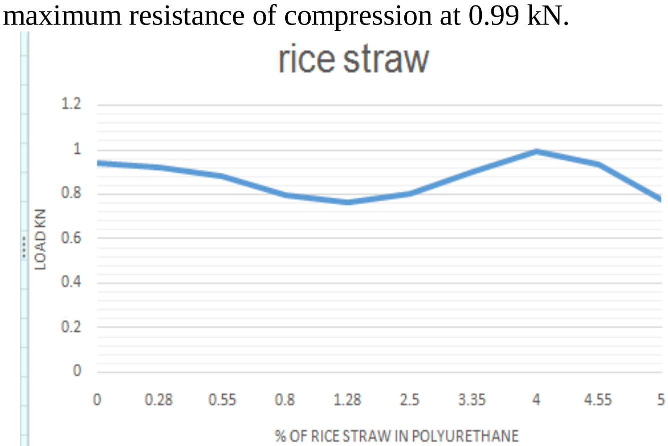

Fig. 9 Load vs. percentage of rice straw in polyurethane

5. Conclusion and Recommendations

Since the reference value is 0.94 kN, this value represents the empty sample with no additives. Why do we need an additive in the polyurethane? This is because polyurethane is very expensive, and Egypt imports it from outside the country. Therefore, the results of our experiment show the following: adding 3.32% wood powder increases the resistance to compression from 0.94 kN to 1.095 kN, adding 1.862% calcium carbonate (which contains no additive) enhances the resistance to compression from 0.94 kN to 0.95 kN, which is not a big change, and adding 8.48% sand that has a particle size after straining it in a standard sieve set that is 600 microns results in the resistance to compression changing from 0.94 kN to 1.359 kN. Therefore, our study found that the sand is the best additive because the large amounts of it that are added will decrease the price.

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