Effects of Particle Size, Pumice Powder Filling on The Water Absorption Behavior, and Elongation at Break Properties of Walnut Husk Particles Reinforced Epoxy Composite

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Abstract

In the present study, three different walnut husk particles were applied as reinforced material used for manufacturing epoxy-based composites, and the influence of pumice powder content (20wt%) on the water absorption, and elongation at break properties of composites was investigated. Composites were prepared by hand lay-up method. Water absorption of the composites decreased with adding filler content. Finally, was concluded that pumice powder-filled is effective for improving the performance of walnut husk/epoxy composites. This behavior was found to relate to the efficient modification of the hydrophilic characteristics of walnut husk particles. However, The elongation at the break of composites significantly decreased with adding of the pumice powder.

Keywords: Green composites, Walnut husk particles, Pumice powder, Water uptake

1. Introduction

Increasing carbon emissions and substantial change in global climate have necessitated the use of biodegradable and eco-friendly materials in various industrial applications [1]. This cause, in recent years, using bio-filters for the development of biodegradable composite has received much attention, as they are environmentally friendly. Acceptably, polymers are reinforced with fibers or fillers to produce materials that are suitable for industrial requirements [2]. In the literature, many different grades of particle-shaped agricultural waste fillers have been investigated, such as almond husk [3], rice husk [4], peanut shell [5], walnut and other lignified plant parts [6] More researchers have recently used walnut husk, and its particles to produce polymer composites

Walnut (Juglans regia L.) is an important crop that is cultivated throughout the world's temperate regions for its edible nuts. Worldwide walnut production reached approximately 7.25 million tons in 2016, being China, USA, Iran, and Turkey the main producers [7, 8]. Whereas the walnut kernel is highly interesting for the food industry, the shell has no economic value or industrial usage. thus representing an annual agricultural waste that accounts for around 2.17 million tons [7, 8]. Several investigators have studied different properties of polymer composites using walnut husk reinforcements Phadhan and satapathy studied Physico-mechanical characterization and thermal property evaluation of polyester composites filled with walnut shell powder. Mortava -jorda et al. show that the dual incorporation into PLA/PCL of up to 20 wt % WSF and 5 phr MLO successfully yielded composites with improved ductility and a minimal loss in mechanical strength and toughness. Barczewski et al reported, application of sunflower husk, hazelnut shell and walnut shell as waste agricultural fillers for epoxy-based composites. However, It has been seen that reinforcement in composite alone does not fulfill the required properties in the applications. Henceforth, a suitable filler is sometimes required to achieve the desired properties. For this purpose, pumice powder was used as a filler in this study. Pumice is one of the important natural fillers. Among them, pumice is one of the volcanic - based alumina - silica, which is composed of 60% of SiO_2 [9]. Pumice has a porous structure and its porous structure is formed by dissolved gases precipitated during the cooling of lava hurtles through the air .Due to its porous structure, it has low density, high thermal insulation, and chemical resistance which make them a preferential material for industrial applications [10]. The present study explores the possibility of developing an epoxy-based composite reinforced with walnut husk particles and to carry out its water absorption behavior and elongation at break characterization.

2. Experimental

2.1. Materials

The investigations were carried out on polymer composite materials based on thePurpox® epoxy resin EFLR-0190 provided by Polikor Inc.Turkey. Composites have prepared with the 20% pumice powder and 80% with walnut husks particle content and fractions of 250 µm and 630, and1000 µm (Table 1). Firstly, the walnut shells used as a reinforced material were ground in a two-step process. Stage I in a The Mortar Grinder RM-200, and Stage II in a Microtrac Retsch GMBH, Germany. After grinding, the resulting particles was passed through sieves with different mesh sizes in order to obtain different particles fractions.

Table. 1 Composition of walnut husk particles with pumice powder

Samples Codes	Sieve mesh size of walnut shell, µm	Walnut shell particles content, (wt%)	Filler content, (wt%)	Type of filler	Sieve mesh size of pumice powder, µm
S_1	250	100	-	-	-
S_2	250	80	20	Pumice powder	< 250
S_3	630	100	-	-	-
S_4	630	80	20	Pumice powder	< 250
S_5	1000	100	-	-	-
S_6	1000	80	20	Pumice powder	< 250

2.2.Manufacturing of composites

Epoxy resin is mixed with the hardener at a 100:50 ratio by weight is recommended.walnut husk particles are then added into this mixture of epoxy resin, at different walnut particles size (100%wt.1000, 100%wt.630, and 100%wt.250 µm) proportions as well as (80 wt .% walnut husk particles and 20 wt. % pumice powder) to prepare the composites. A simple hand lay-up technique is used to prepare the composites by pouring the dough into appropriate metal molds (per an ASTM standard D3039). The mixture is left in the molds for 48 h for curing at room temperature. After complete curing, the composites are taken out of the molds.

