International Science Journal of Engineering & Agriculture
2024; 3(6): 95-100
https://isg-journal.com/isjea
doi: 10.46299/j.isjea.20240306.09
ISSN: 2720-6319

Determination of the main parameters of the modified epoxide oligomer

Ibrahim H. Movlayev
Technology of organic substances and high molecular compounds, Chemical Engineering, Azerbaijan State Oil and Industry University, Baku, Azerbaijan
ORCID 0000-0001-6241-9892

Aynur F. Mammadova
Technology of organic substances and high molecular compounds, Chemical Engineering, Azerbaijan State Oil and Industry University, Baku, Azerbaijan
ORCID 0000-0002-1938-1320

To cite this article:
Movlayev Ibrahim H., Mammadova Aynur. Determination of the main parameters of the modified epoxide oligomer. International Science Journal of Engineering & Agriculture. Vol. 3, No. 6, 2024, pp. 95-100. doi: 10.46299/j.isjea.20240306.09.
Received: 10 03, 2024; **Accepted**: 11 04, 2024; **Published**: 12 01, 2024

Abstract: In order to obtain a high-quality composite material based on the epoxy oligomer that meets the requirements of the operating conditions, research works were carried out in this direction in the dissertation work on obtaining compositions with new quality modified properties based on the modification of the epoxide oligomer with various oligomers. Therefore, ED-20 / MFFO-96/4, ED-20 / SKN-18-1-96/4, ED-20 / MFFO / SKN-18-1-96/2/2, MFFO, SKN-18-1, MFFO / SKN-18-1 and MFFO / . Highly filled compositions based on butadiene-nitrile rubber modified with SKN-18-1 / ED-20 oligomer and oligomer mixtures were prepared and their properties were studied. A number of properties of these obtained adhesive compositions have increased compared to the properties of the composition obtained on the basis of ED-20. For example, strength limit at the moment of breaking, strength of contact with metal on tearing, strength of contact with metal on sliding, strength of contact with wood, resistance to aggressive environments, etc. The influence of fillers (ZnO and dolomite) on the physico-mechanical properties of adhesive compositions was studied and their optimal amounts were determined. It was found that ZnO has a more effective effect than dolomite.
Keywords: oligomer, rubber, butadiene-nitril, modification, effect, research

1. Introduction

In order to obtain a high-quality composite material based on epoxy oligomer that meets the requirements of operating conditions, in this direction, research and study of the properties of compositions with new quality changed properties was carried out based on the modification of epoxy oligomer with various oligomers. Highly filled compositions based on butadiene-nitrile rubber modified with ED-20 / MFFO-96/4, ED-20 / SKN-18-1-96/4, ED-20 / MFFO / SKN-18-1-96/2 / 2, MFFO, SKN-18-1, MFFO / SKN-18-1 and MFFO / SKN-18-1 / ED-20 oligomers and oligomer mixtures were prepared and their properties were studied.

A number of properties of these adhesive compositions are increased compared to the properties of ED-20 based compositions. For example, strength in contact with metal during sliding, strength limit at the moment of failure, strength in contact with metal during rupture, strength in contact with wood, resistance to aggressive environments, etc. Effect of adhesive compositions on fillers. (ZnO and dolomite) physical-mechanical properties are studied and optimal amounts are determined. ZnO is found to be more effective than dolomite.

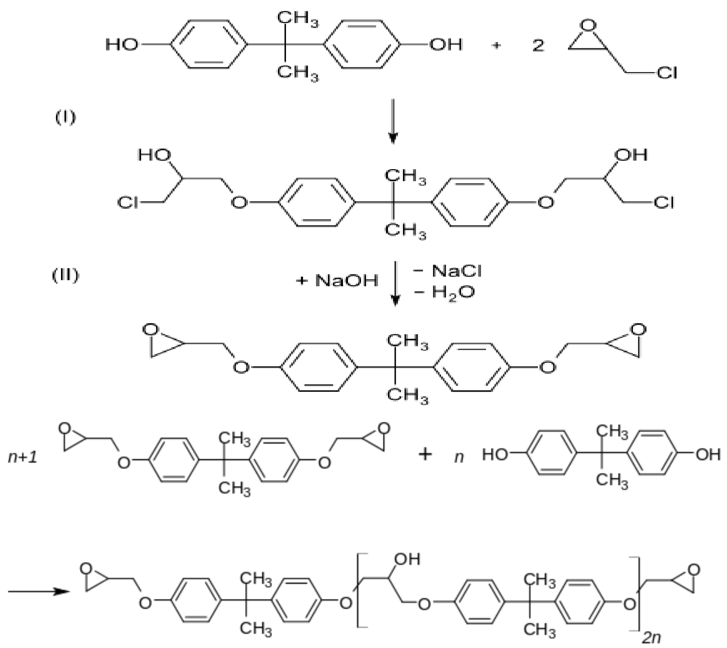
2. Object and subject of research

It is known that epoxide oligomers with reactive functional groups have very high adhesion and electrical conductivity. Therefore, they are also used in the production of coatings, laminates, and adhesives for semiconductor devices. Also due to its strength properties, the properties of epoxide oligomer are much higher than other oligomers. Tensile strength 1400 kgs/cm2, compressive strength 4000 kgs/cm2, flexural strength 2200 kgs/cm2, relative elongation 50000 kgs/cm2, impact viscosity 250 kg/m3, relative elongation 750% (at 20°C). The main disadvantage of epoxy oligomers is that they are expensive. In addition, these compositions based on them are considered fragile and resistant to aggressive environments [1].

