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Research Article

Effect of Boron Factory Components on Thermophysical Properties of Epoxy Composite

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Abstract

In this study, density, Shore D hardness, activation energy, and thermal conductivity coefficients of colemanite, ulexite, and tincal reinforced epoxy composites have been investigated. The components taken in the boron factory were ground to -100/200 mesh particle size and dried in an oven at 105 °C for 2 hours and prepared as a filler. Composite materials have been obtained by adding fillers in different proportions by mass into the epoxy resin. Shore D hardness, activation energy, and thermal conductivity coefficient of the obtained composites increased with fillers. The thermophysical properties of the composite varied according to the unique structures of colemanite, ulexite, and tincal ore. For example, these fillers can be used by using economical methods to improve the properties of the produced composite according to the intended use. According to the results obtained, boron factory components increased the density, Shore D hardness, thermal conductivity coefficient, and thermal stability of the epoxy composite. It has been understood that colemanite, ulexite, and tincal ores are effective in increasing the thermophysical properties of the epoxy composite, respectively.

Keywords: Epoxy composite, Colemanite, Ulexite, Tincal, Thermophysical properties.

Bor Fabrikası Bileşenlerinin Epoksi Kompozitin Termofiziksel Özelliklerine Etkisi

Öz

Bu çalışmada, kolemanit, üleksit ve tinkal takviyeli epoksi kompozitlerin yoğunluk, Shore D sertliği, aktivasyon enerjisi ve ısıl iletkenlik katsayıları incelenmiştir. Bor fabrikasında alınan bileşenler -100/200 mesh partikül boyutuna öğütülmüş ve 105 °C'de 2 saat etüvde kurutulmuş ve dolgu olarak hazırlanmıştır. Epoksi reçinesine kütlece farklı oranlarda dolgu maddeleri eklenerek kompozit malzemeler elde edilmiştir. Elde edilen kompozitlerin Shore D sertliği, aktivasyon enerjisi ve ısıl iletkenlik katsayıları dolgu maddeleri ile artmıştır. Kompozitin termofiziksel özellikleri kolemanit, üleksit ve tinkal cevherinin benzersiz yapılarına göre değişiklik göstermiştir. Örneğin bu dolgu maddeleri, üretilen kompozitin özelliklerini kullanım amacına göre geliştirmek için ekonomik yöntemler kullanılarak kullanılabilir. Elde edilen sonuçlara göre, bor fabrikası bileşenleri epoksi kompozitin yoğunluğunu, Shore D sertliğini, ısıl iletkenlik katsayısını ve ısıl kararlılığını arttırmıştır. Epoksi kompozitin termofiziksel özelliklerini arttırmada sırasıyla kolemanit, üleksit ve tinkal cevherlerinin etkili olduğu anlaşılmıştır.

Anahtar Kelimeler: Epoksi kompozit, Kolemanit, Üleksit, Tinkal, Termofiziksel özellikler.

1. Introduction

The endless combinations of composites formed by polymers with various materials have significant advantages over other materials. While conventional materials have stable properties, composites can gain important properties according to the added additives and fillers. These combinations can give the polymer material properties suitable for all seasons. In addition, their longevity and not being affected by microorganisms further increase the variety of usage areas. Although pure polymers have important properties, new properties are still needed due to advancing technology and increasing needs. In this case, new composite materials formed by adding additives and fillers to polymer materials are helpful. In particular, both the shapes and sizes of additives and fillers also give new features. The size of additives and fillers, from nanostructures to microstructures, becomes important depending on the area used. The areas used have a wide range from the clinic to the pharmaceutical industry, from air technologies to the informatics industry [1].

Matrix, filler, and additive materials play an important role in the formation of composites. The selection of the matrix according to the area to be used and the strengthening or improvement of its properties in the desired direction with contributions is realized with knowledge and experience. The materials commonly used as the matrix in polymer composites are thermoset (epoxies, phenolics) or thermoplastic (polycarbonate, polyvinylchloride, nylon, acrylics) and kevlar, etc [2-3]. This is caused by the superior properties that epoxy resins have in having a wide range of uses. These superior properties can be said to be excellent temperature resistance, mechanical and chemical stability, curing ability, and low cost [4].

