IHJPAS. 36(2)2023

Ibn Al-Haitham Journal for Pure and Applied Sciences
Journal homepage: jih.uobaghdad.edu.iq

Effect of Pistachio Husks Powder Additive on Unsaturated Polyester Composites

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Article history: Received 2 October 2022, Accepted 1 November 2022, Published in April 2023.

doi.org/10.30526/36.2.3055

Abstract

In this study, polyester composites reinforced with pistachio shells powder (P.) with an average diameter (150 – 200 μm) with different weight ratios (0.5%, 1%, 1.5%, 2%, and 2.5%) were prepared to the resin. The Shore D hardness, thermal conductivity (K), and the glass transition temperature (Tg) of the samples were examined. The results showed that the Shore D hardness increases with the increase of the reinforcement ratio and its maximum value is (87.55) at (2.5% P.) While the value of hardness at (0%) is (86.5). The thermal conductivity increases slightly with the increase in the percentage of reinforcement and its maximum value is (0.213253 W/ m. K) at (2.5% P.), while the value of K at (0% P.) is (0.170264W/ m. K), but with this slight increase in thermal conductivity, polyester composites remain from the insulating materials. The minimum (Tg) of (UPE/ P.) composites was the value (113.898°C) at (2.5% P.). Polyester composites are used in wood paints, either in primitive finishes or final finishes.

Keywords: pistachio husks, Shore D hardness, composites, Thermal conductivity.

1. Introduction

Solid wastes resulting from agricultural and industrial wastes were of limited use due to the lack of cost-effective fillers in the manufacture of polymeric composites. Plus, natural materials are eco-friendly, plentiful, and renewable. Nutshells, peanuts, olive stone, coconut and palm trees, rice husks, jute, stalk fibers, bagasse and hulled sugar [1-9] are used as reinforced fillers in polymer matrix composites to improve physical and mechanical properties and to reduce production cost [1]. Polymers are inert and lightweight materials that possess a high degree of Coated and have a low density, low stiffness and high resistance to corrosion. They are also characterized by ease of manufacture and processing, which made them widely used in the field of civil and construction engineering [10]. The composite material consists of matrix material and reinforcement [5] and these materials are characterized by high toughness, lightweight, low density, low-cost manufacturing, does not rust or corrode [11]. Polymer-based composites are one of the best and most common composite materials. Due to its high mechanical properties, the reinforced polymer has been used in various industries [12] [13]. The materials used in the reinforcement, are in different shapes, such as fibers, particles, scales, or Flakes, depending on the type of use [14] [15]. Polyester resin is a type of thermosetting resin [16]. It is prepared by reaction with a dibasic unsaturated acid and it is required that one or both of the monomers have a double bond in its composition, After the linear polymer is formed, it is mixed with an effective vinyl monomer such as styrene plus a catalyst that breaks down into free cracks. Thus, the vinyl monomer is polymerized with the double bonds along the polymer chain, thus forming polyester [17]. Polyester resin has good thermal properties as it withstands high temperatures (for resins) up to 260°C, but suffers spontaneous disintegration at a temperature of about (300°C) even in the absence of oxygen [18]. It is also characterized by excellent chemical and electrical resistance to acids, solvents, wear, salts and environmental influences, in addition to being low in cost, but characterized by weakness and fragility [19]. The importance of particle-supported polymeric materials prompted scientists And researchers to do many studies and research. In 2018, the researcher Mohammed Al-Saadi and others used pistachio husks and their effect on the mechanical properties of polyester matrix. It obtained the dispersion of the pistachio husks particles in the polymer matrix and it obtained the highest tensile strength, flexural strength and impact strength. [1]. In 2021, the researchers Zaynab N. and Samah M. conducted an experimental study of the effect of food trash powder on FWP, Compressive and abrasion behaviour of polyester composite The results showed that FWP improved the tribological and mechanistic behaviour of the UPE composites with a slight difference. FWP acts as reinforcement and increases abrasion resistance [20]. In 2021, the researcher Yahya Hısman Celik and others used the effect of adding hazelnut shells, pistachio skins, and Apricot kernel peel on unsaturated polyester composites. It was concluded that increasing the reinforcements added to polyester increases the compressive strength, stiffness, specific weight and thermal conductivity properties [21]. The study aims to prepare composites of unsaturated polyester, to obtain a new material with qualified physical properties in the manufacture of paint for wooden furniture through the use of fillers of pistachio shells that can be exploited and clear the environment from it by recycling.

