



Effect of date palm rachis base wood waste particulate on physical, thermal and mechanical features of polymeric composite

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The removal of some palm tree parts is a periodic annual process to clean the palm trees every year, as the presence of these parts in the palm trunk leads to the proliferation of rats, scorpions, and worms in them, which leads to their erosion, the spread of diseases in them, and ultimately the death of the palm tree. The removed parts of the palm tree are disposed of by burning them, which in turn causes environmental pollution and possibly the spread of fires. Therefore, palm waste is used to improve the mechanical, physical and thermal features of a polymeric composite. The key to this development lies in the nanoscale topography of the accepted cellulose fibrils inside the palm particles; when uniformly spread, these fibrils create a dense nanostructure that restricts polymer chain flexibility and encourages efficient stress transmission at the interface. Where the results showed that the reinforcement process by the palm Rachis base wood waste particles improved the mechanical features, where the tensile strength increase from 7.76 MPa of the pure specimen to 35.09 MPa of the specimen reinforced by Khistawy particles at 3.5% weight fraction, while for Young Modulus the reinforcement increased it from 23.88 MPa to 95.52 of the specimen reinforced by Barhy particles 8 %weight fraction, the impact strength has been increase from 0.3 0.3 $\frac{KJ}{m^2}$ to 1.65 $\frac{KJ}{m^2}$ as a result of reinforcement at 8% weight fraction of Khistawy particles, the hardness value has been increased from 70 (Shore D) to 76.1 (Shore D) as a result of reinforcing by Khistawy of 8% weight fraction, finally the thermal

conductivity has been increased from $0.79 \frac{W}{m.^{\circ}C}$ to $1.52 \frac{W}{m.^{\circ}C}$ at 8 % weight fraction of Barhy particles, a through consequence of the percolating nanoscale networks that enable phonon transport crossways the matrix, thereby transforming an agricultural burden into a value-added and eco-friendly engineering material.

Keywords: Date palm Rachis base; Barhy Palm Tree; Khistawy Palm; Natural Wood Particles.

1. INTRODUCTION

Composite materials represent combinations of two materials that have different physical and chemical features [1-3]. Composites have been utilized in several applications in every region in the world, for example, equipment that includes auto parts, aircraft, home apparatus, furniture, and so on. In addition to infrastructure applications which include roads, bridges, and buildings [4-6]. Particulate composites with reinforcement particles filler began to be more common in composite industrialization where the weights of the huge structures of the composites will be reduced essentially and at the same time maintain or preserve the desired properties [7-9]. With the advent of nanotechnology, the attention has shifted near engineering reinforcements at the nanoscale, allowing superior interfacial bonding and improved presentation even at little filler loadings. Natural reinforcing composite is a composite material, in which at least the reinforcing phase (in origin) is from natural materials or materials that are capable of being renewed [10-12]. Date palm Rachis base or (Phoenix Dactylifera L. Rachis base) represents the part that is directly attached to the trunk of the palm, which must be removed from the trunk of the date palm every year (in Iraq), which must be must be rid by burning (which constitutes environmental pollution) so that it does not accumulate or stack and be a shelter for snakes, rats, and scorpions.

Chihaoui et al. [8] have used the date palm waste particles to reinforce the polypropylene matrix composites at 40% w/w, where they investigated the effect of date palm waste particles that has been obtained from the tree (different parts of the date palm tree) resulting from the pruning of the tree [13]. Kumar et al. [5] have studied the improvement of biocomposites mechanical, physical, thermal features, and microstructure. The specimens are prepared by using several weight percentages (10, 20, 30, and 40%), of willow and aspen plant particles in a biopolymeric matrix. The tensile, bending strength, hardness, and stiffness of bending rise with the augmentation of wood particle ratios [14]. Including nanoscale wood resulting cellulose fibrils could further improve these properties by making a more uniform nanostructure inside the matrix. Harnany et al. [13] have studied the sustainable use of cassava perennial plants particle as reinforcement material with polyurethane polymer matrices [15]. They have studied Cassava plant waste particles as a raw material for the development of bio-composite material with polypropylene as a matrix material, rice husk as filler, and MAPP as a coupling agent or adhesive. The researchers investigated the physical features, and the mechanical features using elasticity and bending modulus tests. Others [16] have studied the microstructural; mechanical, physical, and thermal properties of the composite samples result are examined. Where the polyhydroxybutyrate matrix is reinforced with coffee parchment and husk [17]. They have prepared and studied the physical, thermal, and mechanical features of the bio-composites of dates palm waste particles as reinforcement material with silicone rubber as a matrix material. The reinforcement particles are used in different particles size with different reinforcement particle ratios, the reinforcement particles improved the mechanical features [18]. While, Zainab et al. [17] have investigated the effect of palm fronds waste charcoal particles on the epoxy matrix as a naturalistic reinforcement with different weight fraction values. Particulate material. The reinforcing process