In general, different types of synthetic fibers such as glass, carbon, and aramid fiber were previously used as reinforcing elements in the production of polymer materials. However, today, due to the development of technology and meeting increasing needs, a wide range of reinforcement materials are used, ranging from inorganic additives to various wastes. In the literature, it is seen that the physical properties of composites are affected by the change in the shape and amount of inorganic additives. It has been found that as the proportions of inorganic additives in the composite increase, the matrix ratio decreases, and accordingly, properties such as thermal expansion coefficient, polymerization shrinkage, durability, and water absorption are affected in different ways [5-17]. In addition, it is a matter of curiosity how the density and porosity change according to the area to be used. Ulexite, colemanite, and tincal which are the most abundant ores in our country and are rich sources of boron in the world are among the strategic minerals. The boron, sodium, and calcium elements they contain have given these minerals different properties. Various studies are underway to take advantage of these features. In addition to increasing the usage areas of these minerals, it is important to discover their superior properties. When these minerals are examined in the literature, it is seen that they have neutron-absorbing properties, extend the life of the material, and improve the flaming point properties. In addition, some studies have shown that thermo-mechanical properties are improved [18-21]. In this context, the properties of the composite formed by the addition of these minerals in different sizes to epoxy polymer matrices are curious.

In this study, boron factory components have been used to improve the properties of composites obtained with epoxy resin. Industrially important inorganic reinforcements such as colemanite, ulexite, and tincal can improve some thermophysical properties of composites. The improvement of some mechanical and thermal properties of epoxy composites makes their usage areas widespread. The physical properties of the polymer composite obtained by adding ulexite, colemanite, and tincal to epoxy resin in different grain sizes have been investigate.

2. Material and Method

Epoxy A and Epoxy B components were purchased from ADS Kimya Company (Turkey). Boron plant components used in this study were supplied from Eti Maden (Eskişehir Kırka Boron) factory. Colemanite with a density of 2.4 g/cm^3, 2.0 g/cm^3 ulexite, and 1.7 g/cm^3 tincal were used as filler. These fillers were ground in the particle size range of 74 to 149 microns and dried in an oven at 105 °C for 2 hours. Composite materials were produced by reinforcing epoxy resin at the rates of 1.96 wt.%, 4.76 wt.%, 6.54 wt.%, 9.09 wt.%, and 13.04 wt.%. In the prepared mixture, epoxy A and the filler were mixed until homogenized (approximately 5 minutes at a mixing speed of 750 rpm). Then, epoxy B was added to the mixture in a certain amount and mixed at 1000 rpm for 2 minutes, and poured into standard molds. After waiting for 24 hours in suitable conditions for curing, necessary tests and analyses were carried out [22-26].

In Table 1, the composition of each filler separately in the mixture is expressed to produce an epoxy composite

Table 1. Experimental working plan

Epoxy A (g)	Epoxy B (g)	Fillers (g)
6.7	3.3	0.0
6.7	3.3	0.2
6.7	3.3	0.5
6.7	3.3	0.7
6.7	3.3	1.0
6.7	3.3	1.5

Figure 1 shows the method followed to produce epoxy composite in experimental studies. Here, it is very important to mix the filler homogeneously and add the additives and fillers to the mixture respectively.

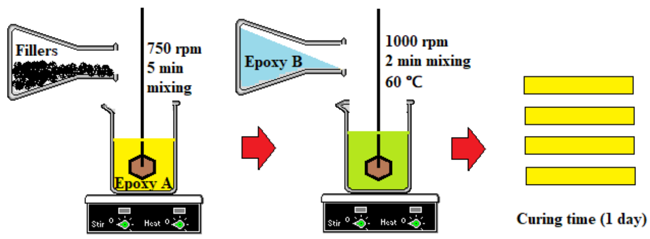

Figure 1. Experiment system for epoxy composite preparation

3. Results and Discussion

According to the results obtained in the experimental studies, the effect of colemanite on the density of the epoxy composite is given in Figure 2. As the mass ratio of the filler increased, the density of the epoxy composite also raised. It is seen that ulexite in Figure 3 and tincal ore in Figure 4 increase the density of the epoxy composite. Colemanite, ulexite, and tincal reinforcements from large to small are effective in the density of the composite.

