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Use of Sunflower Seed Shells as Filler in Polyester Resin and Characterization of Obtained Composite

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***Abstract* –** In this research, the shells of waste sunflower seeds (WSS) are ground and used in polyester resin as filler. The shells of the ground sunflower seeds are mixed into orthophthalic unsaturated polyester (UP) at the ratios of 0 wt.%, 1 wt.%, 3 wt.%, and 5 wt.%, and a homogeneous mixture is prepared for composite production. Then, certain amounts of methyl ethyl ketone peroxide (MEKP) and cobalt octoate (Co Oc) are added to the mixture. After the mixture becomes gel-like with physical interaction and chemical reactions, it is cast into standard molds. The shells of sunflower seeds provide a physical interaction in the polyester composite as filler. UP, MEKP, and Co Oc produce the polyester composite with an exothermic chemical reaction. After waiting for the obtained composite to cure for 24 hours, the necessary physical tests and chemical analyses are performed. According to the results, WSS reinforcement reduces the density, hardness, and activation energy of the polyester composite. The thermal conductivity coefficient of the composite increases with the addition of WSS, albeit slightly. In the experimental results, 3 wt.% WSS reinforcement is determined as the optimum ratio in polyester composite production. The use of higher ratios of filler adversely affects both the surface morphology and the pore structure of the composite.

Keywords – Sunflower Seed Shell, Polyester Composite, Thermal Conductivity, Activation Energy

I. Introduction

The reason why polymeric materials are preferred in industrial areas such as aviation, space construction, packaging, coating of metal objects, storage of radioactive wastes, and electronics is due to their thermal, mechanical, dielectric, morphological conductivity, physicochemical, viscometric, and rheological properties [1-7]. The poor combustion resistance and thermal properties of widely used polymers are conspicuous limitations of their applicability [8].

Polyester polymers are effective for lower shrinkage properties, environmental resistance, water resistance, good electrical insulation, bond strength, and higher chemical resistance. Also, unreinforced polymers exhibit lower resistance to shear due to lower toughness and impact strength. Therefore, reinforcement offers improved wear resistance, improved mechanical properties, lower vibration, lightness, and higher load-carrying capacity [9-11].

Composite materials inherit their impressive properties from their individuals and provide enhanced functionality through the interaction of their perfect parents. Therefore, recent discoveries in the field of new functional composites are paving the way for exciting applications in modern science and technology [12-16].

The conversion of naturally reproducible biomass resources into value-added bio-based products has attracted increasing attention worldwide as it can reduce the problems caused by oil consumption [17]. Biomass materials, which exhibit the properties of nontoxic and renewability, have been considered as a potential alternative to the existing traditional chemical materials in many fields [18,19].

In this study, waste sunflower seed shells are used in the production of polyester composites. A low-density, economical, and environmentally friendly polyester composite is being developed. Both fewer petrochemicals are used and composite materials with low carbon footprint and easy processing can be produced [20-25].

II. Materials and Method

UP, MEKP, and Co Oc components used in this study are purchased from Turkuaz Polyester Company [26-30]. In addition, the shells of sunflower seeds are supplied by a local company (Elazığ).

Figure 1 shows the production scheme of WSS reinforced polyester composite. Table 1 presents the experimental study plan and the proportions of each component.

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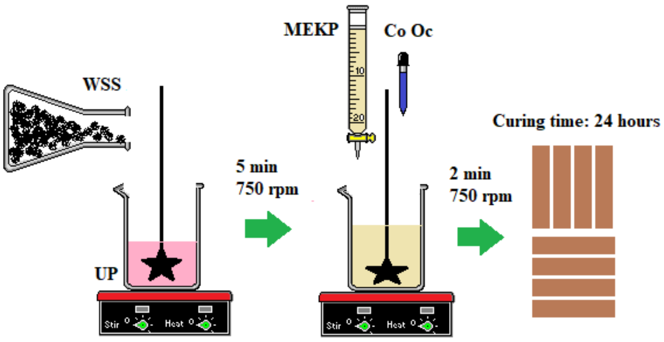

Fig. 1 Production scheme for WSS reinforced composite

Table 1. Experimental work plan for the composite

UP (wt.%)	MEKP (wt.%)	Co Oc (wt.%)	WSS (wt.%)
98	1.5	0.5	0
97	1.5	0.5	1
95	1.5	0.5	3
93	1.5	0.5	5

III. Results and Discussions

The density, hardness, thermal conductivity, and activation energy of the obtained WSS reinforced composites have been determined.