enhanced the mechanical, thermal and acoustic features of the prepared composite specimens. In addition to decreasing the density of the specimens and liquid absorption rates for all prepared specimens [19]. The combination of activated carbon nanoparticles resulting from palm fronds could further enhance these barrier properties, though the resulting nanostructured network may proposal novel multifunctional capabilities, showcasing the potential of nanotechnology in sustainable compound design.

2. EXPERIMENTAL

The production of specimens at first started with cutting the Rachis base waste of two types of Rachis base, the first called Khistawy (K), while the second called Barhy (B) (as reinforcement material) into tiny pieces, after that the Rachis base waste pieces had been washed with distilled water, and then washed with ethyl alcohol to remove the dirt and dust. The next step is drying the waste pieces at 50 °C temperature for 24 hours. In the next step, the two kinds of Rachis base waste pieces have been milled alone by using an industrial mill to get the waste particles. After that the two types of waste particles have been sifted each type alone using a shaker (electric vibrator), with three sieves of 250, 125, and 75 μ m, to get and then use different particle sizes of reinforcement particles (waste particles).

Production of the samples included using reinforcement waste particles rates (0, 2, 4, 6, and 8) % as weight fraction. Teflon material molds are used after cleaning of course, after that the molds have been dried in the oven at a temperature of 50 °C for 1 hour. Moreover, to avoid sticking the casts to the inner surface of the molds, every mold has been lubricated before every molding stage.

Figure 1, (left) shows the dry palm Rachis base (palm fronds base) after removing from the trunk, (right) and the fronds connected with the trunk.



Figure 1 (Left) Palm Rachis base waste (palm fronds base), (right) the trunk and the base of the fronds connected with it.

3. RESULTS AND DISCUSSION

From the following figures, we can notice that the type of the reinforcement material (Composition) has great effectiveness on the properties of the prepared samples. The existence of the reinforcement particles increases the energy absorption and dispersal of the composite materials significantly than in the case of the pure polymer samples, where the failure occurs because of the breakdown of the bonds of the polymer during the growth of primary cracks due to shock stresses, but when reinforcing, the materials particles of various types will storage utmost of energy of elastic stress (Elastic Strain) of the

composite samples because it will sustain the largest part of the applied load relative to the polymer matrix which creates obstacles to fracture and prevent the increasing the small cracks that appear (arise) as a result of shocks, therefore the existence of reinforcement particles in the composite samples increases its resistance to shock [20,21]. There are several conclusions that can be noted from the obvious result of the reinforcement process, the proportion, and the types of reinforcement particles at the stress-strain curves that comprise an elastic and plastic range, ultimate strength (tensile strength), and fracture points [22, 23]. We can notice that the tensile strength values have been increased due to the reinforcement operation, moreover; that the values of tensile strength have been increased too by increasing the ratios of the particles for the two reinforcement types.

The ultimate tensile strength of the composite samples reinforcing with Khistawy (K) Rachis base waste particle (35.039MPa), at particle size 75 μm , and ratio (8%), whilst the ultimate strength of the polyester sample (pure polymer without reinforcement particles) (7.76 MPa), that means the reinforcing process strengthens the ultimate or maximum tensile strength (4.45 times), while the reinforcement process results with Barhy (B) particles came in the second degree or value Where the maximum tensile strength value (31.587MPa). This means, the reinforcement particles bind (join) the polymer (matrix) particles or chains together strongly, without interruption, and therefore resisting the external effect, which means that the samples became stronger because of the reinforcement process and the support of the reinforcing particles, as shown in Figure 3 [24, 25]. Whilst the tensile strength has been decreasing with reinforcement particle size increasing, this is due to the large size of the particles, which increases the distance between the polymer particles from each other and creates voids and pores, therefore, this leads to the weakening of the samples [26]. Figure 2. Illustrates the stress-strain behaviours of the prepared specimens and Weight Fraction (2, 4, and 6, and 8) % respectively.

