Avrupa Bilim ve Teknoloji Dergisi
Özel Sayı 42, S. 176-179, Ekim 2022

Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
Special Issue. 42, pp. 176-179, October 2022

Research Article

Production and Characterization of Waste Corncob Reinforced Polyester Composite

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(2nd International Conference on Applied Engineering and Natural Sciences ICAENS 2022, October 15-18, 2022)

(**DOI:** 10.31590/ejosat.1183062)

ATIF/REFERENCE: Orhan, R., & Aydoğmuş, E. (2022). Production and Characterization of Waste Corncob Reinforced Polyester Composite. *European Journal of Science and Technology*, (42), 176-179.

Abstract

In this study, waste corncobs are ground and used in the polyester composite. Homogeneous distribution is provided by mixing it into unsaturated polyester (UP) as a filler under laboratory conditions. Then, methyl ethyl ketone peroxide (MEKP) and cobalt octoate (Co Oc) catalysts are added to the mixture. After mixing the additives and fillers used in certain amounts for a short time, the polyester composites are poured into standard molds and waited for curing. The density, Shore D hardness, and thermal decomposition behavior of the composite obtained after curing have been investigated. As the amount of corncob in the mixture increases, the density of the polyester composite decreases. Besides, the rise in the ratio of this filler in the mixture also increases the porosity of the polyester composite. In the thermal conductivity measurements, it is seen that the thermal conductivity coefficient of the polyester composite increases, albeit slightly, according to the increasing amount of filler. Also, corncob reinforcement reduces both Shore D hardness and activation energy of the polyester composite. According to the results obtained, it was observed that the use of corncob reinforcement above 3 wt.% negatively affected the surface morphology and mechanical properties of the composite. While obtaining an economical and light polyester composite, attention should be paid to the amount of filler so that both thermal and mechanical properties are not weakened.

Keywords: Polyester composite, Waste corncob, Thermal conductivity, Activation energy, Density, Hardness.

Atık Mısır Koçanı Takviyeli Polyester Kompozit Üretimi ve Karakterizasyonu

Öz

Bu çalışmada atık mısır koçanları öğütülerek polyester kompozitte kullanılmıştır. Laboratuvar koşullarında dolgu maddesi olarak doymamış polyester (UP) içerisine karıştırılarak homojen dağılım sağlanır. Daha sonra karışıma metil etil keton peroksit (MEKP) ve kobalt oktoat (Co Oc) katalizörleri eklenir. Belirli miktarlarda kullanılan katkı ve dolgu maddeleri kısa süre karıştırıldıktan sonra polyester kompozitler standart kalıplara dökülerek kürlenmesi için beklenir. Kürleme sonrası elde edilen kompozitin yoğunluğu, Shore D sertliği ve termal bozunma davranışı incelenmiştir. Karışımdaki mısır koçanı miktarı arttıkça polyester kompozitin yoğunluğu azalır. Ayrıca karışımdaki dolgu maddesinin oranının artması polyester kompozitin gözenekliliğini de artırmaktadır. Isıl iletkenlik ölçümlerinde, artan dolgu miktarına göre polyester kompozitin ısıl iletkenlik katsayısının az da olsa arttığı görülmektedir. Ayrıca mısır koçanı takviyesi, polyester kompozitin hem Shore D sertliğini hem de aktivasyon enerjisini azaltmaktadır. Elde edilen sonuçlara göre ağırlıkça % 3'ün üzerinde mısır koçanı takviyesi kullanımının kompozitin yüzey morfolojisini ve mekanik özelliklerini olumsuz yönde etkilediği görülmüştür. Ekonomik ve hafif bir polyester kompozit elde edilirken hem termal hem de mekanik özelliklerin zayıflamaması için dolgu miktarına dikkat edilmelidir.

Anahtar Kelimeler: Polyester kompozit, Atık mısır koçanı, Termal iletkenlik, Aktivasyon enerjisi, Yoğunluk, Sertlik.

1. Introduction

Today, studies on the production of polyester composites are becoming widespread. Many biomass wastes are used especially to reduce their density and thermal conductivity. Nanoparticles such as graphene and carbon nanotubes are used to strengthen their mechanical properties [1]. Besides, biomass with a fibrous structure can also increase the mechanical strength of the composite. However, it is necessary to pay attention to the amount of fillers used to improve the surface morphology, pore structure and surface hardness of the composite obtained [2].

