

The Effect Of Phoenix Dactylifera L. Pinnae Reinforcement On The Mechanical And Thermal Properties Of Polymer Composite

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Abstract

Phoenix dactylifera l. pinnae (the green leaves of dates palm) were used as natural reinforcing (strengthening) fibers to improve the mechanical properties of polyester as a matrix material, the fibers of the green leaves of dates palm were used in two lengths, 10 and 20mm with five rates of 0, 2.5, 5, 10, and 20% , where the reinforcing with the leaves fibers increases the hardness strength from $76.5MPa$ to be about $86.55MPa$, the Impact value raised from about $0.313KJ/m^2$ to $0.461KJ/m^2$, in addition to that the flexural strength from $2.66MPa$ to be about $55MPa$, and the thermal conductivity increases from $2.54 w/m.^{\circ}C$ to $5.41 w/m.^{\circ}C$.

The results of the present search explains that the composite samples reinforced at rate 20% and 10mm fiber length gives the best results.

Keywords: Phoenix Dactylifera, Biocomposite, mechanical properties, Natural fibers.

Introduction

Composite material has wide range in industrialization and engineering fields using appropriate material such as metal, polymers and ceramics so as to obtain optimum features, these materials are being used according to the growing need of the society [1, 2].

in the last ten years, the natural fibers reinforcement of polymer composites with have received ever-increasing attention, both of the academic field and different manufactories. The attention of polymer composite reinforced by natural fiber material is increasing day-by-day, where the manufacturing of high performance materials from renewable resources is one of the most important goals at the present time pursued by researchers around the world.

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In the recent years, natural fibers have been more and more used as alternative reinforcements in polymer composites because of their relatively inexpensive (cheap), low density, environmental friendly and biodegradability [3-5].

Biocomposite can be defined as the materials combine of a polymer matrices and reinforcements, with the feature that both the matrices and the reinforcements, or one of them should at least be of biological origin [6,7]. it is known that the concept of sustainability has succeed in industries motivating to demand alternative and sustainable materials using natural fibers that can reinforce polymer composite materials for different applications [7]. in a similar way, efforts are made in the process of developing of polymer composite parts that could be an choice to supply the irregular uses of wood [3, 8, 9].

In the last years, there has been attention in developing polymer composites, which based on the short-fibers acquired from agricultural resources. It is anticipated that the fibers would not participate to the wear of polymer processing equipments and may not subjected to size decreasing during processing, which both of them occur at using of inorganic fibers [3, 4, 5, 10].

The composites of thermoplastic matrix reinforced with natural fillers, which essentially improve the mechanical achievement of the original polymers [4, 8, 9].

The additional benefit (profit gained) of reinforcing natural fibers than conventional chemical materials such as carbon fibers or glass fibers, are their specified strength features, are widely available, light weight, ease of separation, enhanced energy recovery, high toughness, non-corrosive nature, low density, low cost, (as well as good thermal and acoustic insulating merits), superior thermal features, reduced tool wear, decreased dermal and respiratory irritation, less abrasion to processing equipment, renewability and biodegradability [4, 5, 7]. Transition of industries towards production of green composite is taking place due to the increasing request of consumer, to reduce the use of synthetic material, higher sustainability, bio degradability, friendly to environment and recyclability, inexpensive etc. [1, 4, 11].

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Natural fibers are biological materials that have two main origins (1) agriculture production and (2) production residue of crops when they are processed for the primary uses. Typically, known natural fibers are wood, silk, jute, hemp, kenaf, coir, flax, bamboo and fruit fibers. Natural fibers are majorly used with thermoplastics and thermoset plastics. Thermoplastics and thermoset polymers both are non-bio degradable but thermoplastics are recycled in an easy manner as compared to thermoset [1, 2, 6]

The most important merit of natural fiber is biodegradability and noncarcinogenic which get it back into its original form, with an feature of being low cost-effective [6, 12, 13].

