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Research Article

Cornus alba Reinforced Polyester-Epoxy Hybrid Composite Production and Characterization

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Abstract

In this study, ornamental cranberry (*Cornus alba*) reinforced hybrid composite is synthesized. The plant leaves have been collected, dried, and ground for composite production. After it is reinforced into unsaturated polyester (UP) at different rates by mass, it is mixed to show a homogeneous distribution. Then, 5 wt.% of the total mixture is added to the epoxy resin and polymerization reactions are started with the help of necessary additives and catalysts. The product obtained is poured into standard molds and after waiting one day for curing, necessary tests are carried out. According to the results obtained, biomass supplementation reduces the density of the hybrid composite. Although the addition of epoxy resin increases the hardness of the composite, the ornamental cranberry supplement reduces Shore D hardness. It is observed that the thermal conductivity coefficient decreases as the ratio of polyester resin in the composite increases. However, both epoxy resin and biomass reinforcement slightly raises the thermal conductivity coefficient. Also, high biomass reinforcement both weakens the mechanical strength of the hybrid composite and negatively affects the surface morphology. In this study, it was determined that the composite obtained by using 88.5 wt.% UP, 3 wt.% Epoxy A, 1.5 wt.% Epoxy B, 5 wt.% biomass, 1.5 wt.% methyl ethyl ketone peroxide (MEKP), and 0.5 wt.% cobalt octoate (Co Oc) showed optimum properties.

Keywords: Polyester, epoxy, ornamental cranberry, hybrid composite, characterization.

Süs Kızılcığı Takviyeli Polyester-Epoksi Hibrit Kompozit Üretimi ve Karakterizasyonu

Öz

Bu çalışmada süs kızılcığı (*Cornus alba*) takviyeli hibrit kompozit sentezlenmiştir. Bitki yaprakları toplanmış, kurutulmuş ve kompozit üretimi için öğütülmüştür. Doymamış polyestere (UP) kütlece farklı oranlarda takviye edildikten sonra homojen bir dağılım gösterecek şekilde karıştırılmaktadır. Daha sonra toplam karışıma ağırlıkça % 5 epoksi reçine ilave edilir ve gerekli katkı maddeleri ve katalizörler yardımıyla polimerizasyon reaksiyonları başlatılır. Elde edilen ürün standart kalıplara dökülerek bir gün kürlenmesi beklendikten sonra gerekli testler yapılır. Elde edilen sonuçlara göre biyokütle takviyesi hibrit kompozitin yoğunluğunu azaltmaktadır. Epoksi reçine ilavesi kompozitin sertliğini artırsa da süs kızılcığı takviyesi kompozitin Shore D sertliğini azaltmıştır. Kompozitteki polyester reçine oranı arttıkça ısıl iletkenlik katsayısının azaldığı tespit edilmiştir. Bununla birlikte kompozite hem epoksi reçine hem de biyokütle takviyesi ısıl iletkenlik katsayısını az da olsa yükseltmiştir. Ayrıca yüksek biyokütle takviyesi hem hibrit kompozitin mekanik mukavemetini zayıflatmakta hem de yüzey morfolojisini olumsuz yönde etkilemektedir. Bu çalışmada, ağırlıkça % 88.5 UP, % 3 Epoksi A, % 1.5 Epoksi B, % 5 biyokütle, % 1.5 metil etil keton peroksit (MEKP) ve % 0.5 kobalt oktoat (Co Oc) kullanılarak elde edilen kompozit optimum özellikler göstermiştir.

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

1. Introduction

Today, the use of composite materials is becoming more common day by day. A composite material can be defined as the joining of two or more materials with better properties than the components used alone. The reinforcement may include fiber-reinforced polymer composites, natural fibers, or synthetic fibers. In the future, it is foreseen that such composites will be preferred with the increase in the usage areas of natural fibers. Being compatible with the environment, having a low carbon footprint, and being economical and easy to work with provide important advantages. However, it should be used in certain proportions (optimum). The use of high proportions in the composite will weaken the mechanical properties of the product. For this reason, in many of the studies in the literature, researchers have paid attention to the mechanical properties of composites in the use of natural fibers [1].

