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Production of Date Seed Reinforced Polyester Composite and Characterization of Its Thermophysical Properties

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Abstract **–** In this research, ground date seeds are reinforced into orthophthalic-based unsaturated polyester (UP). After the physical mixing takes place, methyl ethyl ketone peroxide (MEKP) and cobalt octoate (Co Oc) are added to the mixture for the chemical reaction. After the resulting polyester composite is poured into standard molds, it is waited for 24 hours to cure. Then, physical tests and chemical analyses of the composite are performed. Date seed as a filler reduces the bulk density of the polyester composite. The addition of a high amount of filler (8 wt.%) negatively affects both the pore distribution and surface morphology of the composite. It is understood that the thermal conductivity coefficient and Shore D hardness of the composite decrease by waste biomass filler. In experimental optimization studies, approximately 4 wt.% date seed reinforcement can be recommended for composite production. According to the thermal decomposition activation energy results, date seed reinforcement slightly reduces the thermal stability of polyester composites. Thus, the production of environmentally friendly, low carbon footprint and economical polyester composites can be achieved.

Keywords – Date Seed, Polyester Composite, Bulk Density, Shore D Hardness, Thermal Conductivity

I. INTRODUCTION

New materials obtained by physically mixing at least two different materials are called composite materials. Composite material production aims to develop and combine mechanical (strength, toughness, etc.) and/or physical (electrical conductivity, thermal conductivity, etc.) properties that cannot be achieved with a single material [1]. Composite materials are preferred because they are strong, light, and cheap [2]. When it comes to composite materials, it is desired to further improve the material's qualities and eliminate any current flaws before it is produced [3]. Polyester is a low-viscosity resin with good wetting ability, affordability, and resistance to chemical and environmental impacts. Polyesters are strong there setting polymeric materials that can be classified as aromatic or aliphatic based on their backbone structure. They can be synthetic or natural [4,5].

When choosing reinforcement material for composite constructions, factors including economy, electrical-thermal conductivity, fatigue resistance, strength, and we resistance are crucial. It is a commonly used technique to support composite materials with different types and amounts of natural fibers that alone cannot achieve some of the desired physical and/or chemical qualities in application [6]. Jute, sisal, linen, and other natural fibers are used in place of synthetic fibers like carbon or glass fiber in composite structures that need reinforcement. Natural fibers like fibers are being more and more used every day. Natural fiber-reinforced composites are recommended because of their attributes like biodegradability and recyclability in light of the growing environmental pollution [7].

Commercially and environmentally acceptable items made from renewable resources that are recyclable or biodegradable are known as sustainable bio-based products. The market for biopolymers and biocomposite materials is expanding quickly due to the development of economically and environmentally sustainable production methods as well as material reuse and recycling [8]. These composites' primary benefits include excellent thermal, electrical, and acoustic insulation, ease of processing, availability, non-corrosive behavior, low cost, low density, biodegradability, non-toxicity, and environmental friendliness [9,10].

Vegetable fibers are lignocellulosic by nature, made up of water-soluble and waxy compounds as well as cellulose, hemicellulose, lignin, and pectin. Even for the same type of fibers, these compositions can vary based on growing conditions and testing procedures, and as a result, physical and mechanical qualities can also change. Because they are inexpensive, plentiful, and renewable, natural polymers are some of the polymers that are being studied with attention today. Biocomposites, also known as green polymers, are environmentally friendly because they are made from biodegradable polymers and natural fibers [11-13]. For example, date seeds obtained from the date fruit are often discarded as waste and can be recycled by grinding them and using them as animal feed. It can occasionally be added to soil to raise its organic matter content [15].

Studies in the literature characterize some thermophysical properties of polyester composites. Low-density materials can generally be obtained from polyester composites. This feature makes it lightweight and provides ease of transportation and processing. Especially when used in the industry, its lightness makes clothes comfortable and useful. The hardness and durability of polyester composites make them preferred in many areas. It usually has high levels of hardness, which means the material is resistant to scratches, impacts, and abrasion. This feature makes the material long-lasting and durable when used in areas such as automotive and construction. The thermal conductivity coefficient of polyester composites is generally low, and this feature increases the insulation properties of the material and prevents heat transfer. For this reason, it makes polyester is preferred in building materials, especially in applications requiring thermal insulation. Polyester materials generally have high thermal stability, meaning they can remain stable over a wide temperature range. This property means that the material is resistant to deformation or degradation at high temperatures. These properties help the material provide advantages in certain applications and make polyester preferred in various sectors [16-25].

