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Mechanical Properties of Rosin-based Bio-epoxy Resin

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Abstract: Epoxy resins which are widely used in various industrial fields such as painting, bonding, and coating, are resins of thermosetting group. These resins, which have high mechanical properties, are used as matrix material in composite material production. Composite materials produced by combining epoxy resins with fibers such as glass, carbon or aramid, are used in aerospace, marine and aviation applications. Most of the epoxy resins are industrially produced and the raw materials used in the production phase are largely petroleum-based. Today, it is increasingly important to produce bio-based plant materials instead of petroleum-based materials. These materials reduce dependence on petroleum and encourage the use of cheaper plant materials found abundantly in the environment. In this study, a bio-based epoxy resin was produced by combining petroleum-based epoxy resin and rosin obtained from wood resin at certain ratios. Then, their mechanical and thermal properties were investigated.

Keywords: Epoxy resin, Mechanical properties, Rosin

Kolofan Tabanlı Biyo-Epoksi Reçinesinin Mekanik Özellikleri

Öz : Boyama, yapıştırma ve kaplama gibi çeşitli endüstriyel alanlarda yaygın olarak kullanılan epoksi reçineleri, termoset grubuna ait reçinelerdir. Yüksek mekanik özelliklere sahip olan bu reçineler kompozit malzeme üretiminde matris malzemesi olarak kullanılırlar. Epoksi reçinelerinin cam, karbon veya aramid gibi liflerle birleştirilmesiyle üretilen kompozit malzemeler uzay, denizcilik ve havacılık uygulamalarında kullanılmaktadır. Epoksi reçinelerinin çoğu endüstriyel olarak üretilmekte ve üretim safhasında kullanılan hammaddeler büyük oranda petrol esaslı olmaktadır. Petrol esaslı malzemeler yerine biyo-tabanlı bitkisel malzemeler üretmek her geçen gün daha da önemli hale gelmektedir. Bu malzemeler petrole bağımlılığı azaltmakta ve doğada bolca bulunan ve ucuz olan bitkisel materyallerin kullanımını teşvik etmektedir. Bu çalışmada, petrol bazlı epoksi reçinesi ile çam reçinesinden elde edilen kolofan maddesi belirli oranlarda birleştirilerek biyo-tabanlı bir epoksi reçinesi üretildi ve bu reçinenin mekanik ve termal özellikleri incelendi.

Anahtar kelimeler: Epoksi reçinesi, Mekanik Özellikler, Kolofan

1. Introduction

Epoxy resins, which have been on the market for 45 years, are now being used in many large industrial applications, especially where the technical advantages guarantee a slightly higher cost. The enchanting chemistry of these resins has attracted interest from many scientists [1].

In recent years, the importance of obtaining chemical materials from renewable sources has encouraged new work related to epoxy resins. Park et al. [2], synthesized epoxidized soybean oil and epoxidized castor oil and investigated their thermal properties. Liu et al. [3], investigated the preparation, characterization and mechanical properties of the composite material produced by

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Bu makaleye atıf yapmak için
Demircan, G., Kısa, M., Özen, M., *"Kolofan Tabanlı Biyo-Epoksi Reçinesinin Mekanik"* El-Cezerî Fen ve Mühendislik Dergisi 2018, 5(2); 387-393.

epoxidized soybean oil and clay cured with triethylenetetramine. Bio-based high performance epoxy-anhydride thermosets were produced using sucrose and soybean oil acids by Paramatra and Webster [4]. Many studies have contributed to the literature in this regard [5-9].
Rosin is abundant in nature and has an annual production of 1.2 million tons [10]. The most important among the various rosins is the common rosin obtained from various species of pine trees. Its content is composed of 90% diterpene base acids ($C_{20}H_{30}O_2$). The remaining 10% is a mixture of esters, alcohols, aldehydes and hydrocarbons [11].

Liu et al. [12], produced two different epoxy curing agents using rosin-based acid anhydrides and studied their synthesis method and curing behavior and investigated the properties of cured epoxy resins. In another work, they used rosin-based imid-diacids to produce epoxy curing agent [13]. Atta et al. [14], produced tetra-functional epoxy resins from rosin, and studied synthesis and characterization of them. Deng et al. [15], produced rosin-derived bio-based epoxy resins with different flexible chains and examined their properties.

