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THE MECHANICAL BEHAVIOR OF POLYMER COMPOSITES REINFORCED BY NATURAL MATERIALS

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Abstract: Abstract the waste natural such as groundnut shell, rice husk, eggshell, pistachio shells, etc., are regionally available. All these waste natural has good mechanical characteristics and can be employed more efficiently in the improvement of composite materials for different uses. This paper shows the study of the impact test, tensile test and flexural test properties of the pistachio shell powder strengthened epoxy resin. Pistachio shell powder with different weight fraction (5%, 7%, and 9%) strengthened epoxy resin has been developed by hand lay-up method. The tensile test, flexural test and impact strength displays the sample (epoxy+7% wt. pistachio shells) has the highest comparison with other samples. The principal results extracted from this work that the Samples with (9%) weight fraction of the pistachio shell content in epoxy resin decreases the modulus of elasticity, flexural strength, tensile strength, impact strength and flexural modulus, while at (5% and 7%) weight fraction of the pistachio shell content in epoxy resin raise the modulus of elasticity, tensile strength, flexural modulus, flexural strength and impact strength increased.

Keywords: *Epoxy, Pistachio shells, Tensile test, Flexural **and** Impact test.*

1. Introduction

At present, the use of solid waste natural material from industrial and agricultural waste has become widespread due to the low cost of manufacturing, environmentally friendly and abundant materials, therefore the peanut, coconut, palm, rice husk are generally utilized as fillers in polymer composites with the aim of enhance mechanical and physical properties [1]. The physical and mechanical characteristics of the composite material filled with different materials depending on several factors, including the mean particle size of the filler material, the bond between the polymer and the fillers, length of the fiber, the directivity of the fibers and other factors [2]. Epoxy resin is a type of thermoset polymer used in many applications such as aircraft structures, ship structures, aerospace vehicles and automotive structures because of its many properties including corrosion resistance, thermal, electrical insulators, low shrinkage during processing and ease of operation. In spite of these properties, but it possesses many disadvantages such as lower resistance of water, moisture, a little flexible and hard [3]. R. Pragathees and S. Senthil [4] investigated both tensile and flexural for the vinyl ester resin

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filled with (20%, 25%, 30% and 35% vol %) groundnut shell powder and (0%, 5%, 10%, 15% vol %) calcium carbonate. The results showed the tensile and flexural properties are improved with the addition of calcium carbonate compared to groundnut shell powder. S. Yeshwant et.al., [5] study the tensile, impact and flexural characteristics for the epoxy resin filled with (15% weight fraction) and (0%, 1%, 2% and 3% weight fraction). Events exhibit that the adding of pistachio shell flakes decreased the tensile characteristics while flexural and impact properties improved. M. Alsaadi et.al. [6] Investigated the effect of different weight fraction (0%, 5%, 10%, 15%, 20%, and 25%) of pistachio shell reinforced with polyester resin on the flexural, tensile and Charpy impact tests. Results show that the specimen (polyester + 5% and 10% wt. pistachio shell) has the highest value of flexural, tensile and Charpy impact. R. Haitham and R. Alaa [7] have studied the effect (4%, 8%, 12% ad 16% wt.) eggshell filled with epoxy resin matrix on the tensile strength and hardness tests. The specimen (epoxy +16% wt. eggshell) has maximum values for the tensile strength and hardness shore D.The goal in this research is to improve mechanical properties of composite material.

2. Materials

2.1 Pistachio Shell

Pistachio shells were obtained from attar made in (Iraq). Unsalted pistachio shells were used in order to avoid hassles of washing. To remove any impurities from the outer surface of a pistachio shell, wash with distilled water and dry in air for 24 hours. Grinding the pistachio shell using an electric mill for 2 hours, after which the powder is sieved using an electric sieved to obtain agrain size of smaller than 50 µm. Figure 1 exhibits the shape of a pistachio shell before and after milling. The chemical composition of pistachio shell powder is shown in Table 1 after (X-ray Fluorescence) using reagents Compton secondary molybdenumrand Barkla scatters HOPG.