In studies in the literature, fillers such as borax, colemanite, ulexite, clay, tincal, aerosil, alumina, pumice, perlite, and diatomite were used in polyester composites. Generally, light fillings are preferred to reduce the density of the obtained composite. High-density inorganic additives are used to increase the hardness and density of the produced polyester composite [3-8].

Besides, some polymeric wastes and recycling products are also used in the production of polyester composites. Thus, both environmentally harmful wastes are eliminated and economical composites are obtained [9,10].

It is known that fillers physically strengthen the structure of the composite. Some biomass wastes, modified castor, and palm oils can react chemically. With the use of these, biocomposites can be produced. Thus, fewer petrochemicals are used and environmentally friendly composites are obtained [11-13].

In this study, corncob with a fibrous structure is used as a filler in the polyester composite. Such biomass wastes are preferred to obtain low-density and economical polyester composite. Both the surface morphology and mechanical properties of polyester are improved by the use of filler at an optimum ratio. Also, the thermal stability of the polyester composite should be considered. The density, porosity, hardness, flexibility, and thermal conductivity coefficient of the composite produced according to the purpose of use can be changed by the filler ratio.

2. Material and Method

Waste corn cobs used in experimental studies were obtained after harvesting in Elazığ. Unsaturated polyester (UP), methyl ethyl ketone peroxide (MEKP), and cobalt octoate (Co Oc) were supplied from Turkuaz Company.

After drying at 75 °C for 3 hours, the waste corn cobs were ground to -50/100 mesh particle size and prepared as a filling material. After adding the prepared filler into the unsaturated polyester, it was mixed at 1000 rpm for 5 min. Then, certain amounts of MEKP and Co Oc components were added to the mixture and mixed at 1000 rpm for 2 min, and cast into standard molds. After the obtained polyester composite was cured for 24 hours, necessary tests and analyzes were carried out [14,15].

Figure 1 shows the grain structure of the waste corn cob after drying and grinding. In Figure 2, the polyester composite production process is briefly described. Table 1 lists the amounts of each component used in the composite.

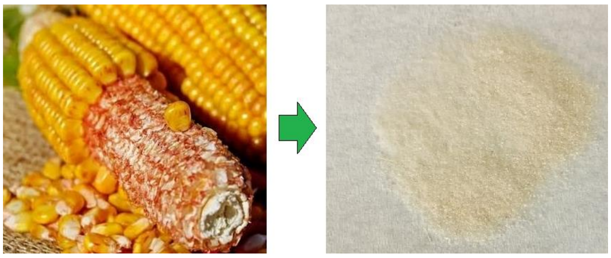

Figure 1. Waste corncob and its ground powder

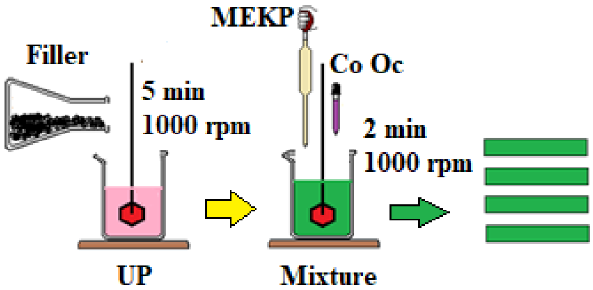

Figure 2. Polyester composite production scheme

Table 1. Quantities of additives and fillers used

UP (g)	MEKP (g)	Co Oc (g)	Filler (g)
9.80	0.15	0.05	0.00
9.70	0.15	0.05	0.10
9.65	0.15	0.05	0.15
9.50	0.15	0.05	0.30
9.30	0.15	0.05	0.50

3. Results and Discussion

According to the results obtained, it is seen that corncob reinforcement reduces the density of the polyester composite (Fig.3). Similarly, as the amount of filler increases, Shore D hardness of the composite decreases (Fig. 4). Fig. 5 shows the variation of the thermal conductivity coefficient of the polyester composite. It is understood from this graph that the thermal conductivity coefficient is increasing, albeit slightly.