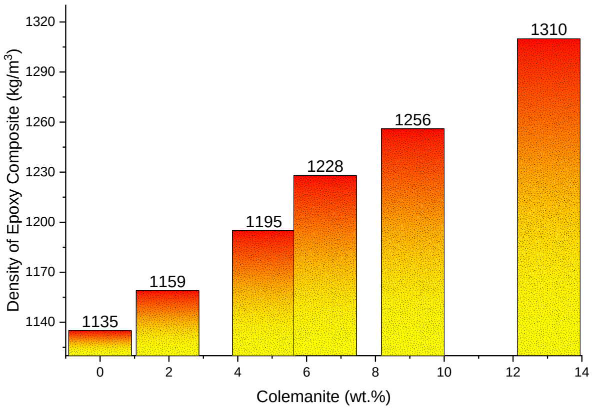

Figure 2. The effect of percent colemanite on the density of the composite

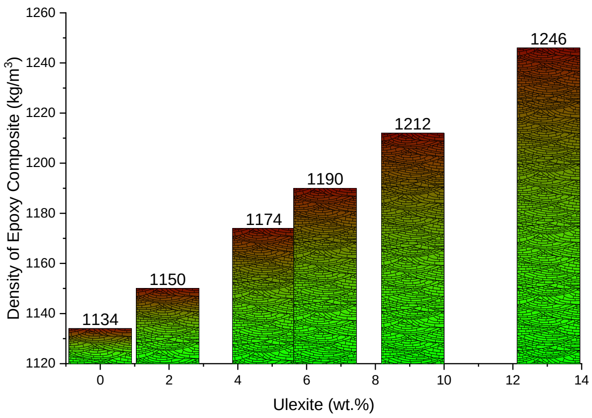

Figure 3. Variation of the density of composite with ulexite ratio by mass

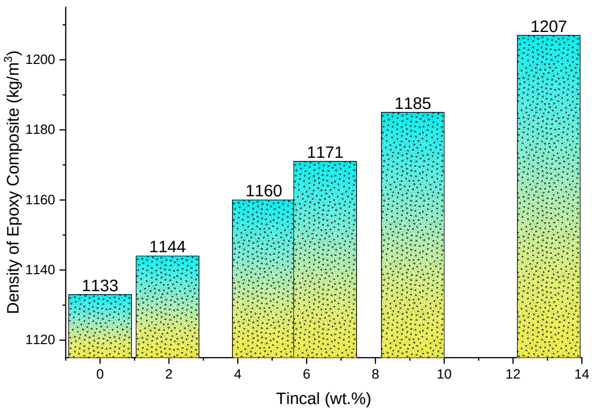

Figure 4. Variation of the density of composite with tincal ratio by mass

Shore D hardness of epoxy composites is compared in Figure 5. Colemanite increased the hardness of the composite the most and tincal ore the least. Curing time is also an important parameter when determining thermophysical properties. Especially before the Shore D hardness test, the obtained composite matrix must be cured sufficiently.

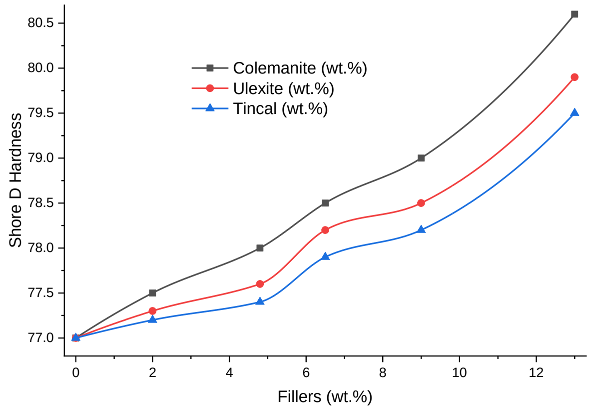

Figure 5. Variation of the hardness of composites with ratios (wt.%) of fillers

The thermal conductivity coefficients of the composites produced are shown in Figure 6. Boron factory components increased the thermal conductivity of epoxy composites. In particular, as expressed in the graph, the thermal conductivity effect of colemanite, ulexite, and tincal ores from large to small is understood.