In this research, waste date seeds are ground and reinforced as filler into the polyester composite. With such studies, it is aimed to produce environmentally friendly composites by using agricultural wastes. In addition, low carbon footprint and economical composites are developed by reducing the petrochemical raw material rates used. Low-density, easy-to-process, low thermal conductivity and economical polyester composites are produced according to the intended use [26-34].

II. MATERIAL AND METHOD

Materials

Turkuaz Polyester Company (Türkiye) provided the orthophthalic-based unsaturated polyester (UP), methyl ethyl ketone peroxide (MEKP), and cobalt octoate (Co Oc) used in this investigation. Furthermore, the local enterprise (Elazığ, Türkiye) provides date seed. The experimental manufacturing scheme in a laboratory setting is depicted in Figure 1. The production rates of each component in the composite are displayed in Table 1.

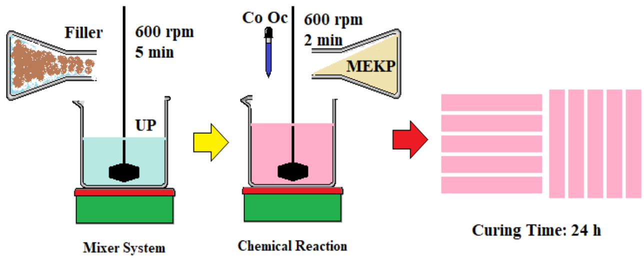

Fig. 1. Date seed reinforced polyester composite production scheme

Table 1. Experimental production plan and usage rates of components

UP (wt.%)	MEKP (wt.%)	Co Oc (wt.%)	Filler (wt.%)
98.0	1.5	0.5	0.0
96.0	1.5	0.5	2.0
94.0	1.5	0.5	4.0
92.0	1.5	0.5	6.0
90.0	1.5	0.5	8.0

Production method in experimental studies

Date seeds are split into tiny bits and then crushed. It is then combined with orthophthalic-based UP. The mixture is then combined with MEKP and Co Oc once it has become homogenous. It is mixed briefly before being poured into molds that are common. The required chemical analysis and physical tests are completed after a 24-hour curing period [35-39].

Bulk density tests

After the curing process is finished, polyester composites' bulk densities are calculated. By measuring the samples once more using a digital caliper, the measurements of the ones collected in standard molds are verified. The rectangular prism-shaped molds' width (0.5 cm), length (2 cm), and length (10 cm) numbers are multiplied to determine the volume. A sensitive scale is used to measure the sample's weight, and the matrix density of the composite is calculated by dividing its weight by its volume [40].

Shore D hardness test

Shore D hardness device is used to measure the samples' surface hardness. Each sample is measured three times on a smooth surface, and the average value is used to calculate the hardness values.

Thermal decomposition experiments

Experiments on polyester composites' thermal degradation are conducted at temperatures ranging from 25 °C to 625 °C. The thermal degradation of samples obtained in an inert environment occurs at a rate of 10 °C per minute. Temperature increases with time in a PID controlled system, and mass losses in the polymer are monitored.

III. RESULTS AND DISCUSSION

Bulk density results of composites

Figure 2 expresses the density of the polyester composite made by reinforcing date seed. It is recognized that the bulk density of the polyester composite reduces when the waste rate rises.

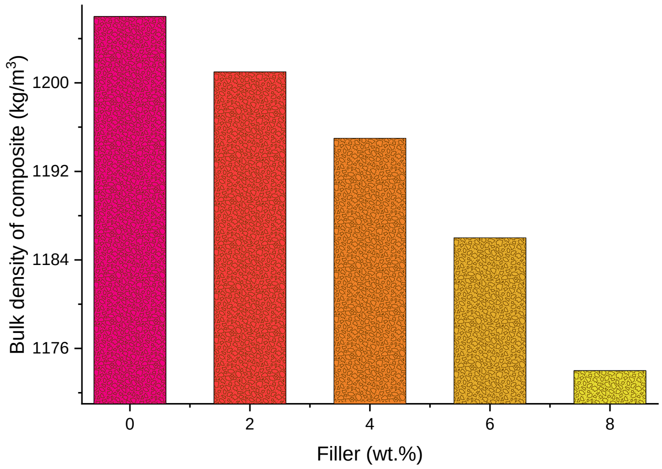

Fig. 2. Effect of filler on the bulk density of the composite

Shore D hardness results of composites

Figure 3 illustrates how the percentage of date seed affects the polyester composite's Shore D hardness. The hardness of the polyester composite diminishes with an increase in the mass percentage of waste cloth. It follows that there has been an improvement in the polyester composite's processability.