The other useful merits of natural fibers are non-toxicity, low energy consumption and absence of the environment pollution. In spite of these affirmative features of natural fibers, their applications are still very little and the same tendency is following for the natural fiber bio degradable composites [6, 7]. Because of that, the natural fibers (on the whole) are in some way lower quality compared with the artificial fibers in the field of the mechanical features, in addition, the compatibility of natural fiber with the polymers is also a big problem because of the natural fiber tendency to mix with other materials [13, 14]. The mechanical characteristics of natural fiber and their compatibility with polymer can be increased with the assistance of physical and chemical methods [1, 7, 15].

Fibers are the reinforcement used to sustain the load transferred through the matrix. They provide strength and stiffness to the polymer. Fibers are obtained either naturally or human-made. Fibers can be classified into three main categories, animal, mineral and plant fibers [1, 11, 16].

Plant fibers are the most abundant (available in large quantities) fiber among all the natural fiber. Hemp, Himalayan nettle, sisal, jute, kenaf, flax, abaca, ramie etc. are the commonly known plant fibers. Plant fibers are also called cellulosic fiber [1, 17-19].

Tensile and hardness tests were examined, the moisture content test was examined too because it plays a very important effect on the mechanical and physical features of the composite fabricated specimens [13, 14, 20].

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Polymers (resin) are in general classified in two types, thermoplastics, and thermosets, and in present research thermosets polymer (matrix) has been used, which has been reinforced by different type of fibers such as natural (plant, animal) and man-made fibers for various applications [9, 14, 21].

Sample Preparation

The green leaves of the palm plant were taken from the date palm directly and where they have been cut immediately with length 10 mm and width of 1 mm (where the average thickness about 1mm), then the results fibers have been washed with distilled water and also by using alcohol to remove the dirt and the suspended soil, and after that were dried (removing the moisture) at room temperature.

The types of specimens were prepared as follows: impact (Charpy) specimens conformable with ISO-179 specification, flexural strength specimens fabricated conformable with ASTM-D790 standard (3 point), hardness specimens that prepared conformable with ASTM-D2240 standard (Shore durometer) and the thermal conductivity specimens conformable with Lees disk.

The molds (Teflon material), have been wash, dry, and then lubricate in all casting steps to prevent the casts from sticking with the mold.

The properties of polymer matrix (polyester matrix), which produced in Saudi Industrial Resins Limited are shown in the following table

Table 1. The properties of the Polyester matrix

Physical State	Liquid. [Clear.]
Color	Yellow
Density	1 To 1.3 G/cm ³
Point	Not Available
Melting Point	Not Available

The casting mixtures specimens details as the following:

- 1- The first casting rate 0% fiber and 100% polyester resin.
- 2- The second casting rate 2.5% fiber and 97.5% polyester resin.
- 3- The third casting rate 5% fiber and 95% polyester resin.
- 4- The fourth casting rate 10% fiber and 90% polyester resin.
- 5- The fifth casting rate 20% fiber and 80% polyester resin.

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Results and Discussion

Figure .1. (a, b, c, d, e, f, e, g, h and i) shows the images of Phoenix Dactylifera L. Pinnae (leaves of dates palm), pure polymer, and reinforced composite specimens at 2.5%, 5%, 10%, and 20%, 3 points flexural strength, hardness (Shore durometer), and impact (Charpy) tests respectively.

Figure 2. Explains the hardness of composite samples opposite reinforcing leaves fibers rates for the two fibers lengths (10 and 20 mm), while Fig 3. Shows the impact strength of prepared samples (pure and composite samples) for the two fibers lengths, and Fig 4. Shows the flexural of prepared samples (pure and composite samples) for the two fibers lengths, while Fig 5. Shows the thermal conductivity of the prepared samples.

For the leaves fibers of **10mm** length , when a crack propagation reaches a along the green leaves fiber matrix interface, the crack front cannot break it, that means the flexible fibers sustained the applied stress, as a result or effect, additional stress is required to propagate across the interface fiber matrix interface. Therefore a lower rate of crack spread has been noticed, increasing the strength of the composites, but for the leaves fibers of **20mm** length the high length creates some voids in the fiber matrix interface (interfacial adhesion between the fiber and the matrix which represents the supporting or binding region at the contact area), which leads to diminish the fibers strength in the samples or decrease the efficiency of stress transfer.

