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Study of the Effect of Various Fillers on the Properties of Epoxy Oligomers

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Abstract: The shell of eggs, kaolin and fiberglass epoxy oligomers and fillers were taken as the object of research and compositions based on them were prepared, the physical and mechanical properties of the composition were studied using the most modern research methods. properties were determined by conducting several tests (tensile, bending, composite density, water absorption, hardness). Epoxy-based compositions were prepared and their properties were studied using various fillers. For this purpose, polyethylene polyamine ED-20 brand epoxy oligomer and its hardener were used. In scientific research, the effect of various fillers on the properties of epoxy resin has been studied experimentally. The dependence of the composition of the insoluble part of ENO on the drying time at a temperature of 110°C - 150°C was determined. It was found that the inclusion of fillers in the composite material greatly affects the mechanical properties. Thus, in a certain mass fraction of kaolin and eggshell powder, the adhesion strength increased, but the subsequent increase in the amount of fillers decreased. In general, it can be noted that the tensile strength of unmodified epoxy resin is higher than the strength of epoxy compositions, and the modulus of elasticity is lower. This indicates that the addition of filler to the epoxy resin and glass / epoxy resin reduced the tensile strength and increased the modulus of elasticity. The result allows the buoy to be used in industry.

Keywords: Epoxy, Oligomer, Eggshell, Kaolin, Glass, Fiber, Composition, Tensile, Bending

1. Introduction

The epoxy oligomer is used in paint, electricity, glue, etc. due to its universal properties. has a wide field of application in various industries such as. This is due to the fact that epoxy resin has excellent bonding properties and excellent mechanical strength, chemical resistance and electrical insulation after hardening. Aggregates are used as materials added to the polymer to reduce cost or improve properties. With the proper selection of these materials, not only economic but also other properties such as processing and mechanical properties can be improved.

In the last few decades, there has been significant interest in the production and development of new composite materials or in the modification of existing composite materials. The production of composite materials with improved mechanical properties and lower cost compared to traditional alloys is a real problem for most material engineers.

Valuable performance of epoxy oligomers has led to a rapid increase in their production and widespread use in various industries.

Materials made of polymers, such as matrix material, are called polymer composite materials. In addition to polymers, these compositions include solvents, hardeners, stabilizers, plasticizers, pigments, flame retardants, accelerators, antioxidants, antistatics, porosizers, antimicrobials, etc. also includes various components such as. Each component of the composition has its own physical-mechanical, physico-chemical, dielectric, etc. causes changes in indicators such as. Both thermosetting and thermoplastic polymers can be used for the matrix material [1-7].

Polymer composite thermosetting matrix materials include polyesters, epoxy oligomers, and thermoplastic matrix materials include polyethylene, polypropylene, polystyrene, polyvinyl chloride, etc. an example can be given [8-13].

The following are some examples of the widespread use of polymers as matrices [14-17]:

1) They are resistant to chemicals;
2) They are heat and electrical insulators;
3) They are lightweight and have different degrees of durability;

Can be processed in different ways to obtain fibers, sheets, foams or complex molded parts.

2. Materials and Methods

Compositions based on epoxy resin were prepared and their properties were studied using various fillers. For this, polyethylene polyamine was used as an ED-20 epoxy oligomer and its hardener. Various fillers were used to prepare the composition.

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The main component (matrix) of the composition was bisphenol A diglycidal ester ED-20. The chemical structure is shown in Figure 1.

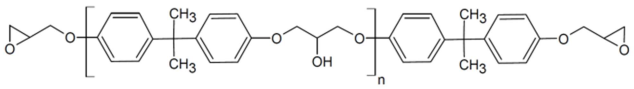

Figure 1. *Chemical structure of the resulting substance.*

ED-20 was used in the work. The properties of ED-20 are shown in Table 1.

Table 1. *Properties of ED-20.*

Molecular weight, g / mol	380
Density, g / sm^3	1.1-1.6
The amount of epoxy groups, %	19.9-22.0
Fluidity, Pa•s	12-25 (20°C-də)

The fillers used to prepare the composition are listed in Table 2.