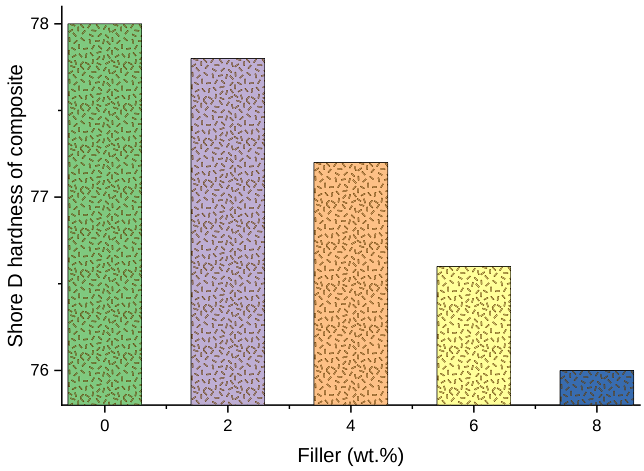

Fig. 3. Effect of date seed reinforcement on the hardness of the composite

Thermal conductivity results of composites

Figure 4 displays the polyester composite's test results for the thermal conductivity coefficient. The composite's thermal conductivity coefficient falls as the date seed ratio in polyester rises.

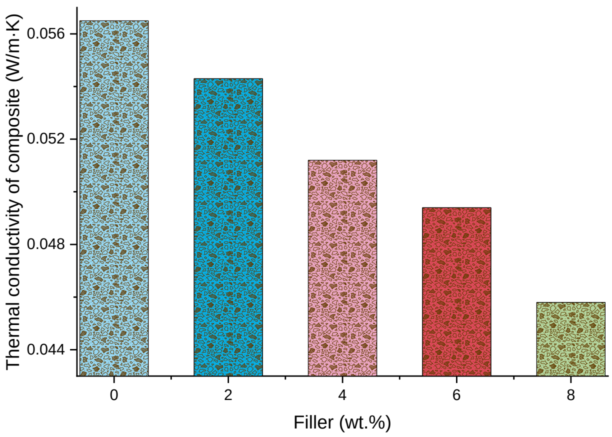

Fig. 4. Effect of date seed ratio on the thermal conductivity of composite

Activation energy results of composites

According to the thermal decomposition experiment results, date seed reduce the activation energy of the composite (Figure 5). Activation energy values are calculated according to Coast Redfern method. The data in the thermal degradation test curves are evaluated according to this method. A slight decrease in the activation energy indicates that the thermal stability of the polyester composite has decreased.

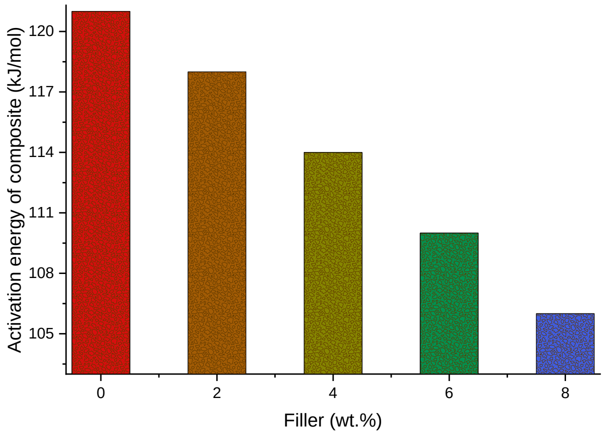

Fig. 5. Effect of date seed supplementation on activation energy

In Coast Redfern method, calculations are made using a three-dimensional diffusion (Jander) equation. The highest R^2 values have been obtained with this equation.

IV. CONCLUSIONS

The findings indicate that adding date seed debris to the mixture lowers the composite's bulk density and hardness. In tests, the finest polyester composites could be produced with five weight percent date seed. The pore distribution and surface shape of the composite are harmed by higher ratios of reinforcement made of these wastes. The polyester composite gains improved mechanical properties and become more processable thanks to these wastes. Shore D hardness evaluations show that date seed reduces the hardness of the composite. It has been discovered that the composite's thermal conductivity coefficient somewhat decreases when date seed reinforcement is added. In polyester composite thermal disintegration studies, date seed reinforcing is found to somewhat reduce thermal stability.

REFERENCES

[1] Şahal, H., Aydoğmuş, E., *Production of SBS Reinforced Polyester Composite: Characterization of Physical and Chemical Properties*. Journal of the Turkish Chemical Society Section A: Chemistry, 2023: 10(3), 827-834.

[2] Fowler, P. A., Hughes, J. M., Elias, R. M., *Biocomposites: technology, environmental credential sand market forces*. Journal of the Science of Food and Agriculture, 2006: 86(12), 1781-1789.