In Figure 2, it is seen that the density of the polyester composite decreases as the filler (WSS) ratio increases. According to Shore D hardness results, WSS reinforcement reduces the hardness of polyester composites (Figure 3). Also, as can be seen in Figure 4, the thermal conductivity coefficients of the composites raise slightly with the addition of filler.

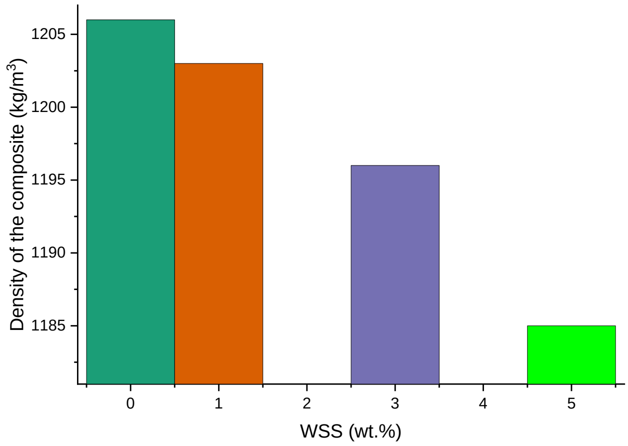

Fig. 2 The effect of WSS reinforcement on the density of the composites

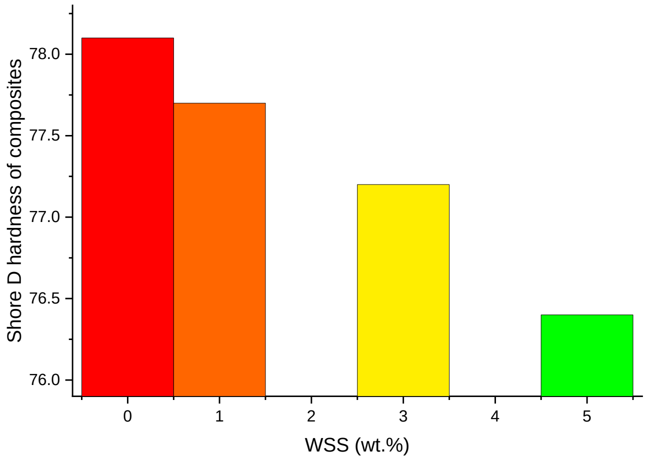

Fig. 3 The effect of WSS reinforcement on the hardness of the composites

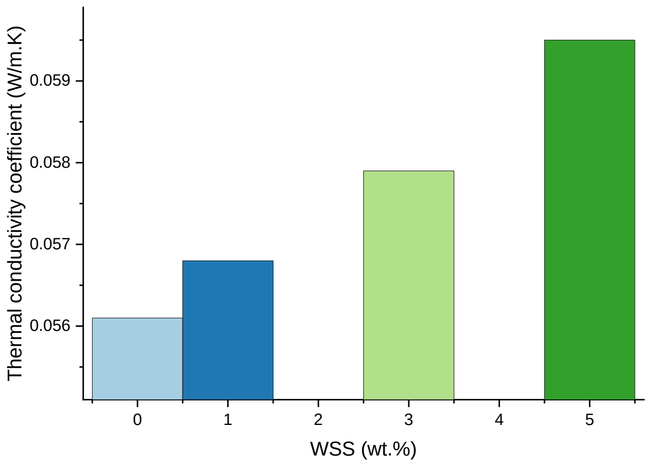

Fig. 4 The effect of WSS reinforcement on the thermal conductivity of the composites

Activation energy values of polyester composites are calculated according to the data obtained in thermal decomposition experiments. Thermal decomposition tests have been carried out at a temperature range of 20 °C to 60 °C, in an inert environment, and at a temperature increase rate of 10 °C/min. In Coast Redfern method, calculations are made at 0.2 to 0.8 conversion ratios using the three-dimensional diffusion function. In Table 2, it has been determined that the activation energy decreases as WSS ratio increases. Thus, it is understood that WSS filler reinforcement slightly reduces the thermal stability of the composites [31-40].

Table 2. The activation energy of the composites

WSS (wt.%)	Activation energy (*E*: kJ/mol)
0	120.813
1	117.594
3	114.673
5	113.108

IV. CONCLUSIONS

In this study, WSS reinforced polyester composite production has been carried out. The use of such biomass waste fillers contributes to the production of economical, easy-to-process, and low-density composites. Reducing petrochemical resources and using biomass wastes in polyester composite production decrease the carbon footprint. In the experimental results, both the surface morphology and the pore structure of the composite produced by using the optimum ratio (3 wt.%) filler material are not adversely affected. This research will shed light on future research on the production of such environmentally friendly composites.

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