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Effect of Pistachio Husk Waste Powder Additive of Epoxy Composites

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Abstract. Polymer composites are among the most insulating, but they have good mechanical flexibility. The main idea of modifying these materials is to be one of the application materials in environmental aspects. In this study, polymeric composites material were prepared from epoxy resin (EP) as a matrix and Ashuri pistachio husks powder from northern Iraq (hw*)* with the average diameter (200 µm) as fillers with different weight percentage (0.5%, 1%, 1.5%, 2% and 2.5%) to resin. Glass transition temperature (Tg), shore a hardness and thermal conductivity (K) testing were investigated. The results show the maximum (Tg) of (EP/ hw) composites were the value (88 °C) at (2.5% hw). Increase shore a hardness with pistachio husk powder concentration increase and it has maximum values of (78.5) for (2.5% hw). (K) decreases with pistachio husk powder concentration increase and it has a minimal value of (0.1673) for (2.5% hw). This compound can be used to paint wooden furniture.

Keywords: epoxy, hardness, composites, thermal conductivity, Tg

Introduction

Pistachio husks are produced in large quantities. Tons of pistachio husks are either burned after harvest or left in the field every year. Particular attention has not been paid to using agricultural residue as raw materials in polymer composite industries. Therefore, the usage of pistachio husks as filler in polymer composites is very important from an economical and environmental view point. Uses of pistachio shells include a medium for orchids, animal feed, fire starter, additives for wood items, etc. Fabrication of polymer composites with this filler is suitable for many engineering applications (Alsaadi *et al*., 2018; Maghsoudi *et al*., 2010).

Interest in composite materials has increased in recent years as an engineering material due to their unique properties. This interest has been prominently embodied in the field of construction uses that require: lightweight and high resistance (Jaafar and Fadhil, 2017). A composite material is a substance consisting of two or more materials, insoluble in one another, which are combined to form a useful engineering material possessing certain properties not possessed by the constituents (Callister, 2006). A polymer composite has taken great attention among researchers both thermoplastic and thermo-setting. Epoxy resins are rigid and brittle in nature; it has chemical resistance and high mechanical strength (Mahdi *et al.*, 2020; Shawky *et al*., 2011). The light weight of polymers, as well as their resistance to rust, makes them suitable for work in many industries and to Strengthen the polymer, which may be little expensive, low-cost fillers are used that are added to the polymer to manufacture composites with commercial uses (Fadhil *et al.*, 2019). Epoxy resin is one of the most important polymers widely used in industries due to its properties that it has such as high thermal stability and resistance to chemicals as well as its low shrinkage (Jasim *et al.*, 2019). Many researchers have used epoxy as a basis in the manufacture of composites and different fillers are added to it according to the purpose for which the composite is made. In 2016, Jassim reported the used white eggshells powder as filler and found there is an effect of the filler in improving the increases the impact strength and high resistance to water. In 2017, the researcher Jaafar and Fadhil used aluminum powder as filler; they found that there is an effect of the filler in improving the mechanical properties of epoxy resin. In 2017, the researcher Jasim and others used copper powder as a filler, they found that there is an effect of the filler in modifying the thermal conductivity of epoxy resin (Jasim and Fadhil, 2018). In 2019 he also used copper powder as filler; they found that there is an effect of the filler in improving the (Tg) and Shore D hardness for epoxy resin (Jasim *et al.*, 2019). The aim of the work was to modulate the glass transition temperature, hardness and thermal

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conductivity. This compound can be used to paint wooden furniture.

Material and Methods

Epoxy resin (G-5533) is used as matrix material, it was supplied by Iraq Modern Paint Industries Company and it is converted to the solid state by adding hardener at a ratio of (3:1), it is a coating used as a middle layer on concrete surfaces, sections and metal equipment and it has a high resistance to air, water and mechanical influences. The physical and chemical properties of epoxy resin shown in Table 1.

Reinforcement materials. Ashuri pistachio husks powder from northern Iraq (hw) is used as reinforcement material. Table 2 shows some basic properties of (hw).

The hand lay-up molding process (Jaafer and Muslem, 2012; Jaafer *et al.*, 2008) was used to prepare six specimens of (EP/hw) composites (Jobayr *et al.*, 2018). At first, we prepare epoxy resin mixed with hardener (3:1) ratio. Then different weight ratios were added from Pistachio husks powder (hw) (0, 0.5, 1, 1.5, 2, 2.5). To get good homogeneity between EP resin and Pistachio husks powder. The different ratios of (EP/ hw) shows in Table 3 and Fig. 1 is a photograph of the samples.