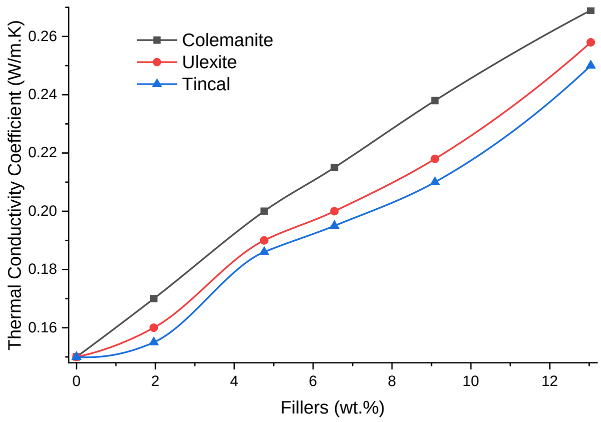

Figure 6. Variation of thermal conductivity of composites with ratios (wt.%) of fillers

4. Conclusions and Recommendations

In this study, it can be said that boron factory components can form a structure compatible with epoxy composite. However, at high rates (9 wt.%), deterioration can be seen on the composite surfaces. It can be said that the composite matrix creates a more regular structure, especially when used below this ratio. Production of epoxy composite with desired density, hardness, and thermal conductivity according to its intended use can be achieved with fillers. In addition, the activation energies of the epoxy composites obtained at the rate of 9 % by mass were compared according to the Coats-Redfern method. The highest correlation coefficient (R^2>0.985) was obtained with the diffusion control (Crank) function. The activation energies of the composites were found to be colemanite (129.5 kJ/mol), ulexite (126.7 kJ/mol), and tincal (125.3 kJ/mol). The activation energy of the pure epoxy resin was calculated as (115.8 kJ/mol). According to the results obtained, colemanite increased the thermal stability of the composite the most and tincal ore the least [27-30].

References

[1] N. F. Zaaba, and H. Ismail, “Polym. Plastics,” Tech. Mater. 58, 349-365, 2019.

[2] S. J. Park, and M. K. Seo, “Types of Composites,” in Interface Sci. Technol., Chapter 7, 501–629, 2011.

[3] Q. Qin, “Introduction to the composite and its toughening mechanisms,” Toughening Mechanisms in Composite Materials. 1-32, 2015.

[4] M. Sogancioglu, A. Yucel, E. Yel, and G. Ahmetli, “Production of Epoxy Composite from the Pyrolysis Char of Washed PET Wastes,” Energy Procedia. 118, 216-220, 2017.

[5] O. I. Rufai, G. I. Lawal, B. O. Bolasodun, S. I. Durowaye, and J. O. Etoh, Int. J. Chem. Molecular, Nucl. Mater. Metall. Eng. 9, 2015.

[6] I. L. Ngo, and V. A. Truong, “An investigation on effective thermal conductivity of hybrid-filler polymer composites under effects of random particle distribution, particle size and thermal contact resistance,” Int. J. Heat Mass Transf. 144, 2019.

[7] R. Kochetov, A. V. Korobko, and T. Andritsch, “Modelling of the thermal conductivity in polymer nanocomposites and the impact of the interface between filler and matrix,” J. Phys. D Appl. Phys. 44(39), 395-401, 2011.

[8] T. F. Luo, and J. R. Lloyd, “Enhancement of thermal energy transport across graphene/graphite and polymer interfaces: a molecular dynamics study,” Adv. Funct. Mater. 22(12), 2495-2502, 2012.

[9] L. Du, T. Shi, P. Chen, L. Su, J. Shen, J. Shao, and G. Liao “Optimization of through silicon via for three-dimensional integration,” Microelectron. Eng. 139, 31-38, 2015.

[10] Z. Liu, T. Shi, Z. Tang, B. Sun, and G. Liao, “Using a low-temperature carbon electrode for preparing hole-conductor-free perovskite heterojunction solar cells under high relative humidity,” Nanoscale. 8(13), 7017-7023, 2016.

[11] Y. Wang, C. Yang, Q.X. Pei, and Y. Zhang, “Some aspects of thermal transport across the interface between graphene and epoxy in nanocomposites,” ACS Appl. Mater. Interfaces. 8(12), 8272-8279, 2016.

[12] Y. Wang, C. Yang, Y. W. Mai, and Y. Zhang, “Effect of non-covalent functionalisation on thermal and mechanical properties of graphene-polymer nanocomposites,” Carbon. 102, 311-318, 2016.