Although the moisture is higher in the longest fibers (20mm length), and the voids created in the interface have reduced the thermal conductivity and declined the mechanical features of the composite samples.

Clearly, increase the rates of the short fibers improved the mechanical features of the samples, because of the existence of additional quantity of fibers, which increase the stress transfer along the fiber matrix interface, in addition to that; the moisture in the fiber increased the thermal conductivity of the samples.

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a



b



c



d



e



f



g



i

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Fig .1. The images of (a) Phoenix Dactylifera L. Pinnae, (b) Pure polymer specimen, and (c-f) reinforced composite specimens rates, (c) at 2.5%, (d) 5%, (e) 10%, (f) 20%, (g) flexural, (h) hardness, and (i) impact tests respectively.

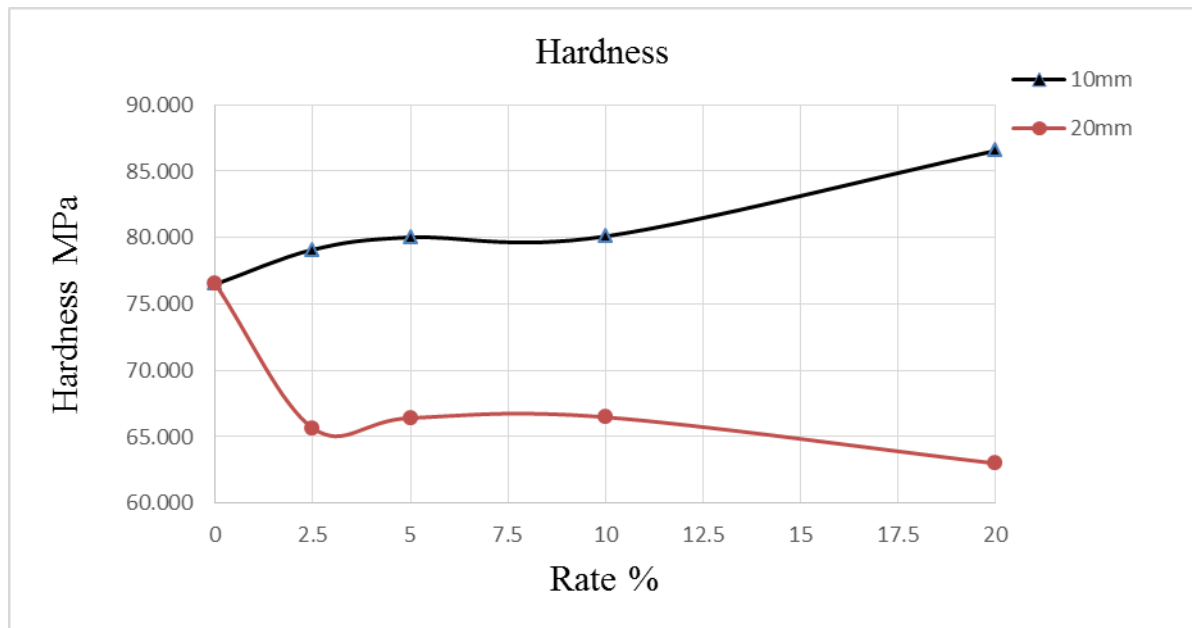


FIGURE 2. Hardness test results of composite samples opposite reinforcing rates for the two fiber lengths.