Test devices. *Thermal conductivity* (*K*). Lee's disc technique is used to calculate the thermal conductivity of the samples (Jasim and Fadhil, 2018).

Hardness test. It is the degree of surface resistance to an indentation or scratching abrasion and wear (Jasim *et al.*, 2019) used Shore A hardness (HT-6510A) to measure the hardness of the samples.

Differential scanning calorimetry DSC. (DSC131 EVO) is one of the most popular methods that can be used to measure the glass transition temperature (Tg) for samples as a function of temperature (Jasim *et al.*, 2019).

Results and Discussion

Thermal conductivity (K). Figure 2 shows the obtained results of (K) for EP/hw composites. (K) values for decrease with increasing filler weight percentage. The minimum value (0.1673 W/m.K) at (2.5%) hw, is shown in Table 4. In polymeric materials (Mahdi *et al.*, 2017) and heat is transferred as an elastic wave (Anjama *et al.*, 2021; Jassim *et al.*, 2017). The wave loses part of its energy at the interface region between the matrix and the reinforcement materials (Mahdi *et al.*, 2020; Mohammad *et al.*, 2017). The decrease in (K) is due to the fact that the Pistachio husks powder good heat insulator. Adding a certain percentage of pistachio powder to the epoxy resulted in a decrease in thermal conductivity compared to the epoxy value pure. This is due to the spread of pistachio powder randomly in epoxy according to the manufacturing process. This powder plays an important role in the process (K).

Table 1. The physical and chemical properties of (Ep)

Properties	Ep
Physical state	Dense liquid
Colour	Gray
Density	(1.4-1.5) Kg/L
Odour	Pungent
Spreading rate	(3-4) m^2/L
Solid by volume	62±2%
Gloss level	matt (0-35)
Flash point	26 °C

Table 2. Basic properties of (hw)

Properties	Pistachio husk powder (hw)
Form	Powder
Colour	Light yellow
Purity	99.9%
Average diameter	(200 µm)

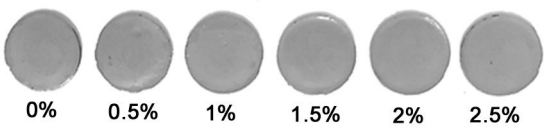

Fig. 1. A photograph of the samples for EP/hw composites.

Table 3. The different ratios of (EP/ hw) composites

EP%	hw%
100	0
99.5	0.5
99	1
98.5	1.5
98	2
97.5	2.5

Hardness tests. Figure 3, shows the obtained results of shore a hardness for EP/hw composites. Hardness values increase with increasing filler weight percentage. The maximum value (78.5) at (2.5%) hw, is shown in Table 5. The increase in the hardness values with the increase in the weight percentage of the pistachio husks powder in the epoxy resin matrix is due to the distribution of the powder between the chains of the epoxy resin.

Table 4. Thermal conductivity for Ep/hw composites

hw%	K (W/m.K)
0	0.8584
0.5	0.8499
1	0.3022
1.5	0.1703
2	0.1700
2.5	0.1673

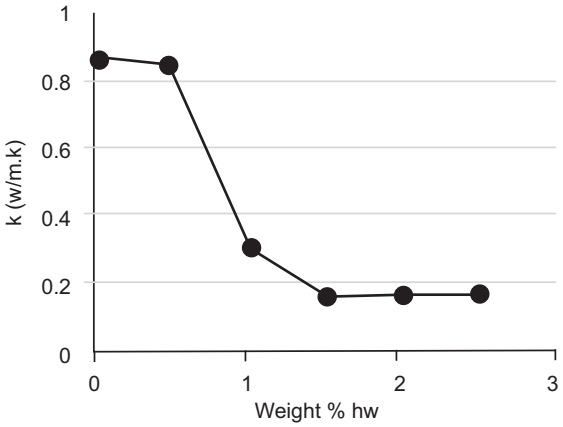

Fig. 2. Thermal conductivity vs hw weight percentage for Ep/hw composites.

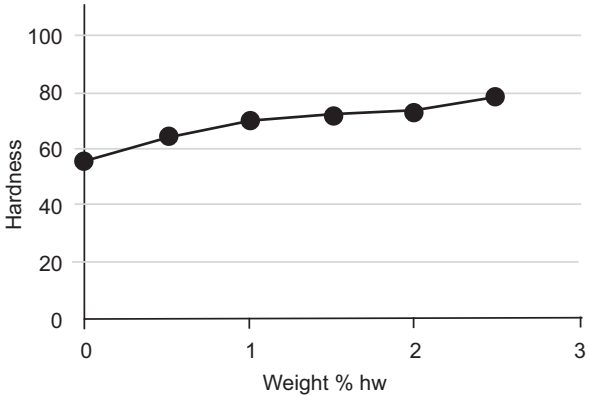

Fig. 3. Shore A hardness of polymer composites as function of pistachio husks powder.