[3] Kuru, D., Akpinar Borazan, A., Guru, M., *Effect of chicken feat her and boron compounds as filler on mechanical and flame retardancy properties of polymer composite materials*. Waste Management & Research, 2018: 36(11), 1029-1036.

[4] Aydoğmuş, E., Demirpolat, A. B., *Evaluation of Production Mechanism of Polyester Composites: Determination of Physical and Chemical Properties*. Pioneer and Contemporary Studies in Engineering, 2023: 141-154.

[5] Valerio, O., Misra, M., Mohanty, A. K., *Poly (glycerol-co-diacids) polyesters: from glycerol biorefinery to sustainable engineering applications, a review*. ACS Sustainable Chemistry & Engineering, 2018: 6(5), 5681-5693.

[6] Karataş, M., Aydoğmuş, E., *Physical and Chemical Properties of Organic Waste Reinforced Polyester Composites*. International Journal of Advanced Natural Sciences and Engineering Researches, 2023: 7(4), 16-19.

[7] Kabir, M. M., Wang, H., Lau, K. T., Cardona, F., *Chemical treatments on plant-based natural fibers in forced polymer composites: An overview*. Composites Part B: Engineering, 2012: 43(7), 2883-2892.

[8] Soroudi, A., Jakubowicz, I., *Recycling of bioplastics, their blends and biocomposites: A* review. European Polymer Journal, 2013: *49*(10), 2839-2858.

[9] Sharma, N. K., Kumar, V., *Studies on properties of banana fiber reinforced green composite. Journal of Reinforced Plastics and Composites*, 2013: *32*(8), 525-532.

[10] Balaji, A., Udhayasankar, R., Karthikeyan, B., Swaminathan, J., Purushothaman, R., *Mechanical and thermal characterization of bagasse fiber/coconut shell particle hybrid biocomposites reinforced with cardanol resin*. Results in

