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Effect of Fillers on Mechanical, Thermal Proper and Combustion Resistance of Polyurethane Foam

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ABSTRACT
In this study, the mechanical and combustion properties of a polyurethane poly investigated as a function of the weight ratio of palm frond ash with a particle less than or equ 5 μm). Several variables were investigated, including elongation, tensile stre oung's modulus, compr ive strength, and rate of burning duration. The obtained results revealed that g palm frond ash reduces the spaces between the polymeric chains, which reflect the polymer's high abi o withstand the stress imposed on it, that the degree of homogeneity between each of the polymers and fi is high. Results sh ed that adding 60% palm frond ash powder to the hardness combination resulted mprovement o proximately (3.78 MPa). Moreover, the percentage 65% was recorded as the greatest the compr e strength of the polymer with the additive. Young's modulus also best value is (1.71 MPa)

Keywords: palm frond ash; polyurethane; ther ties; mechanical properties; fire retardant

INTRODUCTION
The reaction results in the production of polyuret insulation material, a compound made up of polyol a isocyanate. It is better to use polyurethane to insulate th walls of cold stores in order to lower the thickness of the thermal insulation because this material nectivity factor that is smaller than that . The standard acronym for polyurethan U), a used as insulation to provide durab and prot objects it covers from heat, col ear fro use. Products made of polyuretha ificant role in the industry, particul in the rmal and acoustic insulation, and t because d llular structure, it differs from y other polyme s and has a low heat uctivity compared t insulation materials the Inflexible PU foa s hardness rises with ity h better properties is produced. More ifically, e in density of (1000 g/cm3) suggests an inc hardness of approximate 0 Pa)[2].

Currently yurethane is widely used in several industri including nstruction, packaging, and furnit rema of the polyol chain, which is flexible, bonds, wh re rigid, make up polyurethane m carb , mica, and talc are examples of som fil aterials that are more used with hile fiber materials like id, and natu ers for carbon fiber are freque sed as reinforcement additives with polymers. Fillers d with polymers are divided into atural nic) and synthetic fillers. These majority ch are inorganic and either fibers es, are combined with polymers to both increase the s and lower their price [4–7].

The s are an excellent filler to combine with po matrix for reinforcement additives such as, date ree's fibers are utilized as sawdust or burned to keep cts away for space recovery [8–9]. In our earlier rch, we examined the impact of palm ash addition on chanical properties of high density polyethylene (H). To the best of our knowledge, no research has been done on modifying ash from palm frond fillers with yurethane polymers in order to decrease flammability 0]. Additionally, the effect of ash from palm fronds powder on the mechanical properties of low-density polyethylene (LDPE) was investigated. At a specific size of 75 m, several variables, including maximum stress, Young's modules, proportional limit, maximum strength, and elongation, were investigated [11].

The results of this investigation by Atiqah et al. [12] show that the composites' mechanical and thermal properties have improved. The ideal values for the composite formulation with a 40 weight percent sugar palm fiber loading were 17.22 MPa for tensile strength, 13.96 MPa for flexural strength, and 15.47 kJ/m2 for impact strength. The mechanical and thermal characteristics of polyurethane polymer composites with waste additives were examined in the current study (Ash of Palm Fronds). The goal of this study was to determine how fire retardants, mechanical qualities, and thermal properties affected the filler composition of ash from palm fronds.

MATERIALS, METHODS AND FILLERS
Polyurethane was used as the foundation material in this investigation. The two materials (polyol and isocyanate) are in the liquid state, and gas is released as a result of this reaction, carbon dioxide, which works to form cellular spaces within the mass of the mixture.

As a result of the mixing process, a so-called foamy liquid emulsion is formed that responds under the influence of the gas result. Polyurethane is prepared as an insulating material through the chemical reaction shown in Figure 1.

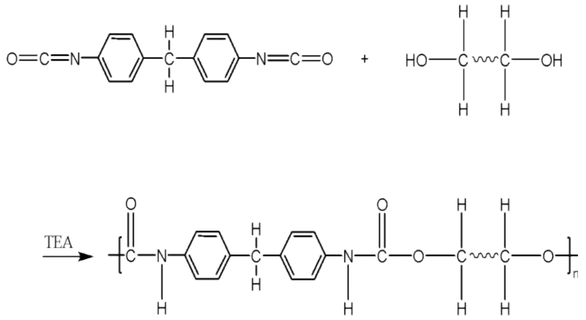
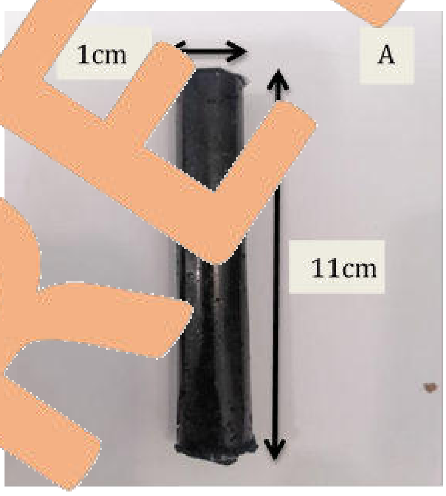