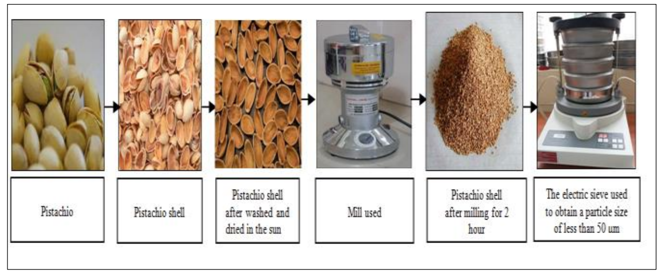

Figure 1. Pistachio shell before and after milling

Table 1: Chemical composition of pistachio shell powder

Chemical composition	Wt %
Cellulose	42
Lignin	13.5
cellulose lignin	3.11
Na_2O	0.06
MgO	0.01
Cl	0.03
K_2O	0.08
CaO	0.07
Fe_2O_3	1
Na	0.04
Cl	0.02
K	0.06
Ca	0.05
Fe	0.8

2.2 Epoxy Resin

The following primary raw materials were utilized in this study work; Epoxy resin (EUXIT 50 KI) made in (Egypt Arabic) produced by (Al-Rakaez Building Materials in Amman). Table 2 exhibits the qualities of epoxy used in the study by the company specifications.

Table 2: Qualities of epoxy resin

You ng Mod	Ben ding Prop	Visc osity (pois	Applic ation Temper	Volu me Shrin	Linea r Shrin	Dens ity (gm/

ulus (GPa)	erty (N/ mm^2)	e)	ature (C^0)	kage (%)	kage (%)	cm^3)
163. 3	45	1.0	5	3.5	0.3	1.05

3. Preparation of Composites

A mold with the dimension (170 mm length 170 mm width and 5 mm thick were utilized to make the all specimens composite. A sheet of wax was used to the mold so that the specimen can be simply remove from the mold. Determined amounts of pistachio shell particles (5%, 7% and 9% weight fraction) and epoxy resin were taken in a plastic container and mixed carefully to get a homogeneous mixture. After addition the right amount of hardener, the mixture was again stirred for 10 minutes and the carefully mixed mixture was put in the mold and compressed homogeneously. Removed samples from the mold after 24 hours and put samples in the oven at 55 for 3 hours in order to remove any stresses and complete bonding between resin and filler [8 and 9]. Details composition of sample composites is presented in Table 3.

Table 3: Details composition of sample composites

Samples	Composition
Sample 1	100% Epoxy resin
Sample 2	Epoxy + 5% Pistachio shell
Sample 3	Epoxy + 7% Pistachio shell
Sample 4	Epoxy + 9% Pistachio shell

4. Mechanical Tests

4.1 Tensile Test

The tensile tests were conducted according to ASTM D638-03 as presented in Figure (2) [10, 11].

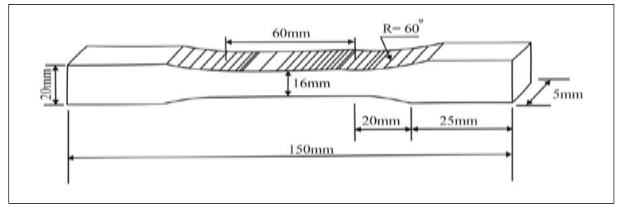

Figure 2. Tensile test standard

4.2 Flexural Test

Figure (3) demonstrates the standard dimension of sample according to ASTM D 790- 86 [12].

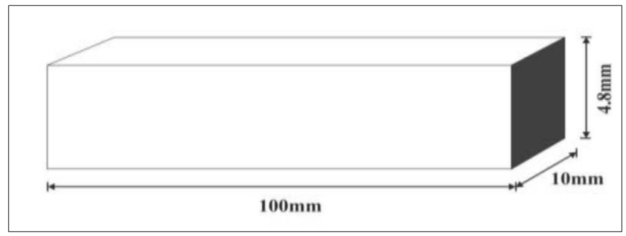

Figure 3. Flexural test standard

4.3 Impact Test

Figure (4) demonstrates the standard dimension of samples according to (ISO-180) [13].

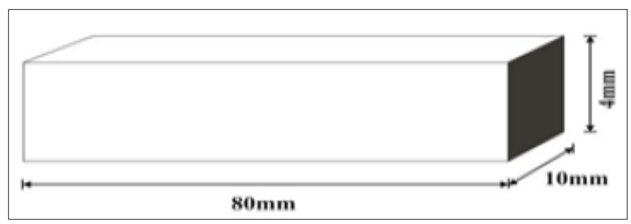

Figure 4: Impact test standard

5. Results

5.1 Tensile Test

Figure (5) shows that the tensile strength of samples epoxy/ pistachio shell increases with an added 5% and 7% weight fraction and begins to decline when adding 9% weight fraction pistachio shell. The improvement in tensile strength values