2. Materials and Methods

2.1 Matrix Material

Unsaturated polyester resins (UPE) were supplied from Saudi Industrial Resins Limited. And it is converted to a solid state by adding a hardener in a ratio of (98:2). The viscosity was average. Table 1 shows the chemical and physical properties of UPE.

Table 1. The Chemical and Physical Properties of (UPE).

Properties	UPE
Physical State	Liquid
Colour	Transparent
Density at (25°C)	1 To 1.3 g/cm^3
Odor	Pungent
Vapor Density	3.6 (Air = 1)

2.2 Reinforcement materials

Pistachio husk powder (P.) is used as Reinforcement material. Some of the basic properties of (P.) are shown in Table 2.

Table 2: basic properties of (P.).

Properties	Pistachio husk waste powder (P.)
Form	powder
Colour	light yellow
Purity	99.9%
average diameter	(150 - 200 µm)

2.3 Method

The unsaturated polyester resin was prepared with a hardening ratio (98:2) and then different weight percentages of pistachio shells powder (P.) (0, 0.5, 1, 1.5, 2 and 2.5%) were added. Six samples of (UPE/P.) composites were prepared according to (ASTM-E 10) using the Hand lay-up modeling process [22]. Figure (1) is a photograph of the samples.

Fig. 1. A photograph of the samples for UPE/ P. composites at (0, 0.5, 1, 1.5, 2 and 2.5) %

3. Results and Discussion

3.1. Thermal conductivity (K)

Fig. 2 and Table .3 show the results of the thermal conductivity of the (UPE/ P.) composites. The thermal conductivity increases slightly with the increase of the reinforcement ratio. It is (0.213253 W/ m. K) at the ratio (2.5% P.) however; composites (UPE/ P.) of insulating materials remain. Heat in polymeric materials is transmitted in the form of an elastic wave [23] [24]. The wave loses part of its energy at the interface area between the matrix and the reinforcing material [25] [26]. Pistachio shell powder is an insulating material, but it slightly increased the thermal conductivity in unsaturated polyester composites. The reason for this may be due to the properties of the unsaturated polyester used in this research in terms of the glass transition temperature, which are equal to (125.5 °C) for pure unsaturated polyester and its high melting point.

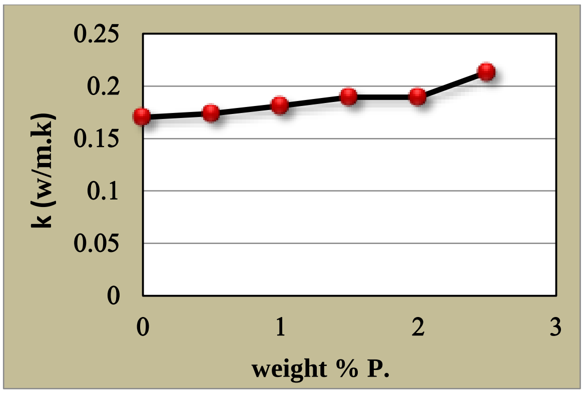

Fig. (2) Thermal conductivity V.s P. weight percentage for UPE/ P. composites.