Plants such as banana, sisal, bamboo, kenaf, jute, bamboo, and sugarcane can be used as natural fibers. Natural fibers have become important in the automobile, textile, manufacturing, and sports industries as they have superior mechanical advantages and properties. Natural fibers are seen as a safer alternative to synthetic fibers [2].

As a result of reinforcing natural fiber to traditional materials in the polymer structure, both renewable resources are used and economical composite materials are produced. The complete decomposition of natural fibers and the evaluation of biomass wastes will ensure that environmentally friendly composites are preferred. Therefore, natural fiber composites are of great interest in various research papers on fiber extraction, chemical treatments, fiber-matrix adhesion, or processing conditions [3].

Due to the decrease in fossil resources, environmental risks, and negative effects of petrochemical resources on human health, natural fibers offer an alternative solution to the production of biocomposite materials [4]. To improve some physical and chemical properties of biocomposite materials, it is necessary to determine the use, compatibility, and interaction of such natural fibers. Fiber strength is also important in choosing the natural fiber determined according to the desired application and purpose of use. This selection should not negatively affect the structure of the biocomposite both physically and chemically [5].

The leaves of ornamental cranberry also called *Cornus alba*, which is a genus of *Cornus L.* from the family Cornaceae, are used in the production of composites [6,7]. Leaf extracts of this plant show acceptable antimicrobial activity against different types of bacteria and fungi. It has also been observed that the leaves of the plant have rich fatty acid and organic acid content [8-12].

In this study, new hybrid composites are produced using renewable resources. Biocomposites with low density, economic and easy workability are being developed by the intended use. It is intended that the obtained composite has decreased petrochemical composition, reduced carbon footprint, and easy-to-recycle, environmentally friendly features [13-17].

2. Materials and Methods

In this study, it was supplied by UP, MEKP, and Co Oc Turkuaz Polyester. Epoxy resin and its components were also purchased from Polisan Company. In addition, the leaves of the *Cornus alba* plant were collected and dried in the province of Elazığ/Türkiye.

In experimental studies, the biomass filler was ground to a particle size of -50/100. By adding this filler to the UP, the mixture was homogenized. Then, certain amounts of Epoxy A and Epoxy B components were added to it. At the last stage, MEKP and Co Oc additives are added to the mixture, mixed, and casting is made into standard molds [18-35].

Figure 1 shows the untreated state of *Cornus alba* leaves and their structure after grinding.

Figure 1. Leaves of Cornus alba plant

In Figure 2, the production scheme of the hybrid composite is given briefly and each stage is shown.

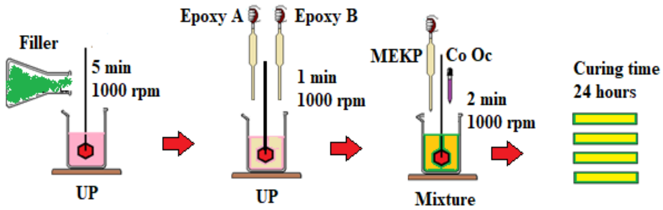

Figure 2. Hybrid composite production scheme

Table 1 indicates each component used in the experiments and their amounts. The ratios of UP and filler change, while the amounts of other components are kept constant.

Table 1. Composite production plan in experimental studies

UP (wt.%)	EA (wt.%)	EB (wt.%)	MEKP (wt.%)	Co Oc (wt.%)	Filler (wt.%)
93.5	3.0	1.5	1.5	0.5	0
92.5	3.0	1.5	1.5	0.5	1
90.5	3.0	1.5	1.5	0.5	3
88.5	3.0	1.5	1.5	0.5	5
86.5	3.0	1.5	1.5	0.5	7

3. Results and Discussion

In this study, the density, Shore D hardness, thermal conductivity coefficient, and pore matrix of the composite obtained have been investigated. In addition, evaluations are made about the mechanical properties and machinability of the composite. In Figure 3, Figure 4, and Figure 5, the density, hardness, and thermal conductivity effects of the biomass filler on the produced hybrid composite have been evaluated, respectively.