In this study, rosin was mechanically pulverized without any chemical treatment, and was incorporated homogeneously into a mass proportion of the bisphenol A epoxy resin. The prepared mixture was cured in a laboratory type furnace for a certain period of time and then its mechanical properties and thermal properties were examined.

2. Materials and Methods

In this study, a dual component Araldite LY 1564 SP epoxy and an Aradur 3487 BD hardener were selected as epoxy materials. Gum rosin obtained by the distillation of the pine resin was used as filler material. A 180 µm sieve, designated by the ASTM E-11 standards, was used to pulverize the rosin material. Seven different mass amounts of rosin powders, as 25 gr, 35 gr, 45 gr, 50 gr, 55 gr, 65 gr and 75 gr, were mixed homogeneously with a mechanical stirrer as a mixture with 100 gr of epoxy and 35 gr of hardener. The prepared mixture cured at 65°C for 3 hours under melting temperature of the rosin. Five samples for each configuration were produced in the sizes shown in Figure 1.

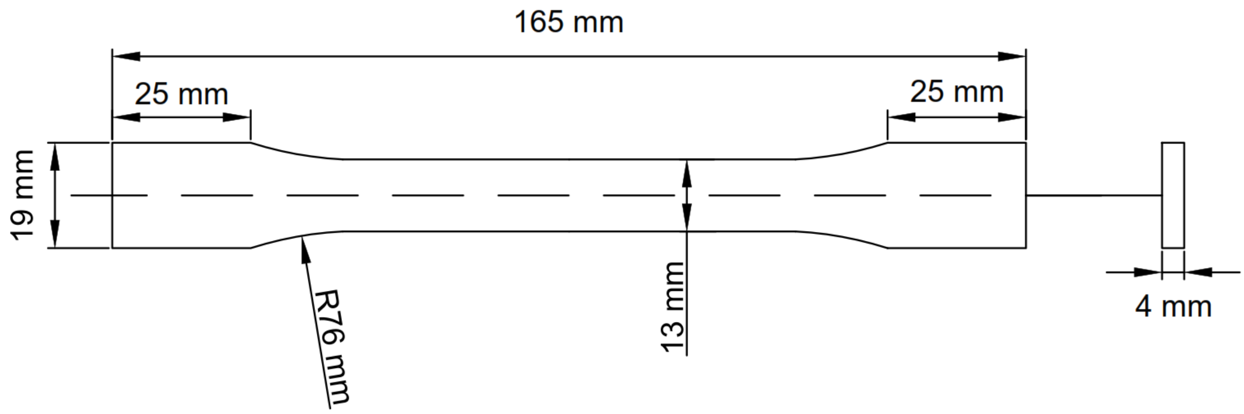

Figure 1. Sizes of test samples

The produced samples were subjected to uniaxial tensile test by Shimadzu AGS-X Plus Universal Tensile Machine. Test speed was selected as 1 mm / min and the average modulus of elasticity, tensile strengths and maximum strains of samples were calculated. The thermal conductivity of the samples were measured with Hot Disk TPS 500 S device and average values were taken.

2.1 Preparation of Samples

Before preparing the epoxy resin, the whole rosin material was pulverized by pestling and 180 µm sieve was used to bring rosin powders dimensions to a certain standard.

Figure 2. Rosin

100 gr of epoxy and 35 gr of hardener were mixed with different mass amounts of rosin powder as 25 gr, 35 gr, 45 gr, 50 gr, 55 gr, 65 gr and 75 gr.

Figure 3. Mechanical mixer and mixing vessels

The prepared mixtures were poured into sample molds made of a thermoplastic polyethylene material. And then subjected 65°C temperature for 3 hours. The cured samples were removed from the molds and made ready for testing.