2.3. Water Absorption Test

The evolution of the water absorption was followed for a period of 23 days with the samples of 4 × 10 × 80 mm^3 immersed in distilled water at 22 ± 1 ^{0}C.and PH 6.7. The samples were taken out and weighed daily, after removing the residual water with a dry cloth, using a Sartorius GL 224i-1CEU, with a precision of ± 0.0001 mg. Measurements were performed in triplicate. Using Eq.(1) the absorbed moisture content of each of the samples was calculated [11].

$$W_{\text{water absorption}} = \left[\frac{Wt-Wo}{Wo}\right] \times 100 \qquad (1)$$

Where, W_t is the sample's weight after immersion time and W_o is the sample's initial weigth.

2.4. Elongation Analysis

Elongation at break properties of the walnut husk particles -pumice powder reinforced epoxy composites were investigated by using (Model BMT 100E, Besmak, Turkey). testing instrument. elongation analyses of the composites were performed according to ASTM D 3039 standard. The tests were conducted at a crosshead speed of 2mm/min with a 100 kN load cell.

3. Results and Discussion

3.1. Water Absorption Test

The water absorption behaviors of the various samples at temperatures 22± 1 ^{0}C, and P^H 6.7 distilled water conditions are presented in Fig 1. A decrease in the water absorption was observed when filled with the pumice powder as shown in the moisture absorption curve. An increase in the water absorption of the S_1 sample was observed. This was attributed to the hydrophilicity property of the walnut husk particles. In the case of the pumice powder filled with 20 wt % and 80 wt % Walnut husk particles (250µm) water absorption increased with immersion time reaching a plateau after approximately 15 days. This can be explained by the good filler/ reinforced materials matrix interaction, which caused a reduction in the movement or speed of the diffusing particles. Similar results have been reported by [12, 7, 2]. Similar absorption curves but with significantly higher values were observed for the pumice powder with 20 wt % and 80 wt % walnut husk particles size (630, µm and 1000µm) compared to S_2 sample. It seems therefore that, in terms of water absorption, the use of the pumice powder to make them more hydrophobic will be necessary to lower water uptake in a damp atmosphere.