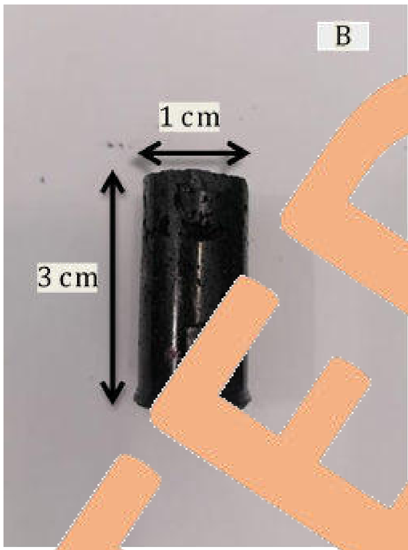
FIGURE 1: Chemical composition of polyurethane.

Since it falls under the category of natural fillers, Basrah-Iraqi palm frond ash has been employed; this substance has a hardness, strength, and a variety of components, proteins, and others, which are among the characteristics that set it apart from other fillers as polymer fillers. It was created by air-burning dried palm fronds completely. After passing through an Allen- Bradley Sonic Sifter Model L3P wire sieve to produce an ultrafine powder with fine-grained consistency and a particle size of at least 125 m, provided by ATM Corp. American, The palm fronds and their ash are seen in Figure 2.

FIGURE 2: A photograph sho[illegible]alm fro[illegible]sh.

By adding several weight ratio[illegible]55%, 6[illegible] and 75%) of palm fronds ash [illegible] mixture during the polymerizatio[illegible] procedu[illegible] samples of polyurethane and palm f[illegible] ash were [illegible]ntil the mixture was homoge[illegible], the mixing op[illegible]as maintained. The finis[illegible]roduct was then put in[illegible]b mold with a cylind[illegible]es[illegible] The measurements of the cylindrical form s[illegible]es [illegible]are 3 cm in length and 1 cm in diamet[illegible]e dimen[illegible]e cylindrical form samples for tensile and bending a[illegible] length and 1 cm in diame[illegible]see Figure 3).





FIG[illegible] B the cylindrical sa[illegible]es.

CHARA[illegible]ZATIO[illegible]

The samp[illegible] created for [illegible] are judged using the follo[illegible]ols:

F[illegible] a German-made (Tensile) equipment was used to [illegible]he models' tensile strength, bending resistance, and [illegible]ression resistance[illegible]The mechanical properties [illegible]rement instrume[illegible] shown in figure (4), and e[illegible](1) is used to [illegible]ute the tensile strength.

Q = F[illegible]

F is the cutting force (Newton), and A is the cross-sectional [illegible]

Th[illegible]lationship was used to compute the Young [illegible]lus using the stress-strain curves:

[illegible]oung's modulus) Y = (Max Stress/Max Strain) (Mpa).

[illegible]d:- the burning rate for each of the manufactured s[illegible]les was calculated using a combustion rate measurement instrument, Average Time of Burning ATB [illegible]1], in accordance with the industry standard method 81 ASTM D635. For each sample, the measurement was made three times, and the results were averaged. The time it took to burn the model to a distance of (75 mm) was calculated.

Third:- The FTIR (infrared thermal imaging) was recorded (as KBr discs) on a Japanese-made JASCO FTIR 4100 equipment with a wavenumber range of (400–4000)cm1. The straightforward method of infrared spectroscopy revealed details on the material's structure and chemical bonds.

RESULTS AND DISCUSSION

- **Average Time of Burning (ATB)**

Flame retardants have gained a lot of attention recently, particularly in the field of applied polymers, and may have the ability to shorten the burning period of flammable materials. The physical and chemical pathways make up the two primary parts of the fire retardant mechanism[13]. The current study examines the impact of palm frond ash fillers on the rate of polyurethane burning time. Figure (4) shows the relationship between the weight ratios of the filler content and the average burning time. Increased filler ratios resulted in a faster rate of polymer burning time, which was plainly seen at higher concentrations (approximately 289 seconds for %75).