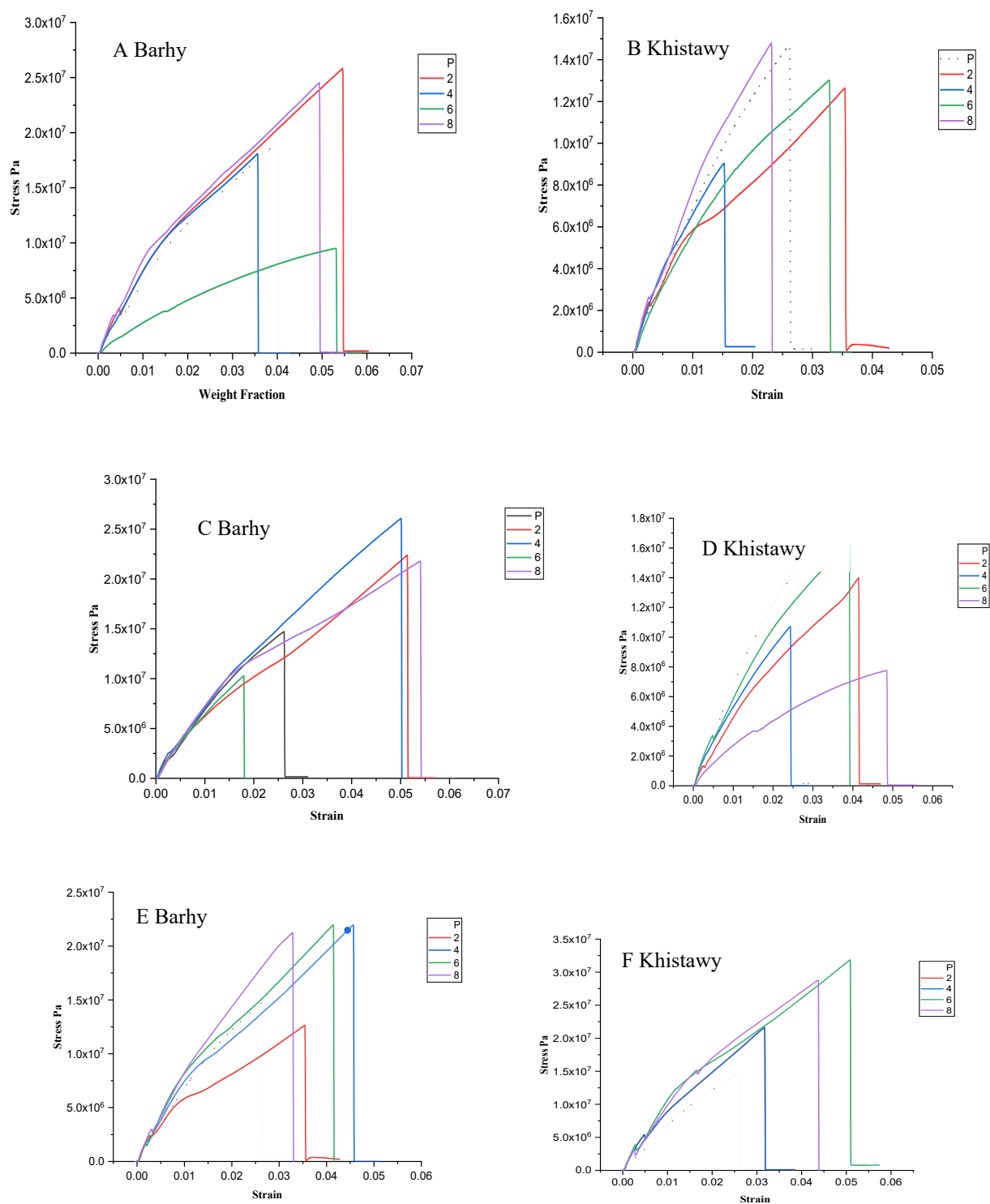


Figure 2 Stress-strain curves of the pure and reinforcement samples at (2, 4, 6 and 8) %, weight fraction, where, A,B (75 μ m), C,D (125 μ m) and E,F (250 μ m).