Table (3) Thermal Conductivity for UPE/ P. composite

P.%	K(W/ m. K)
0	0.170264
0.5	0.173773
1	0.181237
1.5	0.189365
2	0.189371
2.5	0.213253

3.2. Hardness Tests

Figure 3 and Table 4 show the results obtained from the Shore D hardness test for (UPE/P.) composites. It is observed that the Shore D hardness values increase with the increase of the reinforcement ratio. The highest value was (87.55) with a rate of (2.5%). The reason for the increase in hardness is due to the homogeneous distribution of pistachio shell powder among the unsaturated polyester resin chains and the cohesion strength between the matrix material and the reinforcement material [27] [28]. Thus, we obtained a compound that is more resistant to environmental factors than pure unsaturated polyester.

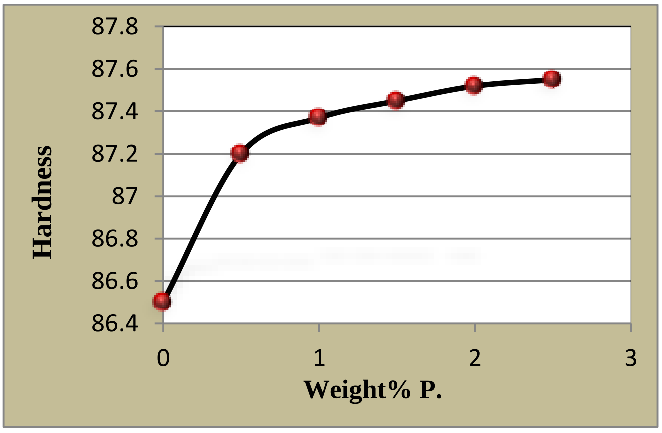

Fig. (3) Shore D hardness of polymer composites as a Function of pistachio husk powder.

Table (4) Shore D hardness for UPE /P. composite.

P.%	Shore D hardness	
0	86.5	
0.5	87.2	
1	87.37	
1.5	87.45	
2	87.52	
2.5	87.55	

3.3. Glass-transition Temperature

The Tg is the temperature at which the polymer changes from a solid to a soft state. Figure 4 and Table 5 show the obtained values for (Tg) for (UPE/ P.) composites. Figures (5, 6, 7, 8, 9 and 10) show the results obtained from the (DSC131 EVO) device, which shows the relationship between heat flow and the sample temperature, through which the values of (Tg) were found. It was noticed in Figure (4) that the values of (Tg) decrease with the increase in the percentage of reinforcement. The lowest value was (113.898°C) at the ratio (2.5% P.). The reason for this is that the value of (Tg) depends on several factors, including the chemical composition, as the hardness of the polymeric chains depends on the presence of compensated groups or chemical bonds that increase the flexibility of the chains and reduce Tg. Structural factors such as molecular weight, as the value of Tg, increases with increasing molecular weight. The degree of branching decreases Tg because with the increase of Tg, the ends of the chains increase, which leads to an increase in the free volume [29].

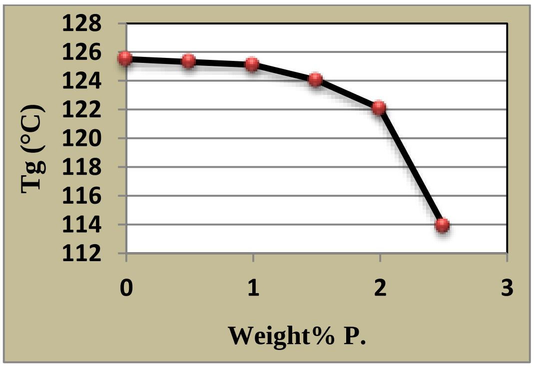

Fig. (4) Tg vs. P. weight percentage for UPE /P. composites.

Table (5) Tg for UPE /P. composite.