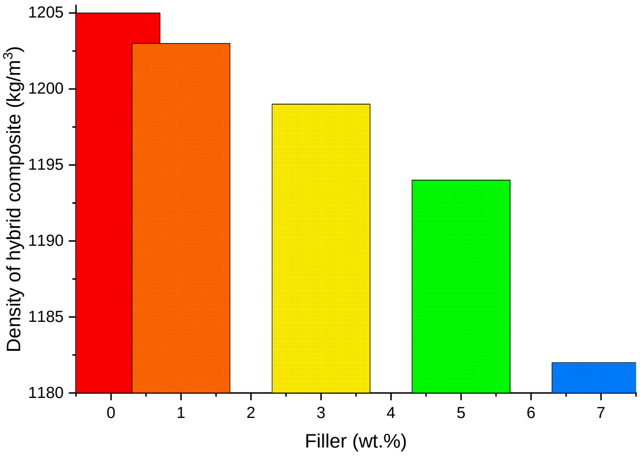

Figure 3. The effect of biomass reinforcement on the density of the hybrid composite

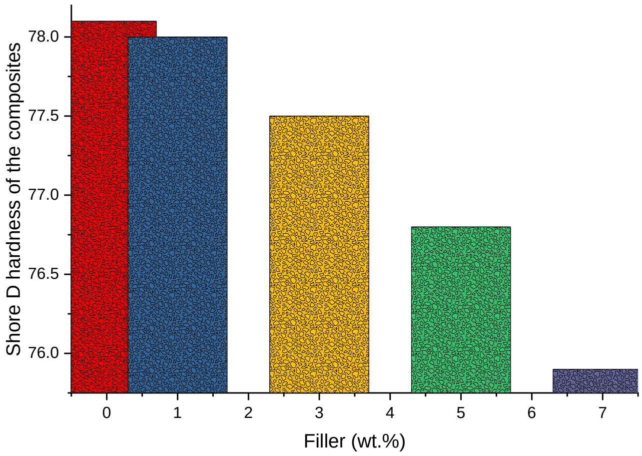

Figure 4. The effect of biomass reinforcement on the hardness of the composites

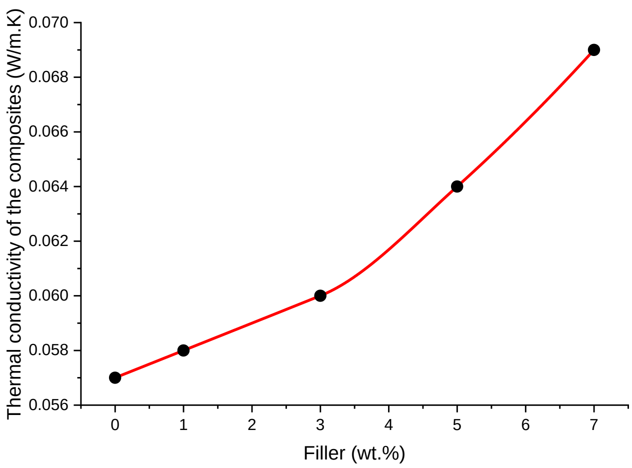

Figure 5. The effect of biomass reinforcement on the thermal conductivity of the composites

Table 2 provides activation energies determined from thermal decomposition tests of the hybrid composites. It is seen that as the filler content is increased, the activation energy of the resulting the composites lowers. Coats-Redfern method has been used to compute activation energy (*Ea*) values. The three-dimensional diffusion equation is found the highest correlation coefficients in this strategy [27-30].