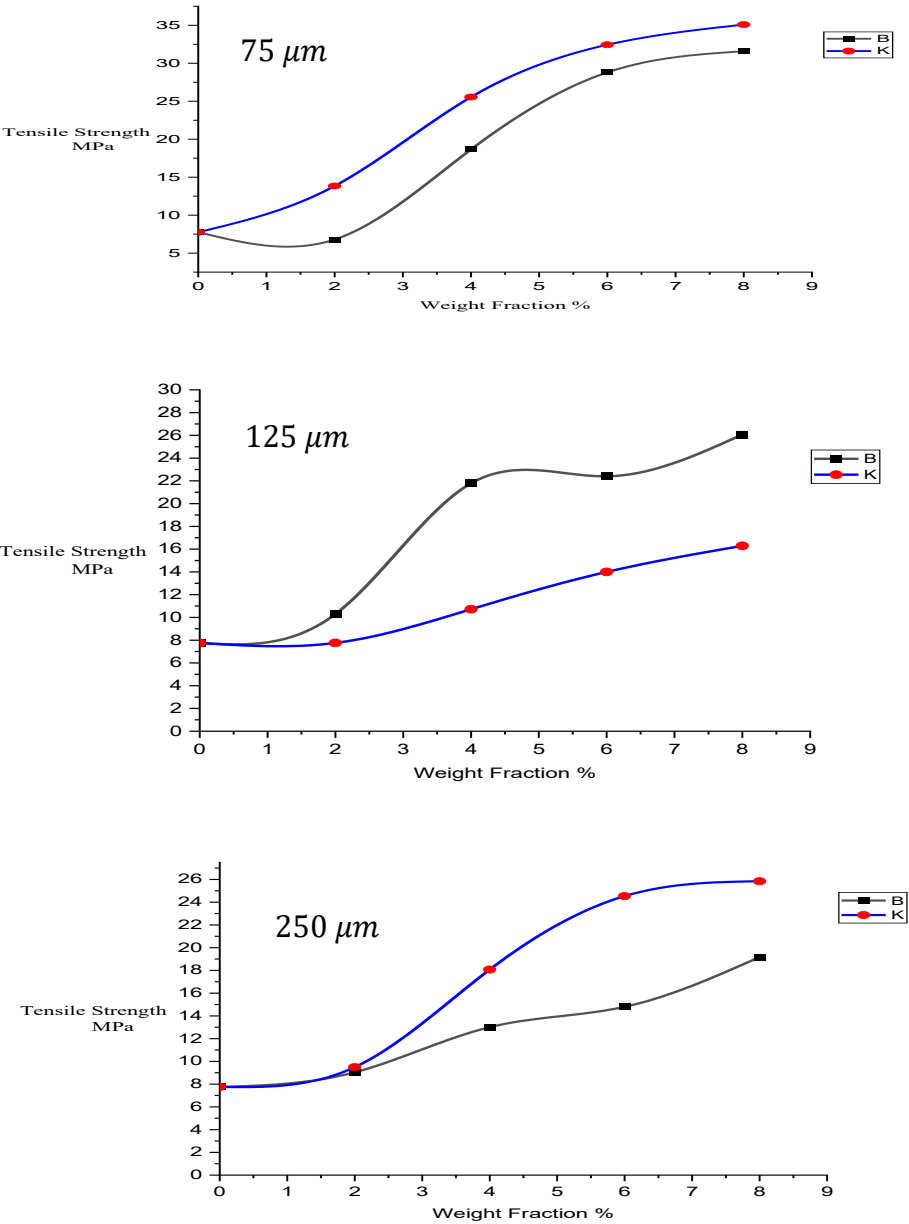


Figure 3 Tensile strength of samples vs weight fraction.