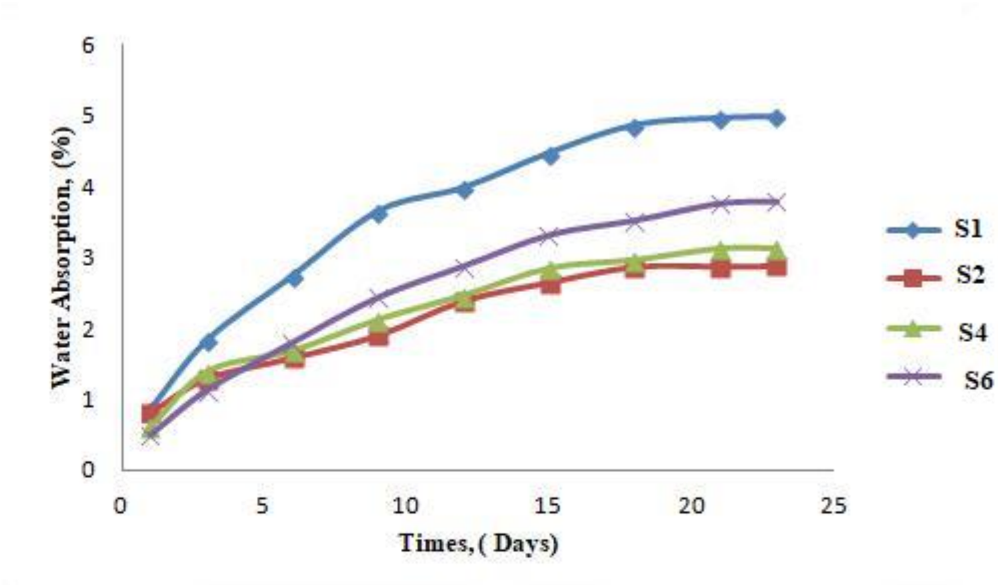

Fig.1. Shows the percentage of water absorption results for composites

3.2 Elongation Analysis

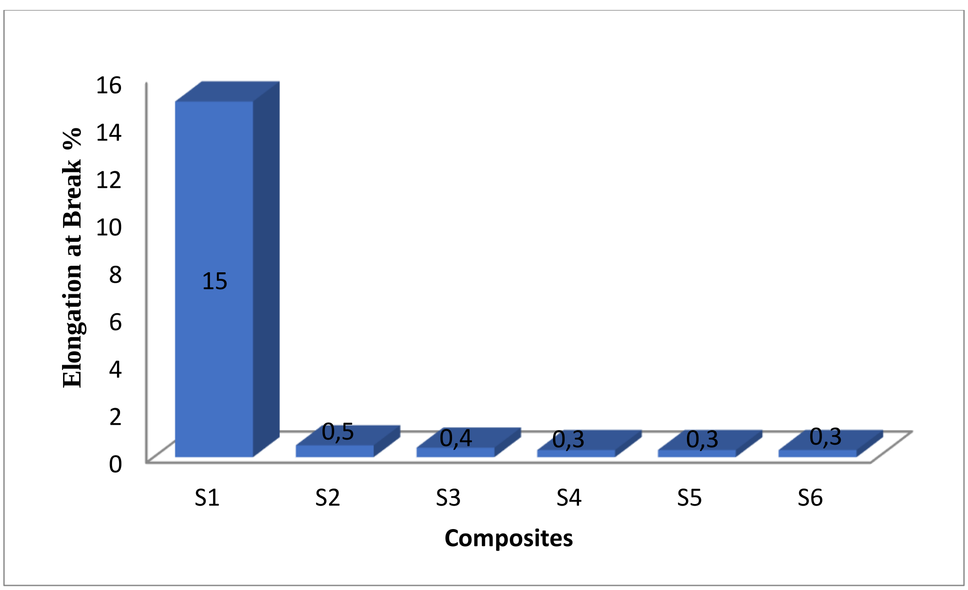

Fig. 2. Elongation at break properties of the composites

The effect of particle size on the elongation at break of epoxy/walnut husk particles composites is shown in Fig.2. The particle size varies from 1000 µm, 630 µm, and 250 µm.

It is clearly shown that for a given particulate size fraction, the composite elongation at break decreases with filled pumice powder. The addition of pumice powder decreased the elongation at break properties of the composites. The highest elongation at break properties was obtained by using 250 µm walnut husk particles. 630µm and 1000 µm walnut husk particles reinforced /epoxy composites have the lowest elongation at break properties. This indicates that the elongation at break increases with a decreasing surface area of the filled particles through a less efficient stress transfer mechanism, and due to loss of plasticizer. On the other hand, The elongation at break of S_2 - S_6 composites decreased with the increase of filler loading. This showed that the mobility of the polymer chains has been reduced by the rigid fillers. Ismail et al. (2004) reported that the addition of maleic anhydride to the waste PVC/NBR blends showed lowerelongation at break, EB compared to the untreated

A similar effect on the elongation properties of filler articles has been described [13]. This results is supported by the [14, 15, 16].

4. Conclusion

Ground agricultural waste materials: walnut husk particles as a reinforced material and pumice powder was used as fillers for the production of inexpensive, and eco-friendly epoxy-based composites. This study demonstrates that the elongation at the break of composites decreased with the increase of filler loading. On the other hand, a higher elongation value at break was observed for walnut husk particles 100 wt % composite compared to S_2- S_6 composites at any filler loading. The water absorption analyses showed that the addition of pumice powder filler increased the water absorption stability of the composites. The results and findings of this study proved that can be successfully used to promote better interfacial adhesion between epoxy matrix and walnut husk particles, and pumice powder thus producing composites.

References

[1] Selvaraj, M., Narayanan, P., Rudramurthy, G., Palanisamy, S. (2021). Physico-mechanical, Chemical Composition and Thermal Properties of Cellulose Fiber from Hibiscus vitifolius Plant Stalk for Polymer Composites. Journal of Natural Fibers, 1-16.

