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Research Article

Physical and Chemical Properties of Organic Waste Reinforced Polyester Composites

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Abstract **–** Organic wastes constitute an important part of environmental pollution. Disposal of these wastes can be achieved either by using recycling methods or as reinforcement material. In this study, research has been carried out on the use of organic wastes in composite materials. For example, the effects of organic fillers on the physical and chemical properties of polyester composites have been investigated. Organic wastes (biomass) are prepared as fillers after drying and grinding. Especially, biomass samples with a fibrous structure improve the mechanical properties of composites. The use of such organic wastes in polyester composites is preferred for obtaining both economical and low-density materials. However, such fillers should be used in optimum proportions in the composite. Because the use of these wastes at a high rate negatively affects both the surface morphology and the pore structure of polyester composites. Besides, the evaluation of these wastes in the production of polyester composites reduces the carbon footprint. Such fillers interact physically in the polyester composite. If no chemical modification is made, it does not react with polyester components and does not make a chemical bond. According to the evaluated results, it reduces the density and hardness of the polyester composite. Also, it decreases the thermal conductivity coefficient and thermal stability, albeit slightly.

Keywords – Organic Wastes, Polyester Composite, Thermal Conductivity, Mechanical Properties, Thermal Stability

I. INTRODUCTION

Increasing environmental and health concerns, efforts to increase independence from non-renewable fossil fuel sources, and lower costs have led to increased interest in natural fiber reinforced biocomposites [1]. In light of the developments in technology, it has gained great importance to develop new generation biomaterials instead of materials that are harmful to the environment and human health. However, due to the uneconomical nature of producing fully biobased materials, combining petroleum and bio-based resources may be a preferable way to develop a cost-effective product with excellent applications [2,3].

It is aimed to produce composite materials with high performance by providing features such as improved mechanical and thermal properties, cost reduction, density control, ease of processing, flame retardancy, abrasion resistance, and improvements in electrical properties with various reinforcement and filler additives [4]. Composite materials are a type of material consisting of two or more different components that are combined to obtain the desired properties consisting of matrix, reinforcement, and filler components. Polyester resins, one of the widely used matrix materials such as polyurethane, epoxy, polyethylene, polyvinyl chloride, polycarbonates, and polypropylene, are also frequently used in polymer composites with their low cost and unique mechanical and physicochemical properties [5-11].

Polyester resins are modified with organic and inorganic fillers to have enhanced tensile, bending, and impact strengths. The harmony between the organic natural fiber and the polyester matrix, or their strong distribution, enables the composite to form a chemical bond with the filler, thereby increasing its strength and stiffness [12].

Uncontrolled disposal of organic wastes has become a major problem all over the world due to environmental pollution, eutrophication, residue flow, land availability, and its negative effects on human health. By incorporating organic wastes into composite materials, a new material with improved physical, thermal, and mechanical properties and better biodegradation is obtained [13,14].

Büyükkaya et al. aimed to determine the mechanical and thermal properties of the composites and to find out whether these composites are suitable for structural applications in their study where they produced polyester matrix composites by using nutshell, corn stalk, nettle fiber, and nettle stalk as filling materials, which are not used in the industry. This study showed that the composites produced with nettle sap wastes, which have the lowest density, are suitable for construction applications as a green insulation material with a low thermal conductivity coefficient and quite light [15].

Dong and Davies investigated the effect of the flexural strength of macadamia nutshell particle-reinforced polyester composites and showed that the addition of macadamia nutshell particles did not improve the flexural strength of polyester and the strength decreased with increasing void content [16].

To determine the tribological performance of polyester composites reinforced by agricultural wastes, İbrahim carried out polymeric composites filled with palm fronds and mango dry leaves. In this study, in which the tribological effects of the type and size of the filler particles were examined, it was found that the friction coefficient decreased significantly and the wear rate decreased with the increase of the soft particles in the dry leaves of mango. Therefore, it has been emphasized that polyester composites reinforced with dry leaves of mango can be used for industrial applications such as lubricants where a low coefficient of friction and high wear resistance are required [17].

In studies on polyester composites, organic and inorganic fillers can be used together, depending on the purpose of use. In composites obtained by reinforcing organic (biomass) wastes, it may be desired to increase in properties such as density and hardness. In particular, the use of inorganic fillers together with organic additives can improve the physical properties of composites. For example, boron factory components (such as borax, colemanite, tincal, and ulexite) increase the thermal stability of the polyester composite. Besides, nanosized particles such as aerosils, microspheres, and alumina can improve the thermophysical properties of composites. Moreover, similar developments can be achieved in nanocomposites produced by inorganic nanocoating [18-27].

The use of some waste polymers in polyester composites makes them economical and functional. Waste polyethylene terephthalate, expanded polystyrene, and waste masks are also evaluated in the composite. Such wastes cause environmental pollution and are recycled. To use these wastes in the composite, they must be prepared as drying, grinding, and reinforcing materials [28-31].

In the production of polyester and epoxy composites, bioresources not only make a physical interaction but also make chemical bonds with some modifications. For example, vegetable oils such as palm and castor oil are preferred in the synthesis of epoxy and polyester raw materials. It has been used with petrochemicals raw materials and provides important contributions to the production of biocomposites [32-34].

Also, many composites are produced by using fibrous structures of plants, biomass wastes, and fillers such as pectin in studies in the literature. Especially the fibrous structures of plants are preferred over polyester composite. The use of such waste biomass reduces the density and hardness of the composite and increases its workability. The choice of bioresources is very important for the development of both economical and environmentally friendly composites and for reducing the carbon footprint [35-39].

This article reports a study reporting the effects of using organic wastes as fillers on the physical and chemical properties of polyester composites. It has been investigated how non-industrial biomass waste affects the density, hardness, thermal conductivity coefficient, and thermal stability of the polyester composite.

II. MATERIAL AND METHOD

Biomass sources are used in polyester composites after they are prepared as fillers. After the vegetable sources or wastes are collected, they are dried, ground, and prepared as filler. Renewable resources are sourced locally.

Unsaturated polyester, methyl ethyl ketone peroxide, cobalt octoate, and similar petrochemical components are supplied by Polyester Companies.

III. RESULTS AND DISCUSSION

The characteristic properties of polyester composites obtained by using organic wastes and biomass sources are given below:

- The use of renewable resources in biocomposites reduces the carbon footprint.
- Biomass wastes have been evaluated and environmentally friendly composites are produced.
- Low density organic wastes reduce the densities of polyester composites.
- Biomass sources used as filler decrease the surface hardness of the composite.
- Organic wastes improve the workability of the polyester composite.
- In particular, the mechanical strength properties of fibrous biomass reinforced polyester composites are improving.
- Both surface morphology and pore structure of highly biomass reinforced polyester composites are negatively affected.
- The use of organic wastes as reinforcing material in the optimum ratio in experimental studies develops some physical properties of composites.
- According to the data obtained from the thermal degradation test results, biomass supplementation slightly reduces the thermal stability of the polyester composite.
- In the thermal conductivity coefficient measurements, the thermal conductivity coefficient of the biomass reinforced polyester composites increases, albeit slightly.
- In the production of polyester composites, chemical reactions can also be carried out by modifying bioresources.
- Biomass resources reduce production costs in polyester composite production.
- It decreases the use of petrochemical raw materials in the production of polyester composites of organic biomass and wastes.
- The use of biomass resources at minimum, optimum, and maximum rates affects the thermophysical properties of polyester composites.

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