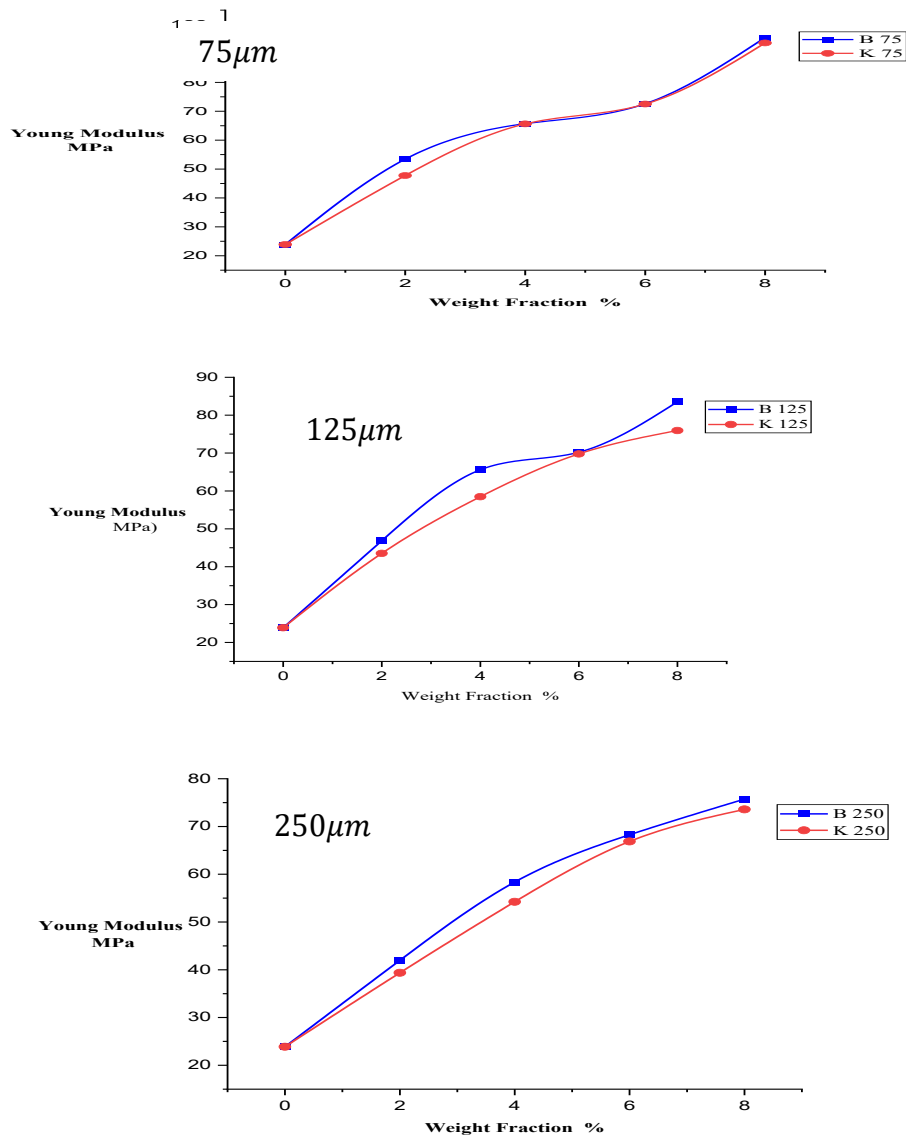


Figure 4 Young Modulus of prepared samples vs the Weight Fraction.

It is observed that there is an increase in Impact Strength value for all reinforced samples when the reinforcement particles are added to the polyester resin, which has low strength value and low impact resistance, and these particles increase the toughness of the composite material because they lead to the deviation and, dispersion, and weakness of the crack, as the crack encountering the reinforcement particles during its progression through the composite material will generate an obstruction in its movement by these particles, which are considered barriers in front of the crack and work to stabilize it in the centers of the presence of these particles. For the crack to overcome these barriers and as it continues to grow, it will change its shape and turn into a group of small secondary cracks, trying to pass between the particles, and this leads to an increase in the surface of the crack, and thus the increases the required energy for the fracture to occur [27,28].

The essential of Impact test is based on the fact that some of the energy presents as potential energy in the hammer, has been absorbed by the sample before the fracture occurs, whereas the energy absorbed by the sample depends on the nature of the components in the composite sample's material and the extent of its resistance to external stress applied on it [29]. The reason for the significant increase in the value of the impact resistance is due to the existence of the date palm particles, which have led to preventing the extension of cracks and increasing their depth in the material because the particles here acted as dispersants of energy and repel the cracks [30], as shown in Figure 5.