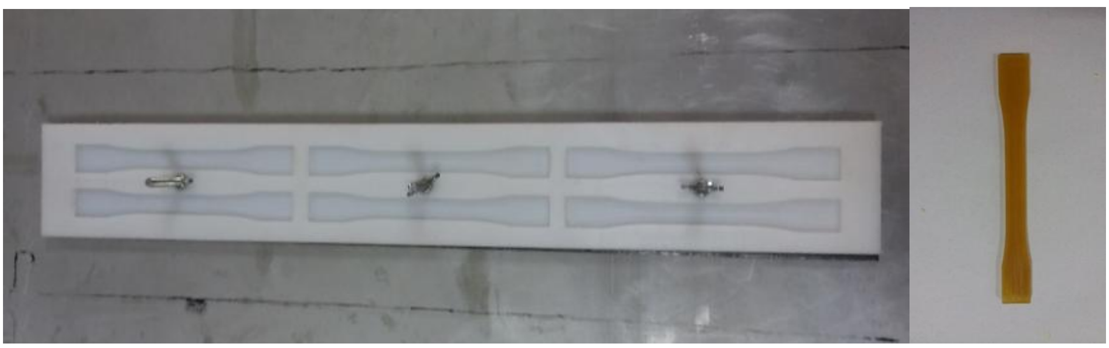

Figure 4. Mold and sample

2.2 Tensile Test

The prepared samples were subjected to uniaxial tensile test and maximum stresses, maximum strains and modulus of elasticity were calculated.

2.3 Thermal Test

After the samples were subjected to the tensile test, the thermal conductivity were measured with the Hot Disk TPS 500 S device shown in figure 5 and the average values were taken

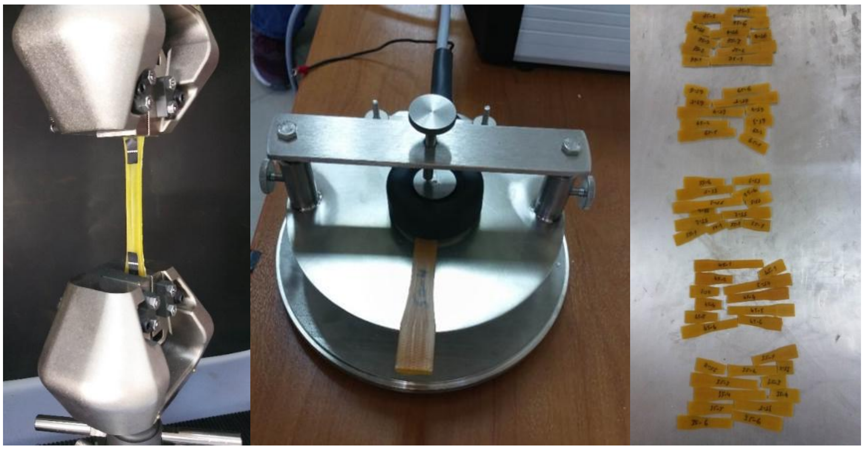

Figure 5. Tensile test, thermal test and broken samples

3. Results and Discussions

The results obtained from the tensile test are summarized in the following tables. The figures show the graphs of the test results. Figure 6 shows that 25% of the powdered rosin additive had the effect of increasing the modulus of elasticity of the epoxy. At the value of 35% the modulus of elasticity became nearly equivalent to the pure epoxy and then the value decreased as the amount of additive increased. While the highest modulus of elasticity was observed at a 25% additive ratio, this value decreased as the rosin additive increased, but an insignificant increase was observed in the transition from 45% to 50%.