Table 2. *Fillers used.*

Eggshell powder	The main chemical composition consists of 94-98% by weight of calcite ($CaCO_3$) and 3-4% of organic matter and small amounts of other elements such as magnesium and phosphorus.
Kaolin	$Al_2Si_2O_5(OH)_4$
Glass fiber (E-glass)	The chemical composition is 52-56% SiO_2, 12-16% Al_2O_3, 16-25% CaO 5-10% B2O3, 1-2% Na_2O, K_2O and so on. includes.
Aluminium oxide	Al_2O_3

The composition of the compositions is based on different amounts of fillers (20 and 30% by weight). Initially, the epoxy resin and fillers were poured into plastic containers, respectively, heated to 45°C and mechanically mixed for 5 min to obtain a homogeneous mixture, then a hardening agent was added and mixing was continued for another 5 min. Finally, the mixture was poured into pre-prepared molds and fixed at room temperature for 24 hours.

The materials to be used as fillers (eggshells) were pulverized into small particles using a grinder and then sifted. Distillation was carried out by adding distilled water to remove some organic matter. The resulting suspension mixture was dried at 105°C for 24 h to obtain a fine-grained powder.

Epoxy resin-based composites were prepared using aluminum oxide in various proportions together with glass fiber. The woven fabric of 150 mm × 100 mm required for the preparation of the composition was cut on a wooden platform with the help of a steel ruler and a sharp cutter without disturbing the actual orientation of the fiber. A layer of woven glass cloth was placed in the mold and the glass fiber layer was coated with a filler-free and Al_2O_3-filled composition based on a 10: 1 resin and hardener mixture, and a soft steel spreader was used to remove air bubbles and ensure uniform distribution of the mixture. Then another layer of glass was placed on top and the process was continued until the fifth layer and fixed at room temperature for 24 hours. The laminate was then removed from the mold and cut to different sizes to perform different tests on the samples.

The samples were first drawn in air (mh) (dry mass) and then re-drawn in distilled water (ms). The density of the samples was calculated according to Equation (1) below

$$\rho_k = \frac{m_h}{m_h - m_s} \cdot \rho_s \qquad (1)$$

Here, the density of the wk.-sample; Density of ρ_k - distilled water

In addition, the theoretical densities of the composites were calculated and compared with the densities obtained from the experiments. The theoretical density of composite materials in terms of mass fractions of different components is obtained by the following equation (2).

$$\rho_k = \frac{1}{w_d/\rho_d + w_m/\rho_m} \qquad (2)$$

Here, w_d, w_m is the mass fraction of the filler and matrix in the composition;

ρ_k, ρ_m, ρ_d- - densities of composite, matrix and filler particles, respectively.

3. Results and Discussion

The results obtained by calculating the density of the materials that make up the compositions are given in Table 3.

Table 3. *Density of materials forming compositions, g / $ым^3$.*

Unfilled epoxy resin	1.109
Kaolin	2.610
Eggshell powder	2.540
Glass fiber	2.590
Aluminum oxide	3.940

Calculation of theoretical density

For epoxy composition filled with 20% eggshell powder:

$$\rho_k = \frac{1}{w_d/\rho_d + w_m/\rho_m} = \rho_k = \frac{1}{0{,}2/2.540 + 0.8/1.109} = 1{,}250$$

30 %: for epoxy composition filled with egg shell powder.

$$\rho_k = \frac{1}{w_d/\rho_d + w_m/\rho_m} = \rho_k = \frac{1}{0{,}3/2.540 + 0.7/1.109} = 1.335$$

20 % For kaolin-filled epoxy composition:

$$\rho_k = \frac{1}{w_d/\rho_d + w_m/\rho_m} = \rho_k = \frac{1}{0{,}2/2.610 + 0.8/1.109} = 1{,}253$$

30 % For kaolin-filled epoxy composition:

$$\rho_k = \frac{1}{w_d/\rho_d + w_m/\rho_m} = \rho_k = \frac{1}{0{,}3/2.610 + 0.7/1.109} = 1{,}340$$