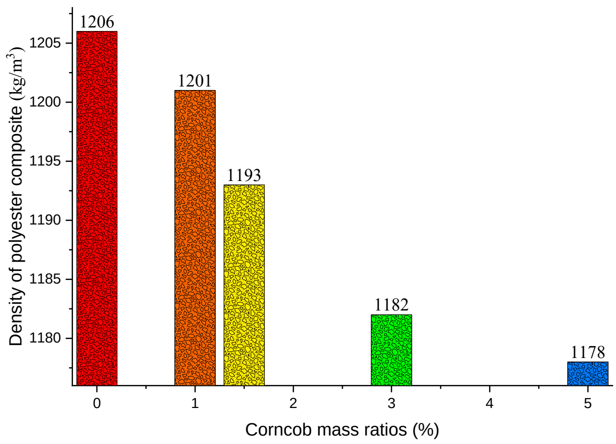

Figure 3. The effect of corncob ratio on the density of composite

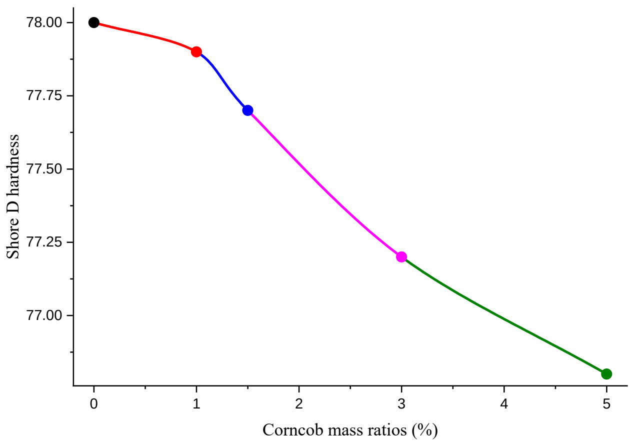

Figure 4. The effect of corncob ratio on the hardness of composite

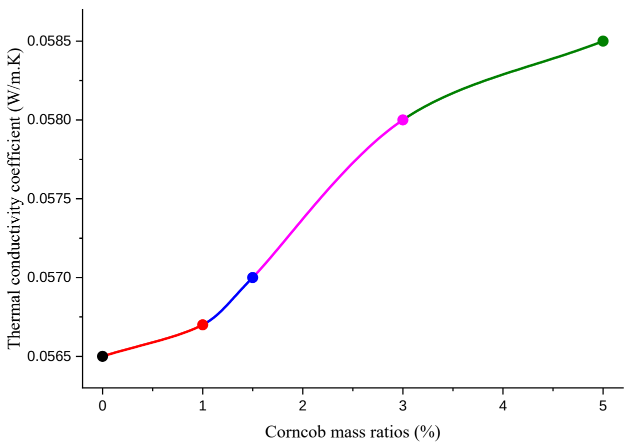

Figure 5. The effect of corncob ratios on the thermal conductivity coefficient of the composite

Activation energies calculated in thermal decomposition experiments of the polyester composite are given in Table 2. It is stated that the activation energy of the polyester composites obtained decreases as the filler increases. Activation energy (*Ea*) values have been calculated according to the Coats-Redfern method. In this method, the highest correlation coefficients were obtained with the three-dimensional diffusion equation. Activation energies of corncob reinforced polyester composites in the range of 0.2 to 0.8 conversion ratio were calculated in thermal decomposition experiments (inert environment) carried out from about room temperature to 10 °C/min heating rate up to 600 °C.

Table 2. Calculated activation energies of composites

Mass ratios (%)	Activation energy (*Ea*: kJ/mol)
0	114.53
1	110.85
3	107.64
5	104.91

4. Conclusions and Recommendations

In the production of polyester composite, 3 wt.% corncob reinforcement has been determined as the optimum ratio. The use of a higher rate of biomass filler negatively affects both the hardness and activation energy of the composite. Also, a high ratio of corncob reinforcement adversely affects the surface morphology and pore structure of polyester composites produced.

The use of biomass wastes such as waste corncob as filler in resins such as polyester and epoxy can be suitable for obtaining low-density, economical, easy-to-process, and flexible composites. Besides, it is recommended to distribute the biomass homogeneously and to keep the curing time longer than pure polymer in composite production.

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