So, that the indenter of the machine will touch the surface of the pistachio husks powder at the surface and the hardness values will increase (Jasim and Al-Sarraf, 2019; Zaidan and Mohammed, 2017). This test gave us a good picture of the strength of the material and the overall cohesion of the material. Thus, we can say that we have obtained a compound that bears more environmental factors than pure epoxy (Jasim and Al-Sarraf, 2020).

Glass-transition temperature. Figure 4 shows the obtained results of glass-transition Temperature (Tg) for EP/hw composites. Tg values increase with increasing filler weight percentage. The maximum value (88 °C) at (2.5%) hw, as shown in Table 6.

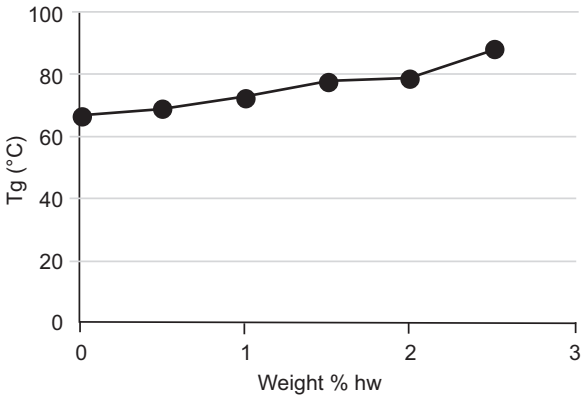

Fig. 4. Tg vs. hw weight percentage for Ep/hw composites.

Table 5. Shore A hardness for Ep/hw composites

hw%	Shore A hardness
0	55.7
0.5	64.7
1	70.3
1.5	72
2	73.3
2.5	78.5

Table 6. Glass-transition temperature for Ep/hw composites

hw%	Tg (°C)
0	67.5
0.5	69
1	73
1.5	78
2	79
2.5	88

Figures 5-10, show the obtained results of heat flow with sample temperature, through which we calculate the glass-transition temperature. Upon heating to (Tg), the solid amorphous polymer changes from a solid to a rubbery state (Mahdie *et al*., 2017). The (Tg) value depends on the molecular weight properties that affect the chain stiffness. Molecular weight gain also tends to raise (Tg), when the molecular weight is too high, due to the decrease in free volume due to the reduced mobility of the ends of the polymer chains because the free volume depends on the concentration of the ends of the chains (Jasim *et al.*, 2019). The (Tg) increases with increasing polymer polarity and increasing cohesive energy density.

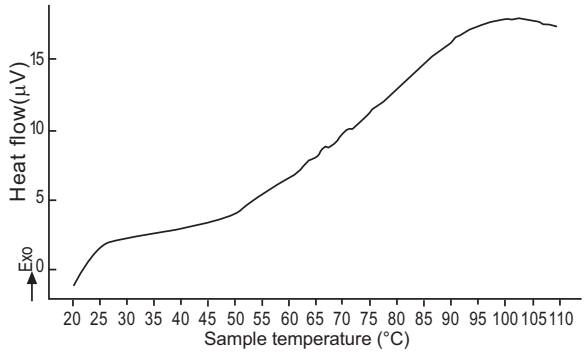

Fig. 5. Heat flow vs sample temperature for weight 0%.

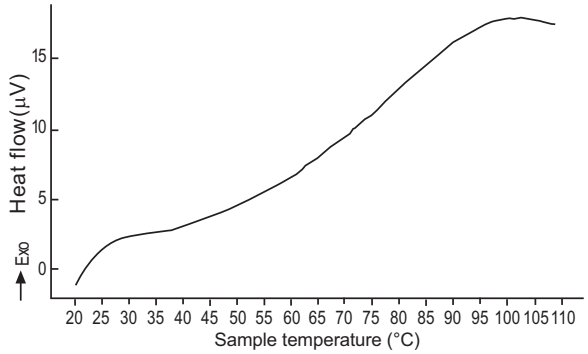

Fig. 6. Heat flow vs sample temperature for weight 0.5%.