From a physical standpoint, the ash layer that has formed on the polymer's surface functions as an insulating layer on the surface, stopping the spread of flame inside the polymeric matrix. Unlike non-additives(0%),

polymer burned at 60 seconds. The percentage change in burning time was calculated by dividing the difference between the percentage's values for the impure and pure states by the percentage's value for the pure state, as shown in Figure 5, The burning time percentage is equal to A-B / B *100%.

A: The fillers' weight in relation to the polymer's, B: The polymer's weight ratio in its purest form. Where we notice from the figure below that this behavior of polymer is attributed to the low decomposition of palm fronds ash at High ratios confined between (50%-75%) and thus reduce the process of heat spread within the polymeric matrix by reducing the total volume of the combustible polymer, a process known as thermal insulation between the burned parts and the unburned parts and thus prevents the spread of flame within the polymer chains, Especially when the weight ratio(75%).

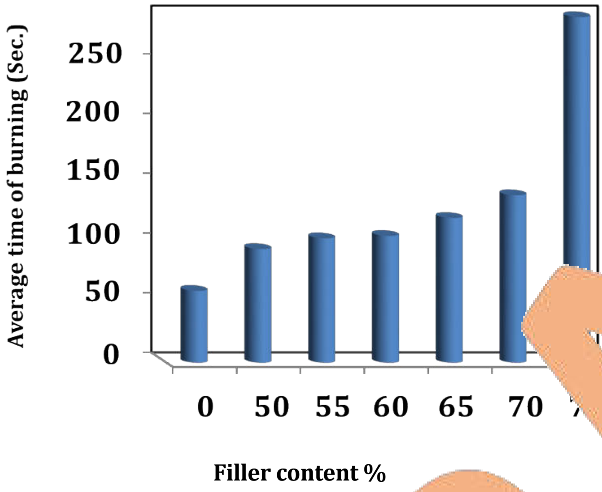


FIGURE 4: Relationship between t[illegible]e of burning with the concentration of pa[illegible]nd ash a[illegible]ve to the polyurethane polymer.

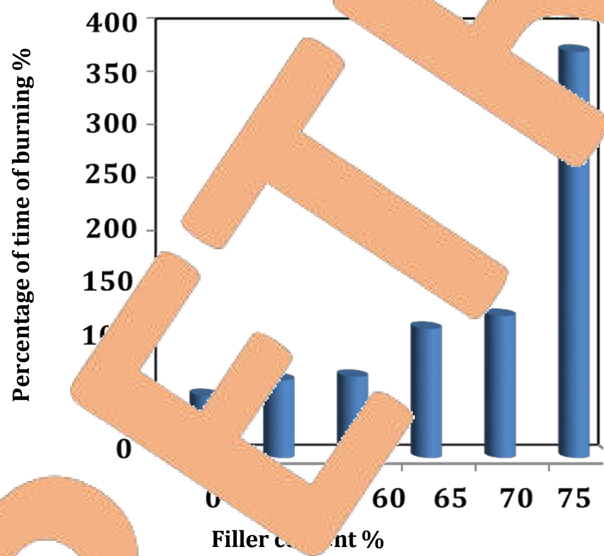


FIGURE [illegible]ip between the percentage of [illegible]nin[illegible]entration of the additive palm [illegible]or a polyurethane polymer.

- **Mechanical properties**

Figure 6, depicts the relationship between bending resistance and additive percentage. The pure [illegible] exhibits bending resistance of (12.6 Mpa), m[illegible] is more elastic than the other samples but l[illegible]. Lower flexibility and higher hardness are cau[illegible]y the rigid filler, which restricts the mobility [illegible] the polymer chains[14]. This discovery is readily ap[illegible] ratio%60, when there is high compatibility between [illegible] of the filler and the polymer. Nonethele[illegible] the addi[illegible]es dispersed uniformly as the [illegible]entage of a[illegible] increased.