Activation energies of biomass reinforced the composites in the range of 0.15 to 0.85 conversion ratio are calculated. Thermal decomposition experiments have been carried out from 293 K to 873 K at a heating rate of 10 K/min.

Table 2. Calculated activation energies of the hybrid

Filler ratios (wt.%)	Activation energy (*Ea*: kJ/mol)
0	120.07
1	116.95
3	113.20
5	110.68
7	109.43

4. Conclusions and Recommendations

In this study, a total of 4.5 wt.% epoxy resin was reinforced to improve some thermophysical properties of the polyester composite. The use of such additives has improved the hybrid composite to both improve its mechanical properties and increase its thermal stability [31-42]. Biomass filler reinforcement obtained by grinding the leaves of Cornus alba plant decreased the density of the composite. Also, the use of filler in high proportions in the composite creates a porous matrix and reduces Shore D hardness. However, the filler reinforcement slightly increased the thermal conductivity coefficient of the composites. The use of such fillers in the composite ensures the use of fewer petrochemicals, economical production, and workability. Besides, the use of renewable biomass wastes in hybrid composites contributes to the widespread use of environmentally friendly products.

According to the results obtained in this study, optimum composite production was made with 5 wt.% biomass reinforcement. Higher filler reinforcement negatively affected both the mechanical properties and surface morphology of the composite [43-51]. SEM images of pure and biomass reinforced composites are given in Figure 6 and Figure 7. It is seen that the surface of the 7% biomass reinforced composite by weight is not homogeneous and regular. Accordingly, it is understood that high rates of biomass reinforcement have a negative effect on both the composite matrix and the surface morphology.

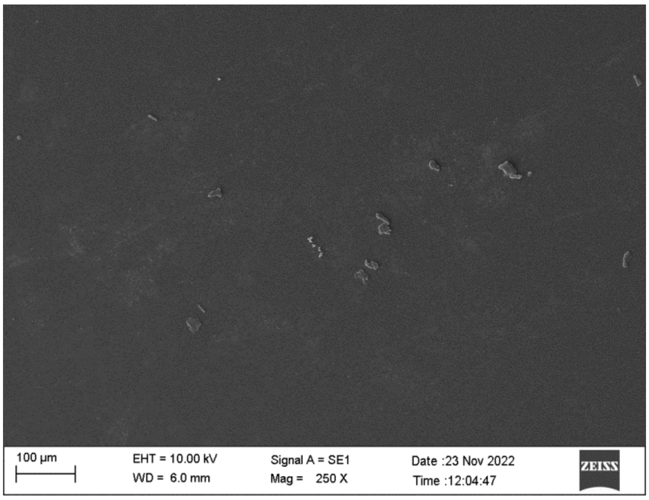

Figure 6. SEM image of the non-biomass-reinforced composite

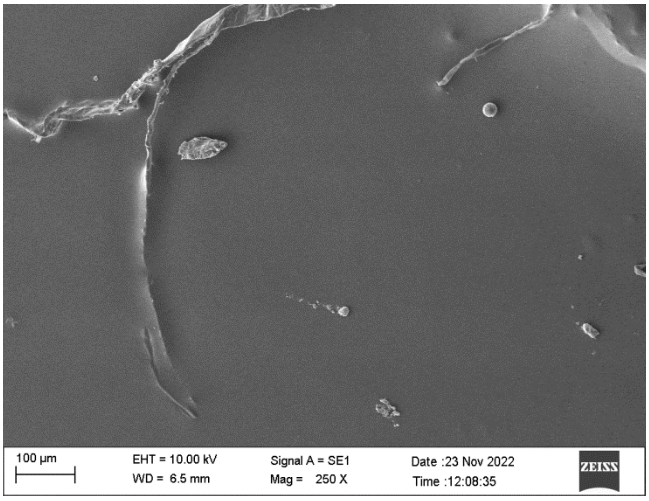

Figure 7. SEM image of biomass (7 wt.%) reinforced hybrid composite

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