50 % For glass fiber-reinforced epoxy composition:

$$\rho_k = \frac{1}{w_ş/\rho_ş + w_m/\rho_m} = \frac{1}{0.5/2.590 + 0.5/1.109} = 1.553$$

50 % şüşə lif və 10 % Al_2O_3 For glass / epoxy composition:

$$\rho_k = \frac{1}{w_ş/\rho_ş + w_d/\rho_d + w_m/\rho_m} = \frac{1}{0.5/2.590 + 0.1/3.940 + 0.4/1.109} = 1.727$$

For 50% glass fiber and 20% Al_2O_3 composite / epoxy composition:

$$\rho_k = \frac{1}{w_ş/\rho_ş + w_d/\rho_d + w_m/\rho_m} = \frac{1}{0.5/2.590 + 0.2/3.940 + 0.3/1.109} = 1.944$$

The effect of egg shell and kaolin particles on the density of epoxy composites is shown in Table 4. As can be seen from the table, the density of epoxy composites increased with the addition of 20, 30% kaolin and egg shell particles. The increase is due to the addition of fillers with a higher density than unfilled epoxy resin.

Table 4. *Density and void fraction values of composites filled with eggshell powder and kaolin.*

The amount of filler in the composition,%	Experimental density, q/sm^3		Theoretical density, q/sm^3		Volume fraction of voids,%	
	Eggshell powder	Kaolin	Eggshell powder	Kaolin	Eggshell powder	Kaolin
20	1.191	1.218	1.250	1.253	4.95	2.87
30	1.256	1.284	1.335	1.340	6.27	4.36

The theoretical and measured densities of glass / epoxy and aluminum oxide-filled glass / epoxy composites, together with the corresponding volume fraction of voids, are given in Table 5. It is clear from the table that the density of the glass / epoxy composite and the volume fraction of the voids increase with the inclusion of alumina.

Table 5. *Density and void fraction values of glass / epoxy and aluminum powder filled glass / epoxy compositions.*

The composition of the composition	Experimental density, q/sm^3	Theoretical density, q/sm^3	Volume fraction of voids,%
50% epoxy + 50% glass fiber	1.538	1.553	0.98
40% epoxy + 50% glass fibre + 10% Al_2O_3	1.696	1.727	1.83
30% epoxy + 50% glass fibre + 20% Al_2O_3	1.898	1.944	2.42

The tensile strength of the epoxy resin during tensile strength was assessed at room temperature and at a deformation rate of 5 mm / min using a universal traction machine. After the test specimens were carefully cleaned and dried, an appropriate amount of epoxy adhesive was evenly distributed over the area at the ends of the metal sheets. The results of the study of the effect of the amount of filler on the adhesive strength of epoxy resin are given in Table 6.

Table 6. *The effect of the amount of filler added to the adhesion strength of the epoxy resin.*

The amount of filler in the composition,%	Adhesion strength during traction, MPa	
	Eggshell	Kaolin
0	13.6	13.6
20	14,2	15.8
30	9.1	12.3

It can be seen that with the addition of kaolin and eggshell powder, this property increased and showed a maximum value with a 20% filler. However, the tensile strength of traction decreased with subsequent increase in the amount of these fillers.

4. Conslusion

For all fillers used, the density and void fractions of epoxy composites increased with increasing mass fraction in the composition.

It was found that the inclusion of fillers in the composite material greatly affects the mechanical properties. Thus, in a certain mass fraction of kaolin and eggshell powder, the adhesion strength increased, but the subsequent increase in the amount of fillers decreased.

In general, it can be noted that the tensile strength of unmodified epoxy resin is higher than the strength of epoxy compositions, and the modulus of elasticity is lower. This indicates that the addition of filler to the epoxy resin and glass / epoxy resin reduced the tensile strength and increased the modulus of elasticity.

An increase in the hardness of the epoxy composition was observed with the inclusion of eggshells and kaolin as fillers.

Unfilled epoxy resin had a lower water absorption rate and increased water absorption with increasing filler content.

The obtained modified resin can be used in the manufacture of anti-corrosion coatings, furniture, decorative, automotive, creative and construction works.

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