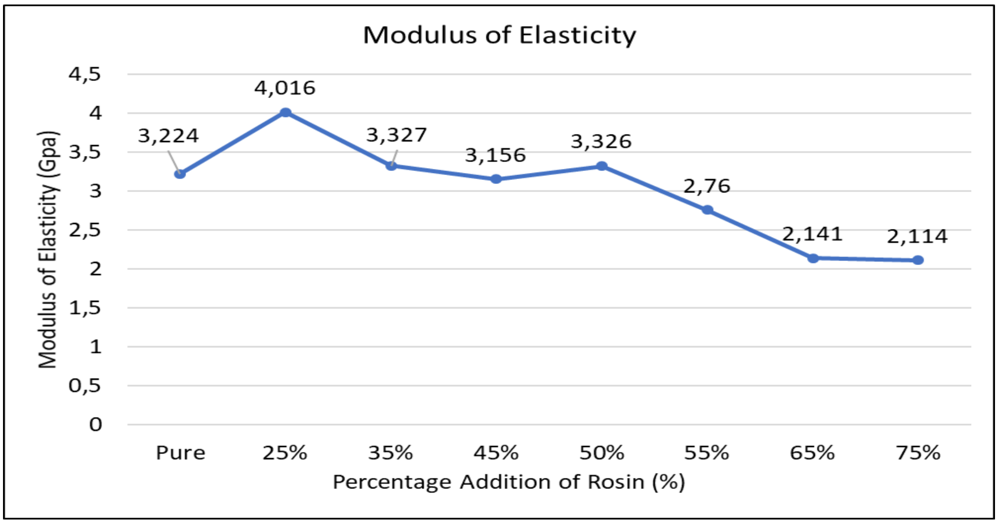

Figure 6. Modulus of Elasticity of Rosin-based Bio-epoxy Resin

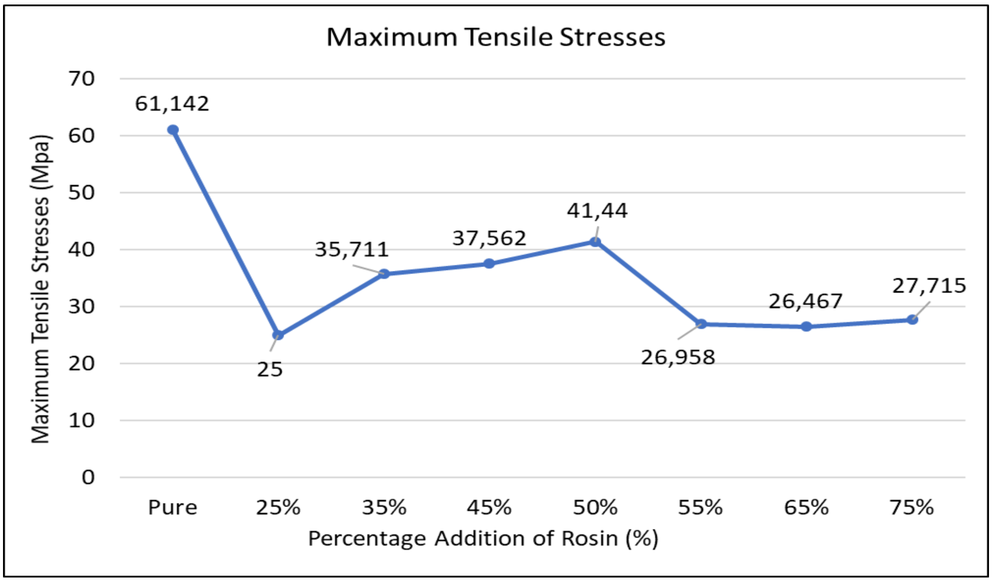

Figure 7. Maximum Tensile Stresses of Rosin-based Bio-epoxy Resin

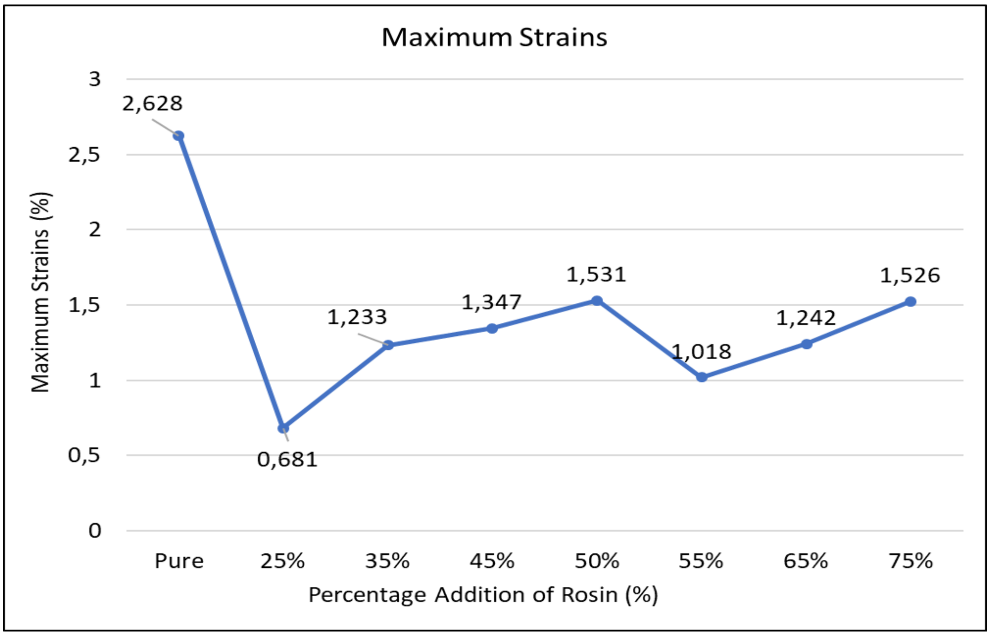

Figure 8: Maximum Strains of Rosin-based Bio-epoxy Resin

Figure 7 shows that powdered rosin additives generally decreased the value of maximum tensile stresses of the epoxy resin. The maximum stress value was minimum at 25%, this value increased at 50%, decreased at 55% and remained almost constant at 75%.

Figure 8 shows that powdered rosin significantly reduced the value of strain. When the minimum strain