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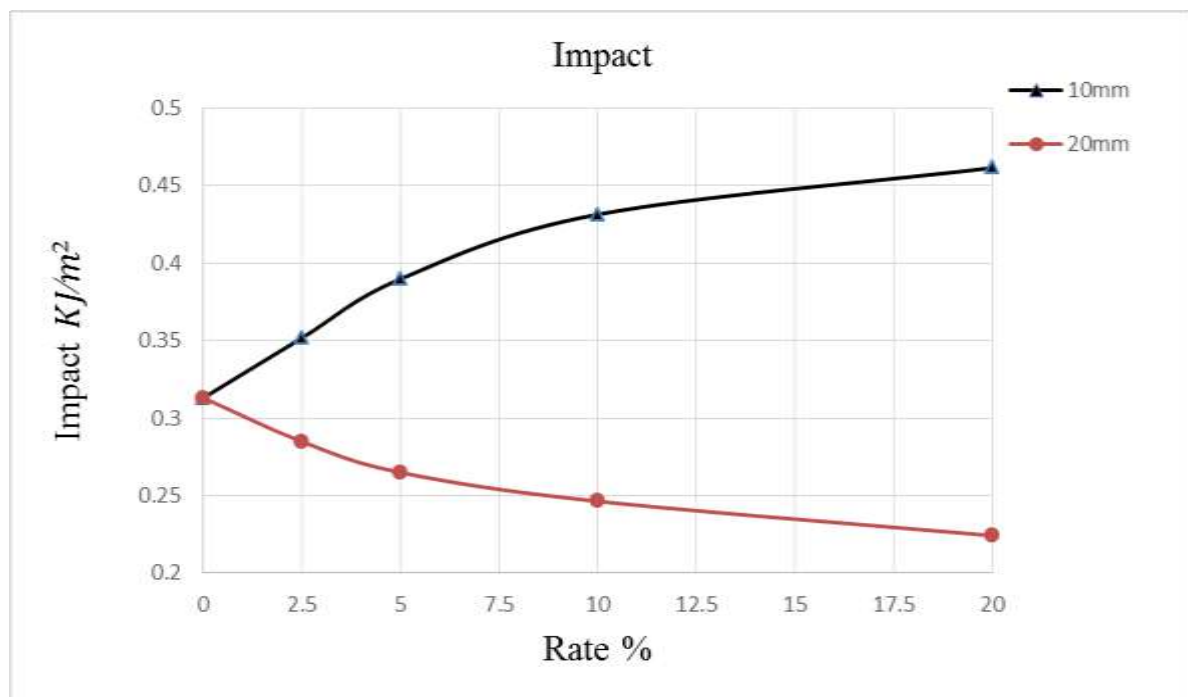


FIGURE 3. Impact test results of composite samples opposite reinforcing rates for the two fiber lengths.