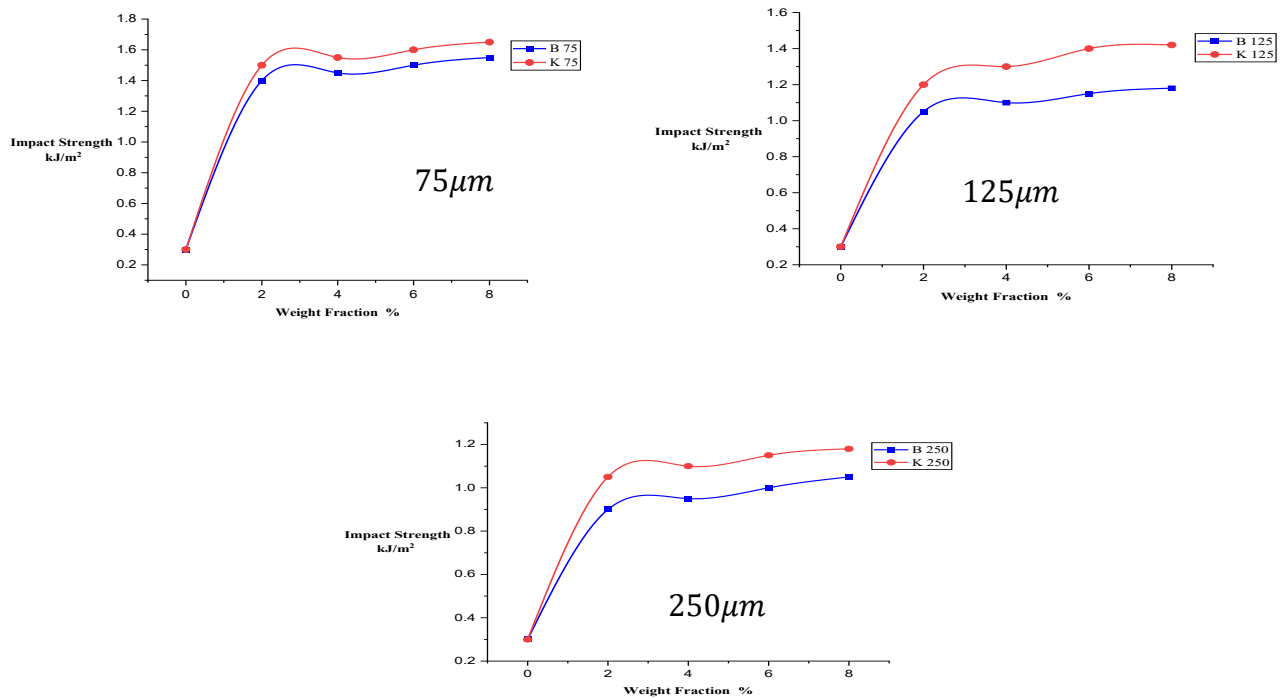


Figure 5 The Impact Strength results of prepared samples vs the Weight Fraction.

Since the prepared samples contain voids (as a result of the preparing process), which behave as weak points within the reinforced material and are the center of stresses, as well as these fibers work to increase the internal distance between the particles, as the breaking energy of the brittle materials supported by the particles increases when the internal distance between the particles is decreased [30], Figure 6 shows the relationship between the hardness and the weight fraction, where the hardness values of the reinforced specimens have been increased as a results of the reinforcing process, because of that the reinforcing process increases the surface hardness is due to the strong adhesion and the binding between the reinforcing particles and the epoxy molecules [27].