value was observed at 25%, this increased at 50% and then decreased at 55% and 65%, respectively, and it had a maximum value at 75%.

The tensile test results showed that the addition of powdered rosin to the bisphenol A epoxy resin increased the modulus of elasticity first and then decreased it while decreasing the maximum stresses and maximum strains.

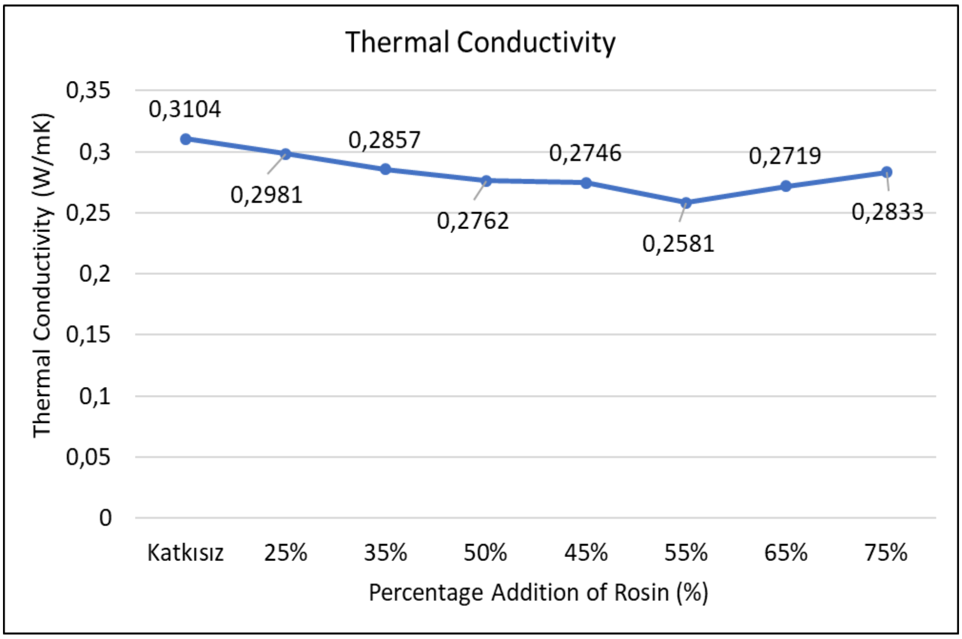

Figure 9. Thermal Conductivity of Rosin-based Bio-epoxy Resin

Figure 9 shows that as the powdered rosin content increased, the thermal conductivity decreased by up to 55% and increased by a small amount at 65% and 75%.

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