Chemistry, 2020: 2, 100056.
[11] Latif, R., Wakeel, S., Zaman Khan, N., Noor Siddiquee, A., Lal Verma, S., Akhtar Khan, Z., *Surface treatments of plant fibers and their effects on mechanical properties of fiber-reinforced composites: A review*. Journal of Reinforced Plastics and Composites, 2019: 38(1), 15-30.
[12] Karimah, A., Ridho, M. R., Munawar, S. S., Ismadi, Amin, Y., Damayanti, R., Siengchin, S., *A comprehensive review on natural fibers: technological and socio-economical aspects*. Polymers, 2021: 13(24), 4280.
[13] Vilaplana, F., Strömberg, E., Karlsson, S., *Environmental and resource aspects of sustainable bio composites*. Polymer Degradation and Stability, 2010: 95(11), 2147-2161.
[14] Robinson, M. L., Brown, B., Williams, C. F., *The date palm in southern Nevada*. University of Nevada Cooperative Extension, 2012: 23, 1-26.
[15] Tafti, A. G., Dahdivan, N. S., Yasini Ardakani S. A., *Physicochemical properties and applications of date seed and its oil*. 2017: 1399-1406.
[16] Karataş, M., Aydoğmuş, E., *Use of Inorganic Wastes as Fillers in Production of Polyester Composites and Evaluation of Properties of Obtained Composite*. International Journal of Advanced Natural Sciences and Engineering Researches, 2023: 7(4), 20-24.
[17] Şahal, H., Aydoğmuş, E., *Use of Sunflower Seed Shells as Filler in Polyester Resin and Characterization of Obtained Composite*. In International Conference on Engineering, Natural and Social Sciences, 2023: 233-236.
[18] Buran, A., Durğun, M. E., Aydoğmuş, E., Arslanoğlu, H., *Determination of thermophysical properties of Ficus elastica leaves reinforced epoxy composite*. Firat University Journal of Experimental and Computational Engineering, 2023: 2(1), 12-22.
[19] Buran, A., Durğun, M. E., Aydoğmuş, E., *Cornus alba Reinforced Polyester-Epoxy Hybrid Composite Production and Characterization*. Avrupa Bilim ve Teknoloji Dergisi, 2022: 43, 116-120.
[20] Karataş, M., Aydoğmuş, E., *Obtaining Pectin Reinforced Polyester Composite and Investigation of Thermophysical Properties*. Avrupa Bilim ve Teknoloji Dergisi, 2023: 48, 64-66.
[21] Orhan, R., Aydoğmuş, E., *Investigation of some thermophysical properties of Asphodelus aestivus reinforced polyester composite*. Firat University Journal of Experimental and Computational Engineering, 2022: 1(3), 103-109.
[22] Dağ, M., Aydoğmuş, E., Yalçin, Z. G., Arslanoğlu, H., *Diatomite reinforced modified safflower oil-based epoxy biocomposite production: Optimization with RSM and assessment of outcomes by ANN*. Materials Today Communications, 2023: 35, 106327.
[23] Yilmaz, E., Aydoğmuş, E., Demir, A., *Life Cycle Assessment and Characterization of Tincal Ore Reinforced Polyester and Vinylester Composites*. Journal of the Turkish Chemical Society Section B: Chemical Engineering, 2022: 5(2), 183-194.
[24] Orhan, R., Aydoğmuş, E., *Production and characterization of waste corncob reinforced polyester composite*. Avrupa Bilim ve Teknoloji Dergisi, 2022: 42, 176-179.
[25] Dağ, M., Yanen, C., Aydoğmuş, E., *Effect of boron factory components on thermophysical properties of epoxy composite*. European Journal of Science and Technology, 2022: 36, 151-154.
[26] Aydoğmuş, E., Arslanoğlu, H., *Kinetics of thermal decomposition of the polyester nanocomposites*. Petroleum Science and Technology, 2021: 39(13-14), 484-500.
[27] Pekdemir, E., Aydoğmuş, E., Arslanoğlu, H., *Thermal decomposition kinetics of synthesized poly (N-isopropyl acrylamide) and Fe_3O_4 coated nanocomposite: Evaluation of calculated activation energy by RSM*. Petroleum Science and Technology, 2023: 1-18.
[28] Aydoğmuş, E., Dağ, M., Yalçın, Z. G., Arslanoğlu, H., *Synthesis and characterization of EPS reinforced modified castor oil-based epoxy biocomposite*. Journal of Building Engineering, 2022: 47, 103897.
[29] Şahal, H., Aydoğmuş, E., *Investigation of thermophysical properties of polyester composites produced with synthesized MSG and nano-alumina*. Avrupa Bilim ve Teknoloji Dergisi, 2022: 34, 95-99.
[30] Demirel, M. H., Aydoğmuş, E., *Production and characterization of waste mask reinforced polyester composite*. İnönü Üniversitesi Sağlık Hizmetleri Meslek Yüksek Okulu Dergisi, 2022: 10(1), 41-49.
[31] Aydoğmuş, E., Arslanoğlu, H., Dağ, M. *Production of waste polyethylene terephthalate reinforced biocomposite with RSM design and evaluation of thermophysical properties by ANN*. Journal of Building Engineering, 2021: 44, 103337.
[32] Aydoğmuş, E., Aydın, M., Arslanoğlu, H., *Production and characterization of microsphere reinforced polyester composite: Modeling of thermal decomposition with ANN and optimization studies by RSM*. Petroleum Science and Technology, 2022: 1-17.
[33] Yanen, C., Aydoğmuş, E., *Characterization of thermo-physical properties of nanoparticle reinforced the polyester nanocomposite*. Dicle Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 2021: 10(2), 121-132.
[34] Şahal, H., Aydoğmuş, E., *Production and characterization of palm oil based epoxy biocomposite by RSM design*. Hittite Journal of Science and Engineering, 2021: 8(4), 287-297.
[35] Yanen, C., Dağ, M., Aydoğmuş, E., *Investigation of thermophysical properties of colemanite, ulexite, and tincal reinforced polyester composites*. Avrupa Bilim ve Teknoloji Dergisi, 2022: (36), 155-159.
[36] Demirel, M. H., Aydoğmuş, E., *Waste Polyurethane Reinforced Polyester Composite, Production, and Characterization*. Journal of the Turkish Chemical Society Section A: Chemistry, 2022: 9(2), 443-452.
[37] Şahal, H., Aydoğmuş, E., Arslanoğlu, H., *Investigation of thermophysical properties of synthesized SA and nano-alumina reinforced polyester composites*. Petroleum Science and Technology, 2023: 41(23), 2173-2189.
[38] Aydoğmuş, E., *Biohybrid nanocomposite production and characterization by RSM investigation of thermal*

decomposition kinetics with ANN. Biomass Conversion and Biorefinery, 2022: 12(10), 4799-4816.

[39] Aydoğmuş, E., Dağ, M., Yalçın, Z. G., Arslanoğlu, H., *Synthesis and characterization of waste polyethylene reinforced modified castor oil-based polyester biocomposite*. Journal of Applied Polymer Science, 2022: 139(27), e52526.

[40] Orhan, R., Aydoğmuş, E., Topuz, S., Arslanoğlu, H., *Investigation of thermo-mechanical characteristics of borax reinforced polyester composites*. Journal of Building Engineering, 2021: 42, 103051.