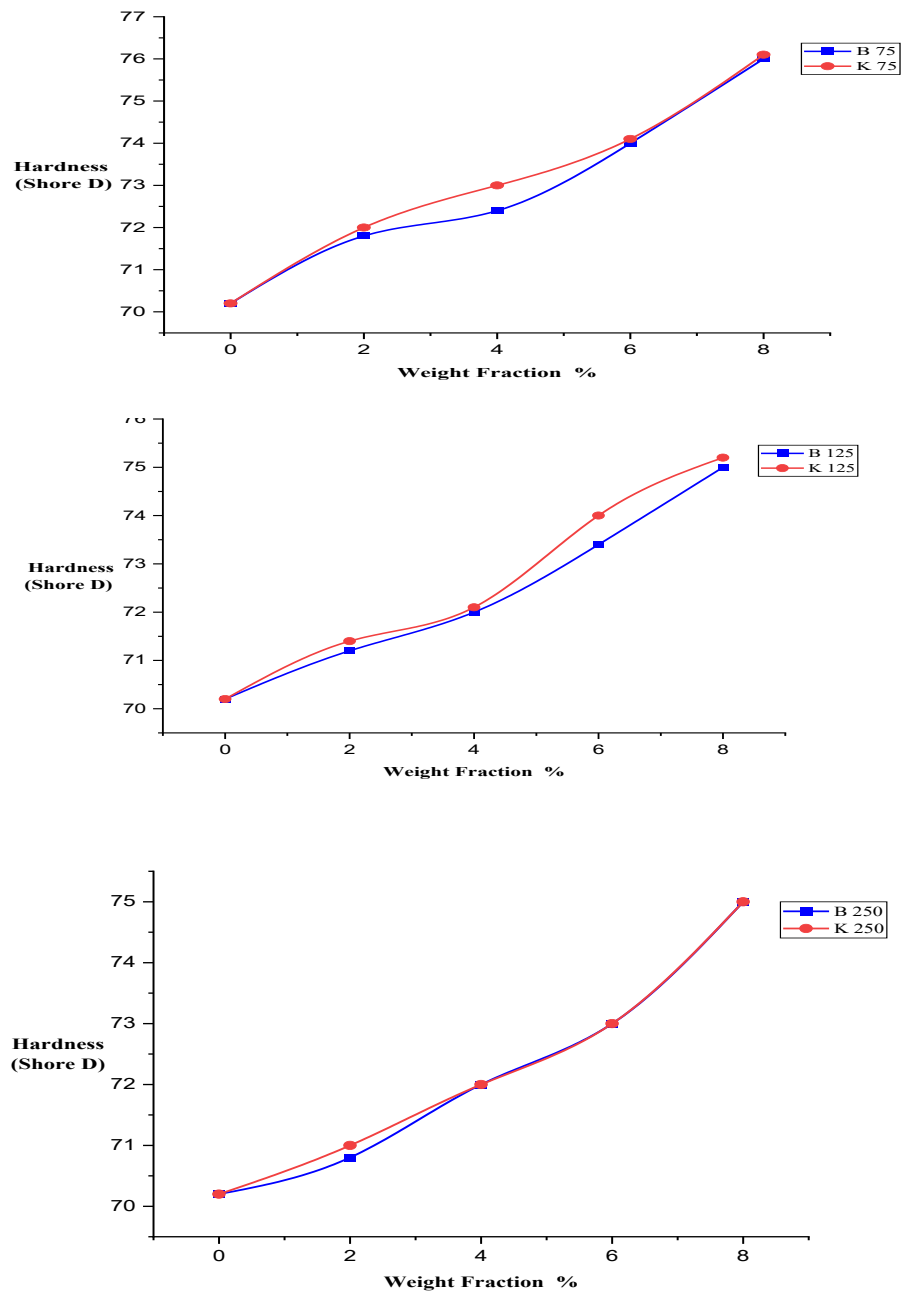


Figure 6 Hardness results of prepared samples are vs. the Weight Fraction.

Concerning polymeric materials, the thermal conductivity is determined by the lattice phonons. As thermal conductivity is a process similar to other energy transfer processes and it occurs when there is a temperature difference and leads to a heat flux that continues until the material reaches the thermal equilibrium or the temperature difference becomes equal to zero as a result of energy transfer from the side that has a higher temperature [28,31]. As we can observe the reinforcing particles increase the

thermal conductivity from about 0.818 to 1.51 $W/m.^{\circ}C$, and this is due to the existence of some minerals elements in these particles [13, 29], as shown in Figure 7.