P.%	Tg (°C)
0	125.5
0.5	125.313
1	125.1
1.5	124.039
2	122.086
2.5	113.898

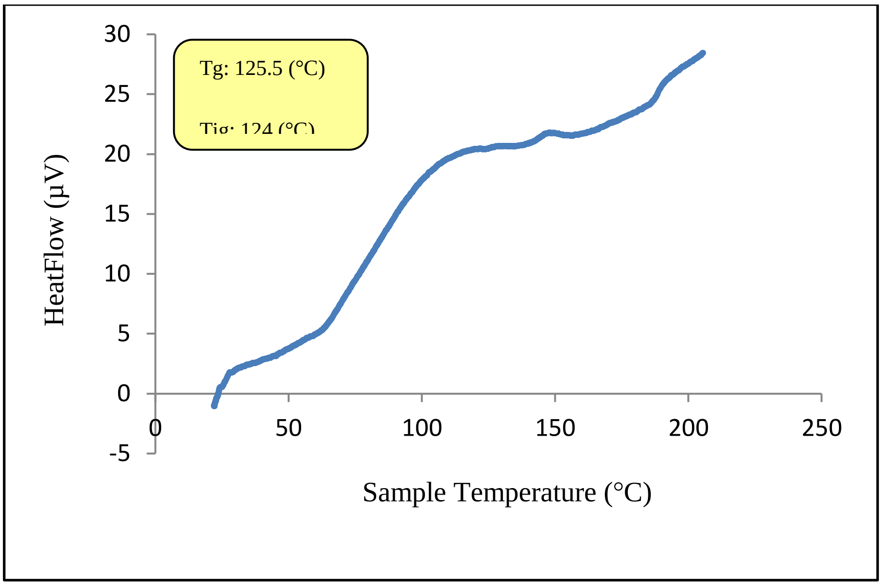

Fig. (**5**) Heat Flow vs. Sample Temperature for weight percentage 0%.

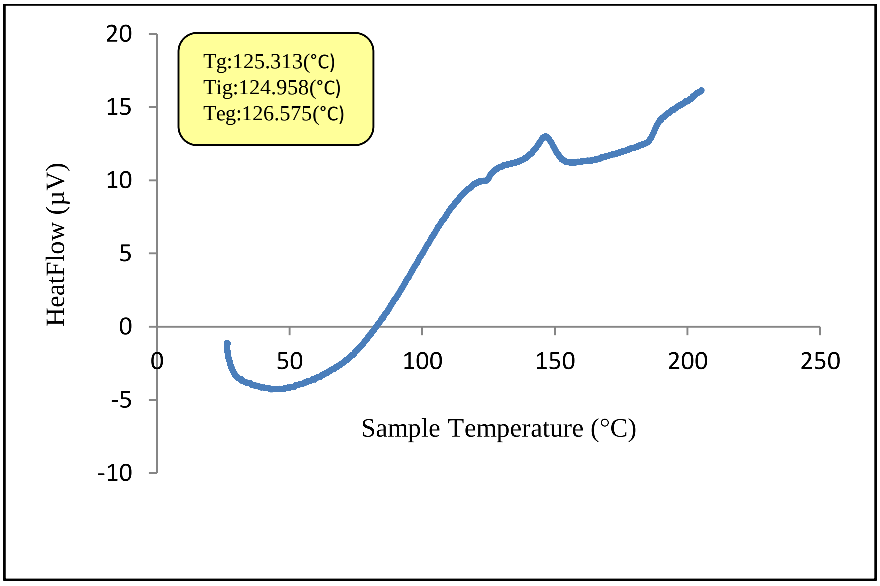

Fig. **(6)** Heat Flow vs. Sample Temperature for weight percentage 0.5 %.