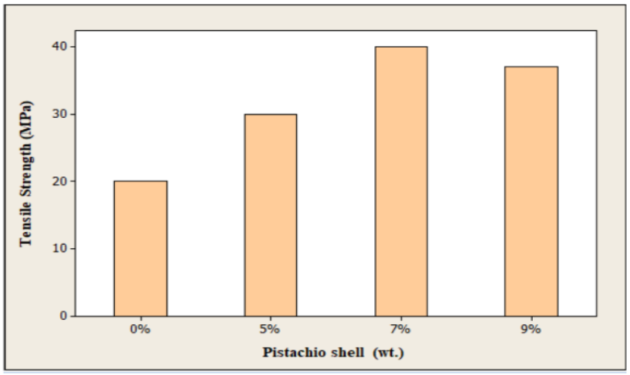

Figure 5: tensile strength of samples

at (5% and 7% weight fraction pistachio shell) is due to the tensile properties perhaps depend on many factors such as the filler content rather than particle-matrix interface and stiffness of the reinforcing particles and distribution of particles homogeneously

Within the resin thus these factors tensile properties enhanced [14 and 15]. The tensile strength decreased from (40 MPa to 37 Mpa) with addition 9% weight fraction pistachio shell to the epoxy resin, this observation may be due to poor bonding between resin with filler which promoted micro-cracks at the interfaces during the sample composites loading [16].

Figure 6 refers to the relation between modulus of elasticity and weight fraction of pistachio shells into epoxy resin. It can be seen that the properties of the elasticity modulus improve with increasing weight fraction of (5% and 7% weight fraction pistachio shell) into epoxy resin, but decreased by the addition (9% weight fraction pistachio shell) into epoxy resin. This advance in the properties modulus of elasticity depends on to the nature of pistachio shell in terms of high strength. Thus modulus of elasticity values increased from (2.3 GPa) for epoxy resin to (12.1 GPa) for (epoxy + 7% pistachio shell). The elasticity modulus values improvement about (4.2%) compared with the pure sample this is due to the mean particle size, distributed regularly of pistachio shell inside the epoxy resin and easiness the penetration of polymer matrix material this leads to make a good interfaces between reinforcing material and the matrix material [17]. The modulus of elasticity decreased from (12.1 GPa to 10.2 GPa) with addition 9% weight fraction pistachio shell to the epoxy resin, this is due to the decrease in the deformation (δ) by increasing the surface contact area between the reinforcement and matrix [16].

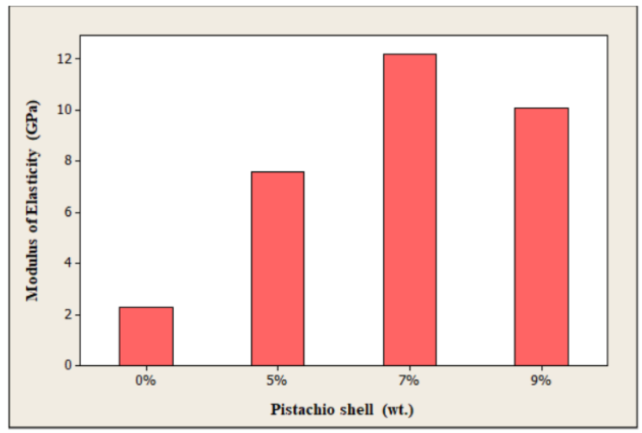

Figure 6: modulus of elasticity of samples.

5.2 Flexural Test

The flexural strength of epoxy /pistachio shells of different filler weight fraction is shown in Figures 7. The neat epoxy display flexural strength of 160 MPa and increased slightly on the adding of pistachio shells through 168 % equal to 7wt.% pistachio shells, but decreased to 166% with addition 9% pistachio shells as shown in Figure 7. The reason that can be attributed to the increased flexural strength is that the addition of (7% wt. pistachio shells) gives a positive modified for the adhesive qualities of the composite by enhancing the mechanical interlocking between filler and epoxy and thus enhancing the stress transfer through an applied load [19]. The reason for the decreased flexural strength with the addition 9%wt. pistachio shells occur there is deterioration in structural integrity due to the presence of agglomeration and the voids of pistachio shells in the matrix were found to be a primary cause of the decreases in flexural these results agree with [20].