[2] Stalina, B., Nagaprasadb, N., Vigneshc, V., Ravichandrand, M., Rajinie, N., Oluwarotimi Ismailf,S., Mohammadg, M. (2020). Evaluation of mechanical, thermal and water absorption behaviors of Polyalthia longifolia seed reinforced vinyl ester composites. Carbohydrate Polymers, (248), 116748

[3] Quiles-Carrillo, L., Montanes, N., Garcia-Garcia, D., Carbonell-Verdu, A., Balart, R.; Torres-Giner, S. (2018). Effect of different compatibilizers on injection-molded green composite pieces based on polylactide filled with almond shell flour. Compos. Part B Eng. 147, 76–85.

[4] Yussuf, A., Massoumi, I., Hassan, A. (2010). Comparison of polylactic acid/kenaf and polylactic acid/rise husk composites. The influence of the natural fibers on the mechanical, thermal and biodegradability properties. J. Polym. Environ. 18, 422–429.

[5] Garcia-Garcia, D., Carbonell-Verdu, A., Jordá-Vilaplana, A., Balart, R., Garcia-Sanoguera, D. (2016). Development and characterization of green composites from bio-based polyethylene and peanut shell. J. Appl. Polym. Science, 133.

[6] Barczewski, M., Salasinska, K., Szulc, J. (2019). Application of sunflower husk, hazelnut shell and walnut shell as waste agricultural fillers for epoxy-based composites: A study into mechanical behavior related to structural and rheological properties. Polymer Testing, 75, 1-11.

[7] Montava-Jordà, S., Quiles-Carrillo, L., Richard, N., Torres- Giner, S., Montanes, N. (2019). Enhanced Interfacial Adhesion of Polylactide/Poly(ε-caprolactone)/Walnut Shell Flour Composites by Reactive Extrusion with Maleinized Linseed Oil. Polymers, 11,(758), 1-21

[8] Ebrahimi, A., Zarei, A.; Fatahi, R., Varnamkhasti, M.G. (2009). Study on some morphological and physical attributes of walnut used in mass models. Sci. Hortic. 121, 490–494

[9] Sever, K., Atagür, M., Tunçalp, Altay, L., Seki, Y., M., Sarıkanat, M.(2018). The effect of pumice powder on mechanical and thermal properties of polypropylene. Journal of thermoplastic Composite Materials, 32(8), 1092-1106.

[10] Ramesan, M-T., Chippy, J., Jayakrishnan, P., Anilkumar ,T. 2018. Multifunctional Ternary Composites of Poly(Vinyl Alcohol)/ Cashew Tree Gum/Pumice Particles. Polymer Composites, 38-45.

[11] Krishna, M.P., Kireeti, M.P., Krishna, M.R., Jyothi, Y., Swami, G.R.K. (2018). Mechanical properties of fly/sawdust reinforced epoxy hybrid composites. Materials today proceedings, (5), 13025-13030.

[12] Koyuncu, M. (2022). Experimental investigation of epoxy matrix and pine wood sawdust reinforced wood-polymer composite materials. Bioresources, 17(1), 1161-1172.

[13] Rokbi, M., Khaldoune, A., Sanjay, M-R., Senthamaraikannan, P., Ati, A., Siengchin, S. (2019). Effect of processing parameters on tensile properties of recycled polypropylene based composites reinforced with jute fabrics. International Journal of Lightweight Materials and Manufacture, 1-6.

[14] Ramli, N-F., Ghani, S-A., Teh, P-L. (2015). Effect of PVC-MA Coupling Agent on Tensile, Water Absorption and Morphological Properties of Recycled High Density Polyethylene/Ethylene Vinyl Acetate/Eggshell Powder Composites. Journal of Advanced Research in Materials Science, 10(1), 1-11.

[15] Ovalı, S., Mıstık, S-I. (2017). Investıgatıon of tensile strength and elongation properties of basalt fiber-pumıce reinforced polypropylene composites. The journal of science and techology, 7(1), 63-67.

[16] Ismail, H., Supri, A-M., Yusof,M. (2004). Blend of waste poly(vinylchloride) (PVCw)/acrylonitrile butadiene-rubber (NBR): the effect of maleic anhydride (MAH), Polymer Testing, 23 (6), 675–683.