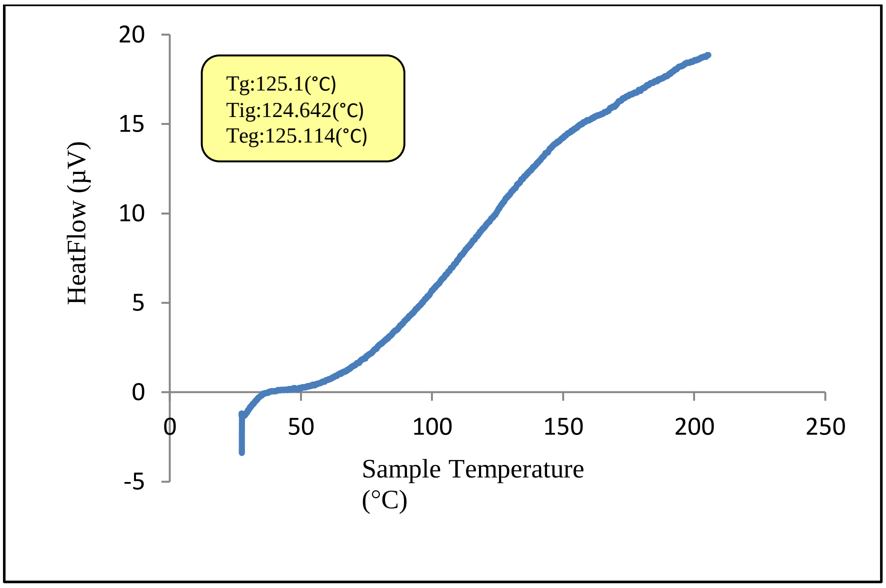

Fig. **(7)** Heat Flow vs. Sample Temperature for weight percentage 1 %.

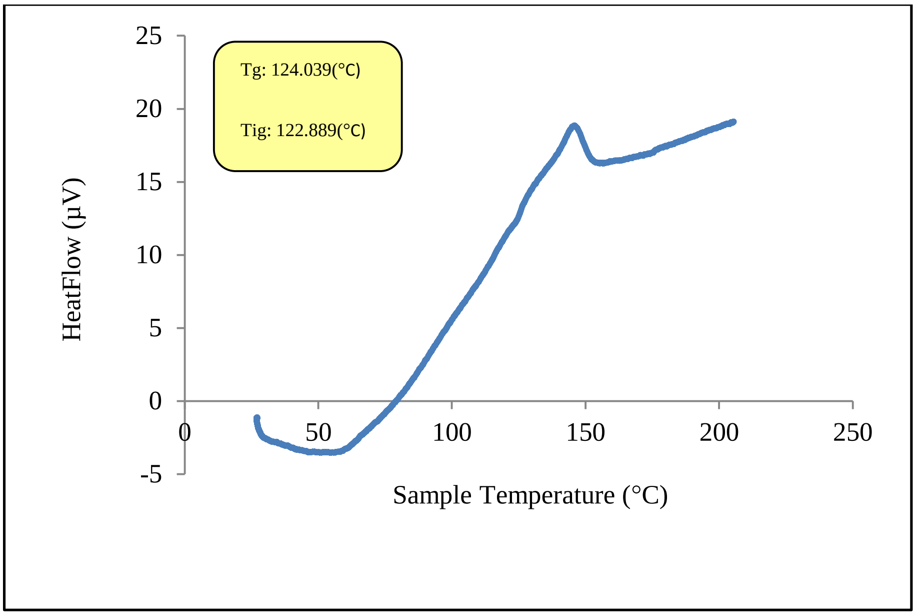

Fig. **(8)** Heat Flow vs. Sample Temperature for weight percentage 1.5 %.