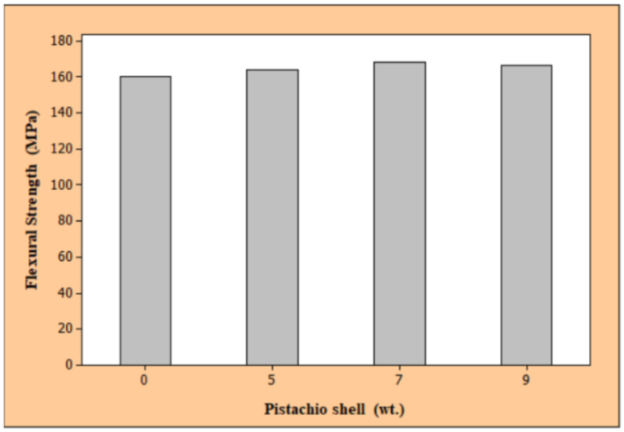

Figure 7: flexural strength of samples

The flexural modulus of epoxy /pistachio shells of different filler weight fraction is shown in Figures 8. The neat epoxy display flexural modulus of 2 GPa and increased slightly on the additng of pistachio shells by 8.5 GPa % up to 7wt.% pistachio shells, but decreased to 7.2 GPa with addition 9% pistachio shells as shown in Figure 8. The rigidity of the epoxy resin joint with [20] its content may be connected to improved flexural modulus of composites. The filler might obstruct the free flow of the polymer chain and so limit the capability of the polymer to deform. This could be linked to the enhanced interfacial bonding between the matrix and filler, where the stiffness depends on the nature of the filler content, filler , and the homogeneity of the filler dispersion. These notes, who decided that good filler dispersion in the composite structure could be confirmed by observing the slightly improve in the modulus of the composite [21]. The adding of pistachio shells by 9% wt. leads to the weakness of the flexural modulus properties. This is due to the conglomeration of the material and the lack of homogeneity filler with the resin polymer and reduces the stiffness of the samples.

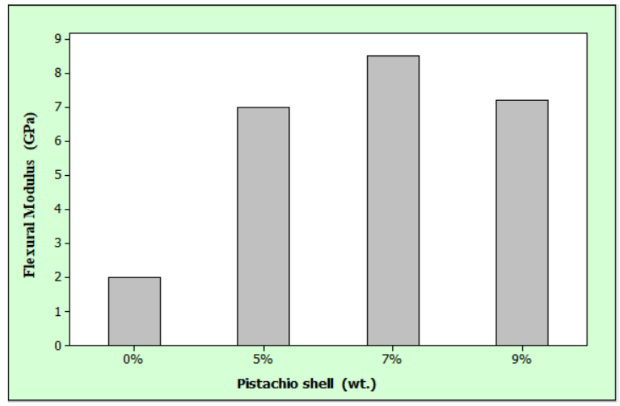

Figure 8: flexural modulus of samples

5.3 Impact Strength

The impact strength results of the epoxy/ pistachio shell samples are shown in Figure 9. Graphical presentation a steady increase in impact strength with added in pistachio shells content, indicating 6.2 KJ/m^2 with 7 wt % of filler addition, such behavior indicates improved filler matrix (epoxy) adherence and was due to fewer void spaces in polymeric composites, this probably attribute to the reality that the filler particles will cellulose absorb more stress energy as its content raise in the matrix resin [22 and 23]. Also from this graph shows the impactstrength decrease with added (9% wt.) pistachio shells due to the matrix resin is maybe not enough to transfer the stress effectively throughout a sudden impact in combination with the smalller absorption property of the filler. It has been detected that high filler content increases the chances of fiber agglomeration, which results in regions of stress concentration needing less energy for crack propagation [24].

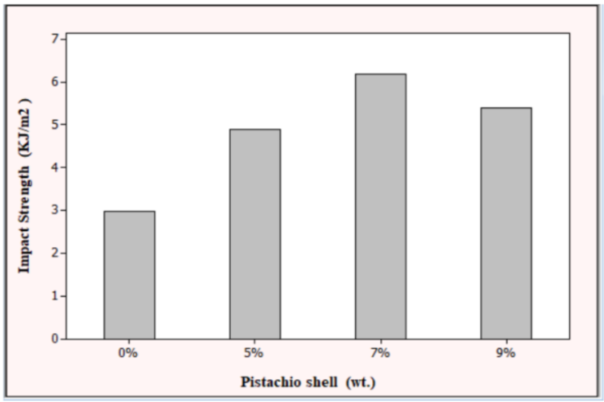

Figure 9: impact strength of samples

6. Conclusions

The principal results extracted from this work were waste natural material was successfully fabricated from pistachio shell filled with epoxy

Resin. Samples with (9%) weight fraction of the pistachio shell content in

Epoxy resin decreases the modulus of elasticity, flexural strength, tensile strength, impact strength and flexural modulus due to weak interfacial bonding between the epoxy resin matrices and reinforced, while at (5% and 7%) weight fraction of the pistachio shell content in epoxy resin raise the modulus of elasticity, tensile strength , flexural modulus, flexural strength and impact strength increased.

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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