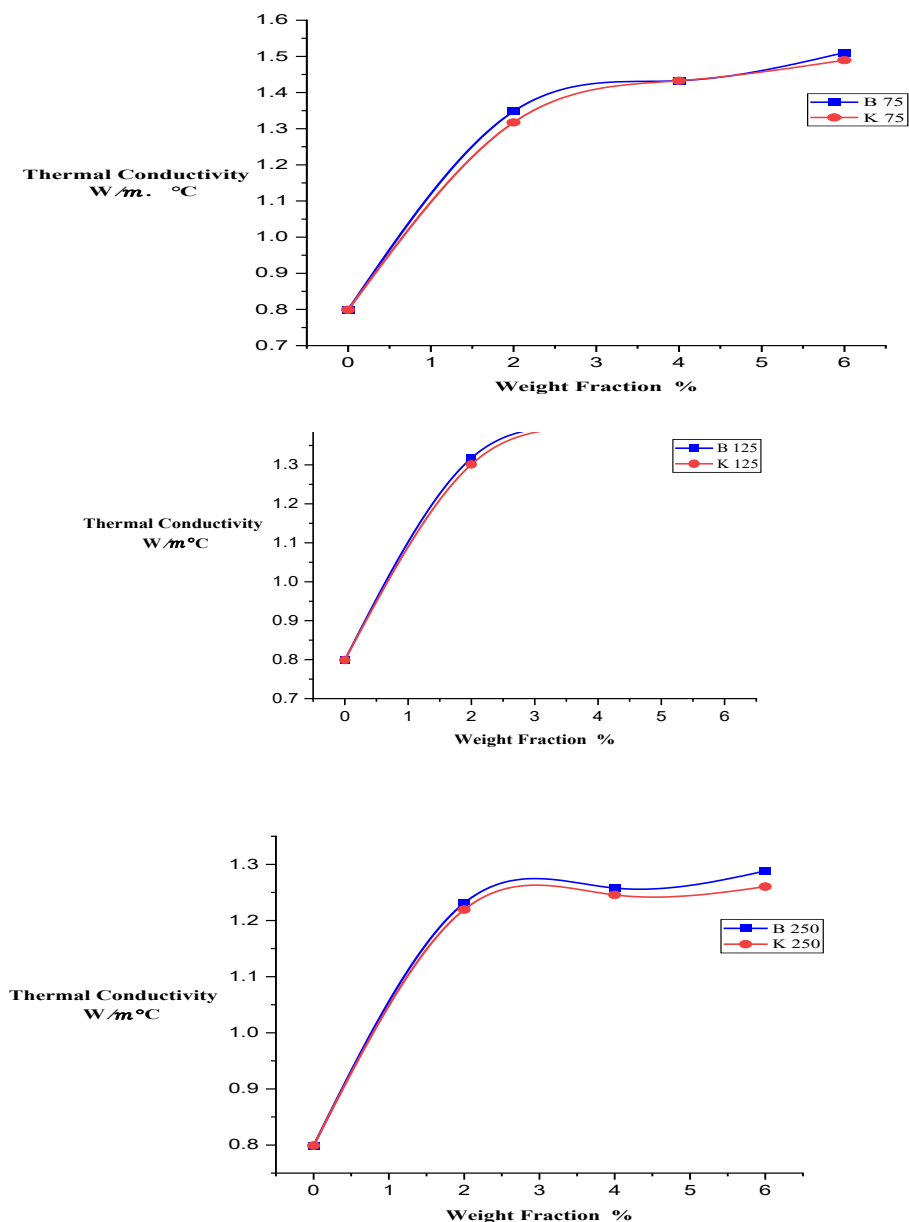


Figure 7 Thermal conductivity results of prepared samples vs the weight fraction.

4. CONCLUSIONS

Utilization of Phoenix Dactylifera L. Rachis base waste particles as a composite's reinforcement material has many advantages together, (1) improvement of the polymer composite (mechanical and thermal) properties utilizing natural waste particles as a reinforcing particle, (2) decrease and reduce

the environmental pollution, (3) decrease the diseases transition and the risks because the accumulation of these wastes is a haven for snakes, scorpions, mice, and insects. In addition, the results of mechanical features, and thermal conductivity tests of the reinforced specimens indicate the improvement of those features of the polymer composite, this indicates that they can be used in practical industrial applications.

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