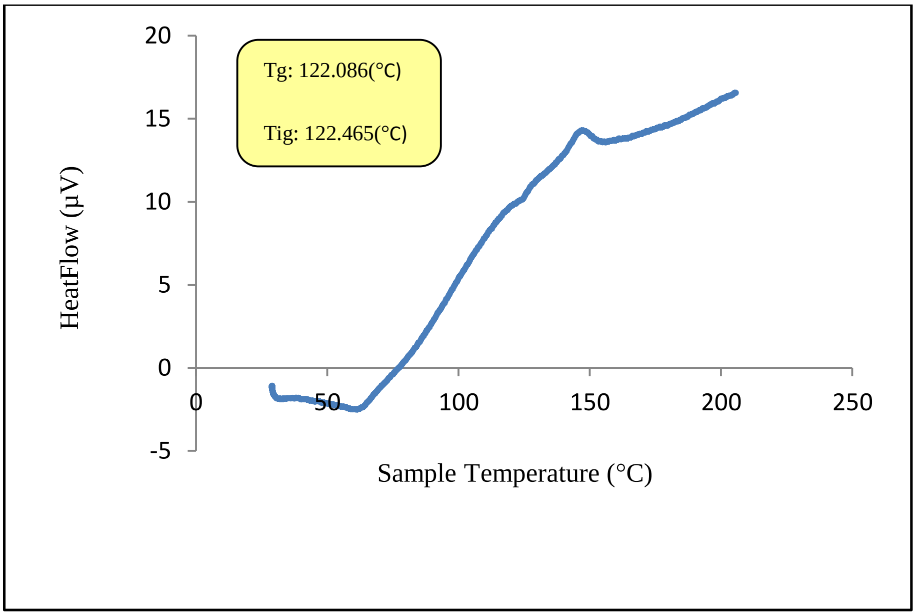

Fig. **(9)** Heat Flow vs. Sample Temperature for weight percentage **2** %.

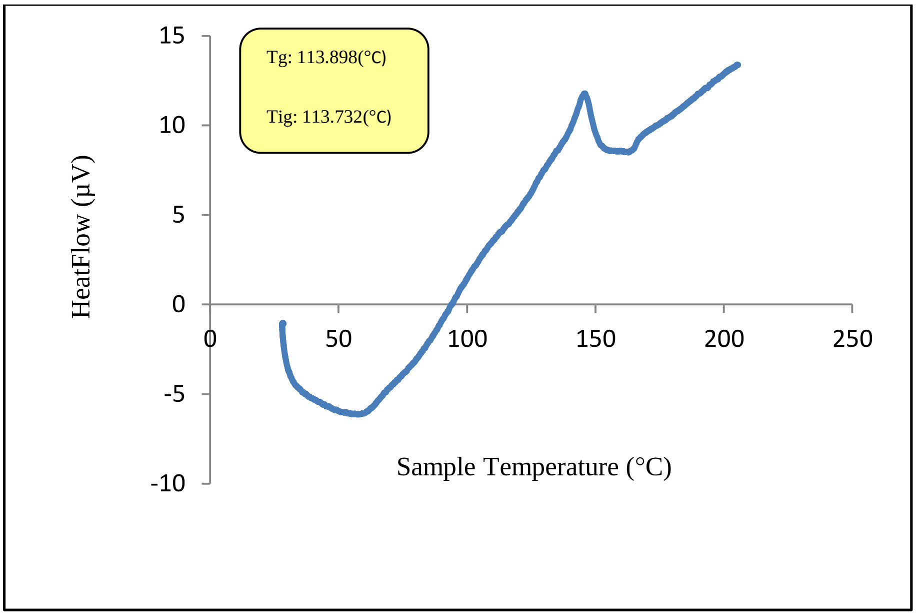

Fig. **(10)** Heat Flow vs. Sample Temperature for weight percentage **2.5** %.

5. Conclusion

We concluded Thermal conductivity increases slightly with the increase in the percentage of reinforcement and its maximum value is (0.213253 W/ m. K) at (2.5% P.). The Shore D hardness increases with the increase of the reinforcement ratio and its maximum value is (87.55) at (2.5% P.). Glass transition temperature (Tg) decreasing with the increase of the reinforcement ratio, and its minimum (Tg) value is (113.898°C) at (2.5% P.). Polyester composites are used in wood paints, either in primitive finishes or final finishes.

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