[13] T. Y. Wang, and J. L. Tsai, “Investigating thermal conductivities of functionalized graphene and graphene/epoxy nanocomposites,” Comput. Mater. Sci. 122, 272-280, 2016.

[14] M. Derradji, X. M. Song, and A. Q. Dayo, “Highly filled boron nitride-phthalonitrile nanocomposites for exigent thermally conductive applications,” Appl. Therm. Eng. 115, 630-636, 2017.

[15] I. Jang, K.H. Shin, and I. Yang, “Enhancement of thermal conductivity of BN/epoxy composite through surface modification with silane coupling agents,” Colloids Surf. A-Physicochem. Eng. Aspects. 518, 64-72, 2017.

[16] M. Uluakay, H. İnan, K. Yamanel, and N. Arhun, “Kompozit Rezinler ve Polimerizasyon Büzülmesi,” ADO Klinik Bilimler Dergisi. 5(2), 895-902, 2011.

[17] I. L. Ngo, C. Byon, and B. J. Lee, “Numerical analysis for the effects of particle distribution and particle size on effective thermal conductivity of hybrid-filler polymer composites,” Int. J. Therm. Sci. 142, 42-53, 2019.

[18] İ. Bilici, B. Aygün, C. U. Deniz, B. Öz, M. I. Sayyed, and A. Karabulut, “Fabrication of novel neutron shielding materials: Polypropylene composites containing colemanite, tincal and ulexite,” Progress in Nuclear Energy. 141, 2021.

[19] G. Guzel, O. Sivrikaya, H. Deveci, “The use of colemanite and ulexite as novel fillers in epoxy composites: Influences on thermal and physico-mechanical properties,” Compos. Part B Eng. 100, 1-9, 2016.

[20] R. Orhan, E. Aydoğmuş, S. Topuz, and H. Arslanoğlu, “Investigation of thermo-mechanical characteristics of borax reinforced polyester composites,” J. Build Eng. 42, 103051, 2021.

[21] M. Dogan, S. Dogan, L. Savas, G. Ozcelik, and U. Tayfun, “Flame retardant effect of boron compounds in polymeric materials,” Compos. B. Eng. 221(1), 109088, 2021.

[22] E. Aydoğmuş, H. Arslanoğlu, and M. Dağ, “Production of waste polyethylene terephthalate reinforced biocomposite with RSM design and evaluation of thermophysical properties by ANN,” J. Build. Eng. 44, 103337, 2021.

[23] E. Aydoğmuş, and H. Arslanoğlu, “Kinetics of thermal decomposition of the polyester nanocomposites,” Petroleum Science and Technology. 39(13–14), 484–500, 2021.

[24] E. Aydoğmuş, M. Dağ, Z. G. Yalçın, and H. Arslanoğlu, “Synthesis and characterization of EPS reinforced modified castor oil-based epoxy biocomposite,” J. Build. Eng, 47, 103897, 2022.

[25] E. Aydoğmuş, “Biohybrid nanocomposite production and characterization by RSM investigation of thermal decomposition kinetics with ANN,” Biomass Conversion and Biorefinery. 2022.

[26] H. Şahal, and E. Aydoğmuş, “Production and Characterization of Palm Oil Based Epoxy Biocomposite by RSM Design,” Hittite Journal of Science and Engineering. 8(4), 287-297, 2021.

[27] H. Şahal, H. and E. Aydoğmuş, “Investigation of Thermophysical Properties of Polyester Composites Produced with Synthesized MSG and Nano-Alumina,” European Journal of Science and Technology. 34, 95-99, 2022.

[28] M. H. Demirel, and E. Aydoğmuş, “Production and Characterization of Waste Mask Reinforced Polyester Composite,” Journal of Inonu University Health Services Vocational School. 10(1), 41-49, 2022.

[29] M. H. Demirel, and E. Aydoğmuş, “Waste Polyurethane Reinforced Polyester Composite, Production and Characterization,” Journal of the Turkish Chemical Society Section A: Chemistry. 9(1), 443–452, 2022.

[30] C. Yanen, and E. Aydoğmuş, “Characterization of Thermo-Physical Properties of Nanoparticle Reinforced the Polyester Nanocomposite,” Dicle University Journal of the Institute of Natural and Applied Science. 10(2), 121–132, 2021.