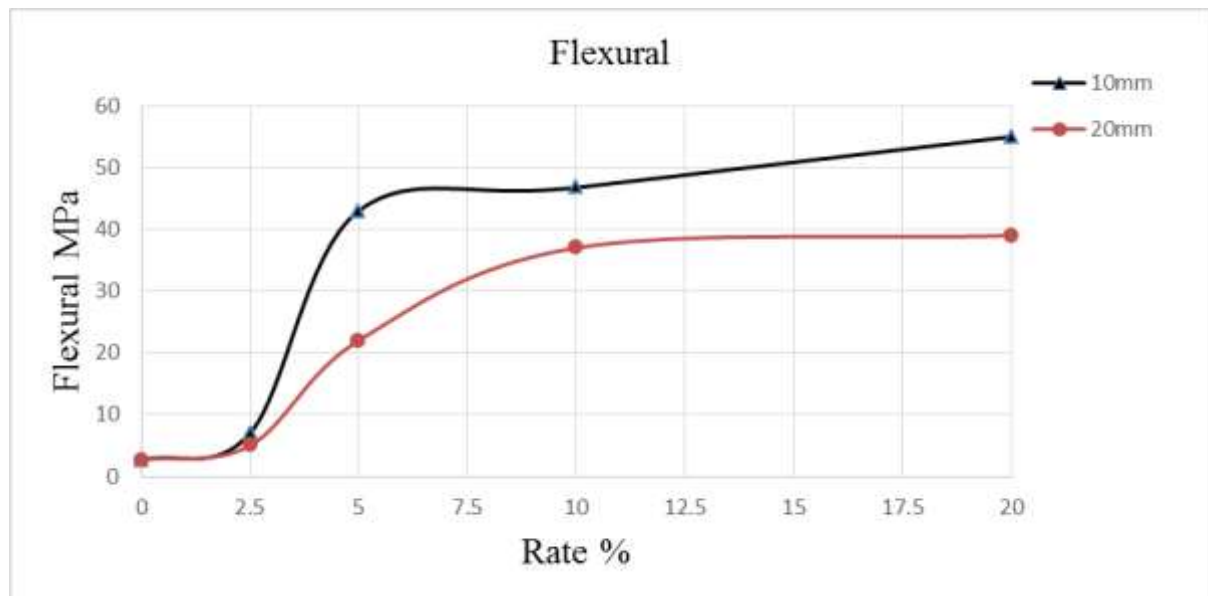


FIGURE 4. Flexural test results of composite samples opposite reinforcing rates for the two fiber lengths.

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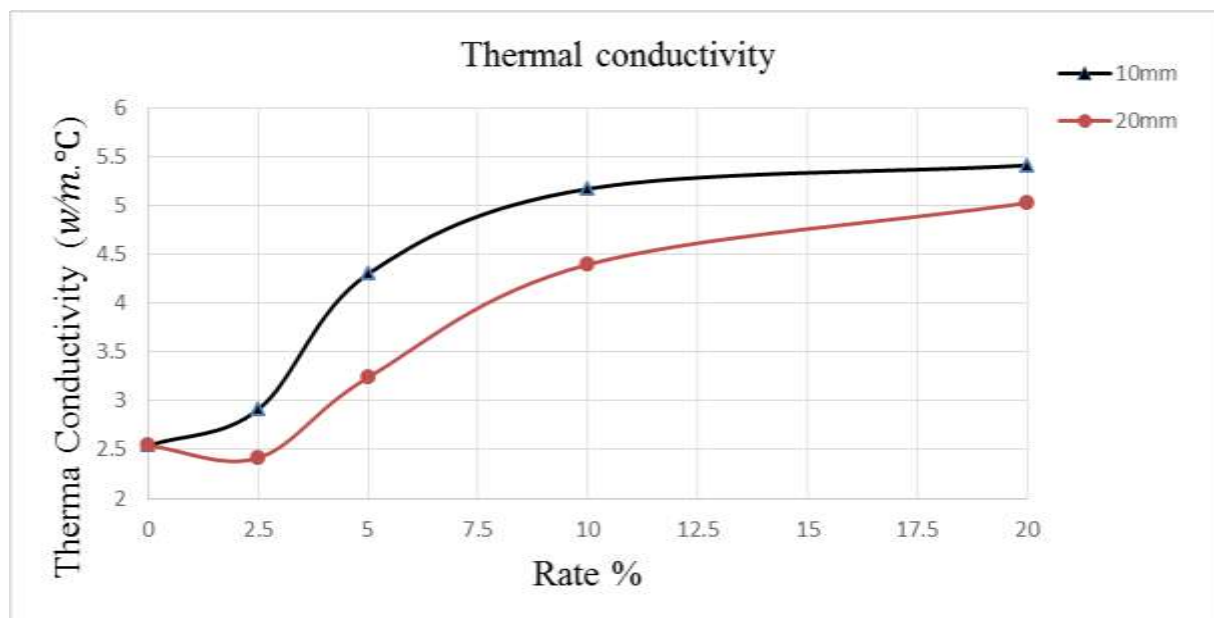


FIGURE 5. Thermal conductivity test results of composite samples opposite reinforcing rates for the two fiber lengths.

Conclusion

Using of Phoenix dactylifera l. pinnae (the green leaves of dates palm) as a reinforce fiber for polymeric composites (polyester) has many advantages at the same time. The first benefit is the improvement the mechanical features of polymer composite by using the natural fiber (Biocomposite) as a reinforcement fiber, the second is the reduction of environmental pollution by reduced of using chemical (materials) fibers. Where the results of the hardness, Flexural, impact, and thermal conductivity tests of the samples reinforced by green leaves of dates palm demonstrated the improvement of the mechanical properties of polymer composite prepared samples, making it useful in practical applications.

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