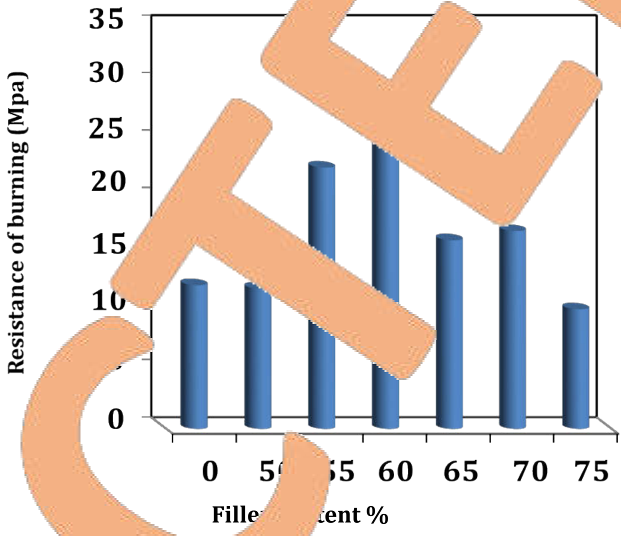


FIGURE [illegible]etween the bending resistance and the filler co[illegible]

[illegible] the effect of ash of palm frond powder affec[illegible] coefficient, which is a measure of a mat[illegible] capa[illegible]y to withstand compressive pressures act[illegible] perpendicularly on solid materials. While the [illegible]essive modulus at 65% is at its highest value (10.7 [illegible]), the compressive modulus at 0% is noticeably low, [illegible]o (4.5 Mpa). It has led to the realization that the a[illegible] through a homogeneous interphase with the poly[illegible]eric chains, imposes on the polymer's hardness. [illegible]ever, the behavior of the polymer begins to decline at [illegible] percentages of the additive, especially at the percentage 75%, where the compressive strength was recorded by (6.8 Mpa). It may attribute to excesses bubbles formation which make walls easier to collapse.

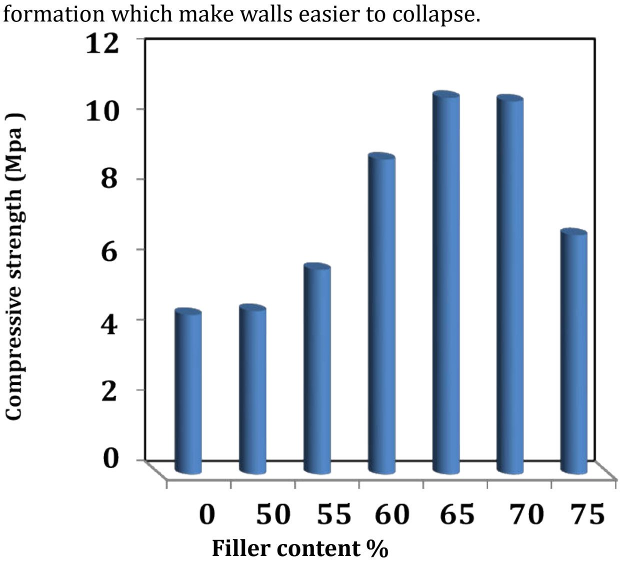


FIGURE 7: The relation between the compressive strength and the filler content.

The relationship between the tensile force (stress force) and the proportion of the polymeric additives is depicted in Figure 8. At lower filler content levels as low as ratio (50%), there was a modest reduction in tensile strength, however at higher filler content levels from ratio (60%), the maximum strength is comparable to that of pure polymer. This is because the additive powder is distributed uniformly throughout the polymeric chains. However, the maximum strength rapidly decreases with greater percentages. The ratio (60%) of the powder additive was best for the mixture's hardness, which is estimated to be (3.78 MPa).

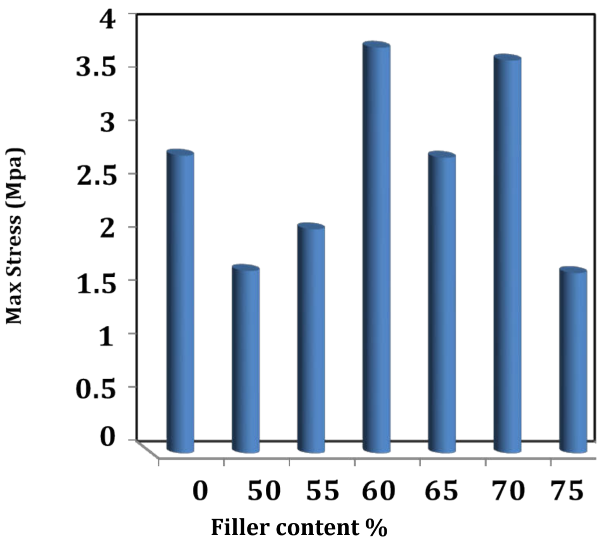
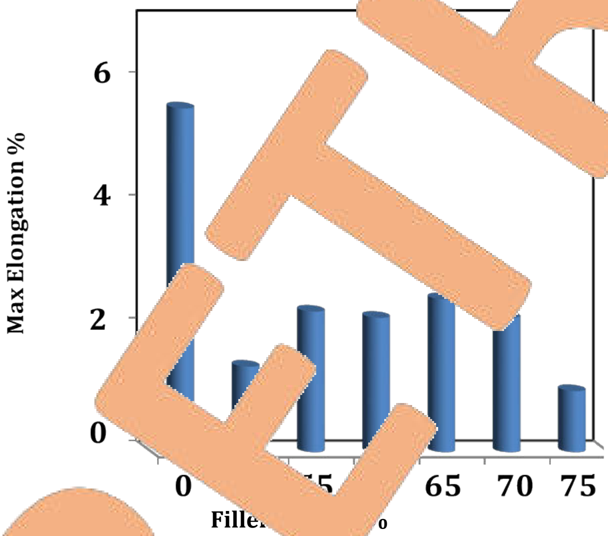