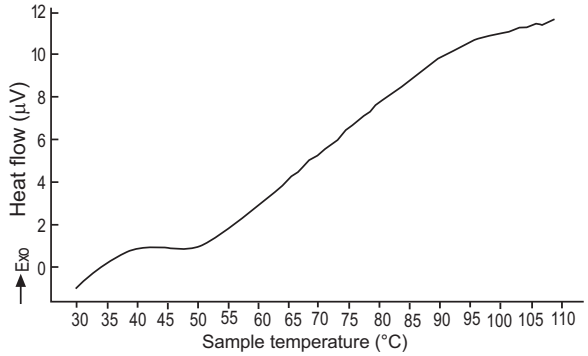

Fig. 7. Heat flow vs sample temperature for weight 1%.

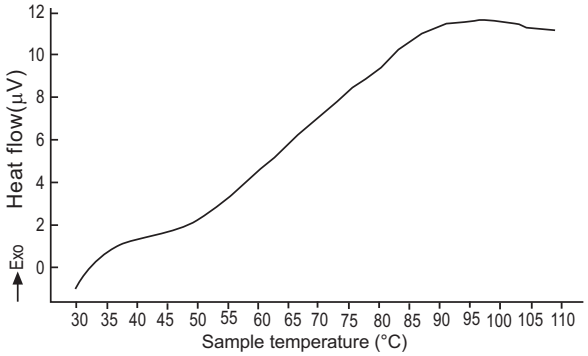

Fig. 8. Heat flow vs sample temperature for weight 1.5%.

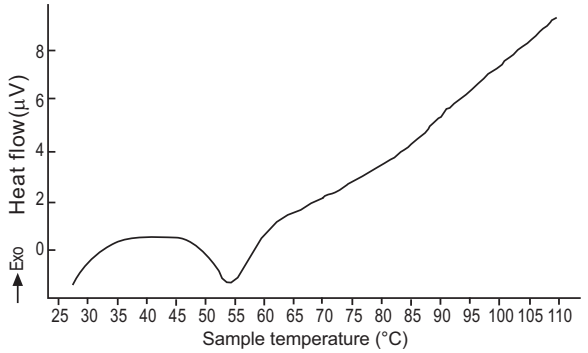

Fig. 9. Heat flow vs sample temperature for weight 2%.

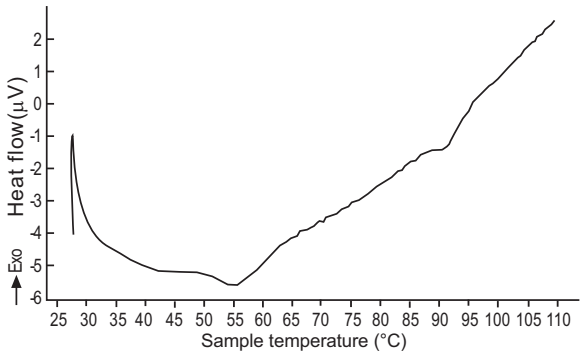

Fig. 10. Heat flow vs sample temperature for weight 2.5%.

Conclusion

In this study, we concluded thermal conductivity decreases with pistachio husk powder concentration increase and it has a minimal value of (0.1673) for (2.5% hw). Increase hardness with pistachio husk powder concentration increase and it has maximum values of (78.5) for (2.5% hw) and the maximum Glass transition temperature (Tg) of (EP/hw) composites were the value (88 °C) at (2.5% hw). Depending on the results obtained, this compound can be used for painting wooden furniture. Because it contains pistachio shells powder, which is an environmentally friendly organic material and because of the physical and chemical properties of the epoxy used.

Conflict of Interest. The authors declare that they have no conflict of interest.

References

Alsaadi, M., Erklig, A., Albu-khaleefah, K. 2018. Effect of pistachio shell particle content on the mechanical properties of polymer composite. *Arabian Journal for Science and Engineering*, **43:** 4689-4696. https://doi.org/10.1007/s13369-018-3073-x

Anjam, Q., Hussain, F., Imran, M., Amin, N., Munir, T. 2021. Investigate the effect of temperature, length, width and thickness of substrate on thermal conductivity of graphene copper nanocomposites. *Journal of Ovonic Research*, **17:** 353-365.

Callister, W.D.Jr. 2006. *Materials Science and Engineering: An Introduction*, 7th Edition, pp. 520-528, John Wiley & Sons, Inc., New York, USA.

Fadhil, R.N., Jobayr, M.R., Khazaal, A.R., Mahdi, S.H. 2019. Evaluation of the optical properties for thick films of epoxy-diamond paste blend prepared by the casting method. *Energy Procedia*, **157:** 626-634. DOI: 10.1016/j.egypro.2018.11.228

Jaafar, H.I., Fadhil, R.N. 2017. The effect of utilization aluminum powder at the mechanical properties for epoxy resin. *International Journal of Science and Research*, **6:** 1847-1850.