FIGURE 8: The relation between tensile strength and t[illegible] filler content.

Figure 9, shows the polymer elongation model w[illegible] concentration. With rising ash percentages, the effect o[illegible] filler addition on the polymer's elongation % became less pronounced. The elongation reduced as the polymer filler concentration rose because the particles fill[illegible] the gaps between the polymeric chains, preventin[illegible]ting the mobility of those chains. The ratio ([illegible]he polymer's elasticity, while the lowest v[illegible] of elong[illegible] is (1 MPa) at the ratio (75%).



[illegible]URE 9: [illegible] relation between elongation and the filler [illegible]ntent.

[illegible]ustrates how palm frond ash powder affects the [illegible]dulus, which is the ratio of stress to strain for solids [illegible]is defined as the elasticity modulus. In general, ad[illegible] filler had a beneficial effect on the elasticity modu[illegible]

Elasticity would be decreased while homogeneity would be increased since the powder increases the polymer's hardness, and perhaps the decrease in the Young m[illegible] is explained by the ratio between (65%) for the [illegible] the heterogeneity of the mixture, despite the [illegible]at the samples were mixed in the same conditions [illegible]indicates that the polymer has high elasticity, that [illegible]e polymer chains are not restricted to a certain rati[illegible] stiffness is low at this ratio, that is, it is free to m[illegible]hese results are consistent with many other pieces [illegible] in this field.

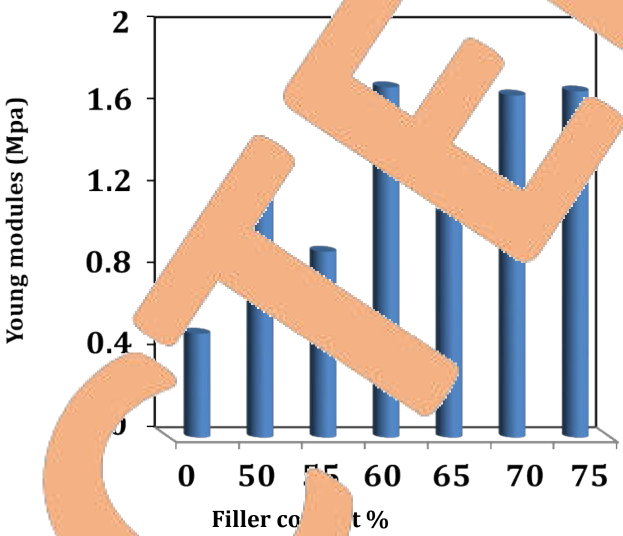


FIGURE [illegible]latio[illegible]een Young's modulus and the filler co[illegible]

[illegible]LUSIONS

[illegible] adding ash powder to polyurethane has a sign[illegible]on the mechanical properties. The ratio ([illegible]) of [illegible] powder additive was best for the [illegible]ixt[illegible] hardness, which is estimated to be (3.78 MPa), [illegible]e ratio (0%) is best for the polymer's elasticity. [illegible]onally, the greatest value of Young's modulus (1.71 M[illegible]as recorded at the ratio (60%). We draw the con[illegible] from this study that the average burning time of a p[illegible]ner containing an additive behaves in a manner [illegible]istent with an increase in the percentage of the [illegible]ve, which ranges from 50 to 75%, as it recorded the [illegible]hest value of the average burning time (289 Sec.) at the percentage (75%).

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