Jaafer, H.I., Muslem, Z.R. 2012. Effect of nano and micro SiO_2 weight percent on interlaminar fracture toughness of woven roving/epoxy composites. *Iraqi Journal of Physics*, **10:** 117-121.

Jaafer, H.I., Yousif, R.H., Kadem, M.J. 2008. Interlaminar fracture toughness of some polymer blends reinforced by fiber glass. *Iraqi Journal of Physics*, **5:** 7-14.

Jasim, K.A., Fadhil, R.N., Shaban, A.H. 2019. The effects of copper additives on the glass transition temperature and hardness for epoxy resin. *Progress in Industrial Ecology – An International Journal*, **13:** 163-172. DOI: 10.1504/PIE.2019.099357

Jasim, K.A., Fadhil, R.N. 2018. The effects of micro aluminum fillers in epoxy resin on the thermal conductivity. *Journal of Physics Conference Series*, **1003:** 012082, DOI: 10.1088/1742-6596/1003/1/012082

Jasim, K.A., Thejeel, M.A., Salman, E.M.T., Mahdi, S.H. 2017. Study characteristics of (epoxy–bentonite doped) composite materials. *Energy Procedia*, **119:** 670-679. DOI: 10.1016/j.egypro.2017.07.094 https://chalcogen.ro/353_AnjamQ.pdf

Jasim, O.A., Al-Sarraf, A.R. 2020. Study the preparation of polymeric coatings supported by nanomaterials to inhibit corrosion in the oil tanks. *Journal of Petroleum Research and Studies*, **26:** E55-E69. https://www.researchgate.net/publication/342014282

Jasim, O.A., Al-Sarraf, A.R. 2019. Study the tribiology properties of (polyester/epoxy blend) composite reinforced by nanomaterial's. *American Institute of Physics Scoups Conference Proceedings*, **2123:** 020034. https://doi.org/10.1063/1.5116961.

Jasim, W.H. 2016. Preparation of the epoxy/chicken eggshell composites to use in surfaces coating. *Ibn Al-Haitham Journal for Pure and Applied Science*, **29:** 437-444.

Jobayr, M.R., Abd Al Razak, A.H., Mahdi, S.H., Fadhil, R.N. 2018. Study optoelectronic properties for polymer composite thick film. *American Institute of Physics Scoups Conference Proceedings*, **1968:** 030021-1-030021-9. DOI: 10.1063/1.5039208

Maghsoudi, H., Khoshtaghaza, M.H., Minaei, S. 2010. Selected geometric characteristics, density and mechanical properties of unsplit pistachio nut. *International Journal of Food Properties*, **13:** 394.

Mahdi, S.H., Aleabi, S.H., Ghadhban, R.Q., Salman, E.M-T. 2020. Effect of pyrex waste on the electrical and mechanical properties of an epoxy resin. *Journal of Xi'an University of Architecture and Technology*, **XII:** 303-311. https://www.xajzkjdx.cn/gallery/33-may2020.pdf

Mahdi, S.H., Jassim, W.H., Hamad, I.A., Jasima, K.A. 2017. Epoxy/silicone rubber blends for voltage insulators and capacitors applications. *Energy Procedia*, **119:** 501-506. https://www.sciencedirect.com/science/article/pii/S1876610217326012

Mahdie, S.H., Abd Saloom, Q., Abd Alaziz, D.S. 2017. Preparation of unsaturated polyester/nano ceramic composite and study electric, thermal and mechanical properties. *Iraqi Journal of Physics*, **15:** 188-201.

Mohammad, M.R., Rafeeq, S.N., Khammas, R.A. 2017. Evaluation of mechanical strength of epoxy polymer concrete reinforcement with different types of fibers. *Ibn Al-Haitham Journal for Pure and Applied Science*, **30:** 63-72. https://jih.uobaghdad.edu.iq/index.php/j/article/view/1060

Shawky, A., Jaafer, H.I., AL-Ajaj, E. 2011. The effect of metals as additives on adhesion properties of epoxy resin. *Iraqi Journal of Physics*, **9:** 55-62.

Zaidan, S.A., Mohammed, A.Z. 2017. Study the electromechanical strength properties for epoxy dispersed silica powder composite. *Ibn Al-Haitham Journal for Pure and Applied Science*, **30:** 339-354. https://jih.uobaghdad.edu.iq/index.php/j/article/view/1083