In order to overcome this deficiency, they modify them with various functional group compounds. This is what we have used in our current work in elastomers. We use polybutadiene (PB) and polyisoprene (PI) as elastomers. It has been determined that the temperature resistance of polyisobutylene is stronger than that of polybutadiene. In order to determine good and quality mixing, the polymer particles must be very well crushed (d=0.14mm). First, therefore, we grind the elastomer well in a mill. Also, at this time, electrical conductivity also improves. The addition of elastomer to the epoxy oligomer increases the viscosity of the mixture and thus prevents clumping during the curing process, increases impact resistance, flexibility, as well as strength and hardness of the oligomer. Therefore, the received compositions are resistant to oil, gasoline, water, solutions of low concentration sulfate and hydrochloric acid, and alkalis. Also, the resistance of this composition to water and heat was determined [3].

3. Target of research

Epoxy oligomer is a universal oligomeric material that is used in the production of joints and composites, as well as in the casting of various surfaces and in the production of glue. Due to the unique combination of useful main properties, the epoxy oligomer is useful both in industry and in everyday life. It is obtained by the following reaction.



4. Literature analysis

Physico-mechanical parameters of epoxy oligomer are shown in table 1.

Table 1. Physico-mechanical parameters of ED-20 brand epoxide oligomer.

Tensile strength, kgs/cm^2	Compressive strength, kgs/cm^2	Flexural strength, kgs/cm^2	Impact viscosity, kg/m^3	Relative elongation (at 20 degrees),%	Dynamic viscosity, Pa/s
1400	4000	50000	250	750	13-20

5. Research methods

The results of the study of the processes occurring during the mixing of butadiene-nitrile rubbers and dianepoxide oligomer are summarized. The mechanism of mutual diffusion, rheokinetics and chemical reactions in resin-epoxide systems is considered. Kinetic parameters, activation energy of chemical andolomid diffusion processes are evaluated. The process of mixing epoxy oligomer and rubber can be divided into four stages. The first stage involves mutual diffusion in the absence of any chemical interaction. The second stage is characterized by the predominant interaction between carboxyl and epoxide groups. The third stage includes the parallel interaction of carboxyl, epoxy and secondary hydroxyl groups; resulting in the formation of an adduct compound. In the fourth and final stage, gel formation occurs and thus changes the mechanical and adhesion properties of the composites.

The simultaneous processing of low-density polyethylene with the addition of epoxy oligomers increased the strength of the polymer; this is due to changes in PE and its chemical reaction with the epoxide oligomer. The intensity of this reaction, evaluated on the basis of viscosity, depends on the epoxy value of the oligomer. IR-spectroscopy and mass spectrometry confirmed the existence of a chemical reaction of the polymer with the additive [23].

Epoxy oligomers are considered one of the most important classes of thermosetting polymers for many industrial applications, but unfortunately they are characterized by relatively low stiffness. In this regard, many efforts have been made to improve the hardness of epoxy resins by introducing hard particles, reactive rubbers, intercalated polymer networks and thermoplastics in the matrix. In this work, hydroxyl group-restricted polybutadiene was taken and first cross-linked with variable content of divinylbenzene (DVB) in the presence of an epoxide oligomer as a modifier and then cross-linked with the modified matrix 1-methylimidazole. Infrared spectra indicated the existence of a chemical reaction between polybutadiene and ER restricted by the modified hydroxyl group. Most of the tensile properties reached a peak at about 20 percent (per hundred rubber) DVB content, where hardening reached a maximum. Overall results showed that it is possible to obtain excellent impact strength and good mechanical properties by using hydroxyl group-restricted polybutadiene as a curing agent for epoxy oligomers.

Three-point bending tests were performed with two types of resin-modified epoxides: liquid resin and nano-elastomer particle-modified epoxide oligomer. In most studies on resin-toughened epoxy resins, the fracture toughness was evaluated by the critical stress intensity factor or critical energy free dissipation rate, where the crack is assumed to propagate rapidly and the propagation of stable cracks is not considered. However, stable crack propagation was observed for the present rubber modified epoxide oligomer. Fracture toughness was characterized using crack growth resistance curves (R-curve) to account for crack propagation. In this study, the evolution behavior of the damage zone near the crack tip was observed using a video microscope for two types of rubber modified resins. In addition, to investigate the microscopic fracture mechanisms, the fracture surfaces were monitored by electron microscopy, and the side points near the crack layer were also observed by hidden laser electron microscopy.

Compositions based on epoxy oligomers have the ability to harden in the cold as well as in the heat. We use the process of cold hardening of these compositions based on epoxide oligomer, we use polyethylene polyamine as a cold hardener. To prepare the adhesive composition, we heat the epoxide oligomer in a water bath to a temperature of 60-70℃ and add antioxidant, PEPA to it. We study the properties of the prepared adhesive composition and we determine the amount of optimal PEPA.

In order to improve the physico-mechanical, adhesive properties and moisture resistance of epoxy oligomer-based adhesive compositions, epoxy oligomer is modified with aniline-modified phenol-formaldehyde oligomer (MFFO), butadiene-nitrile oligomer (SKN-18-1) in liquid form, and the adhesive based on it compositions are prepared. The procedure for preparing the adhesive composition is the same as for the epoxy oligomer. It is simply added here in modifying compounds. Samples are prepared to study the physical and mechanical properties of the obtained adhesive compositions, the surface of the parts to be glued is first cleaned to determine their adhesion, then a layer of glue is applied to the surface and the glued parts are stored at room temperature for 20-24 hours or processed at 100-120 ℃ to improve the quality of adhesion.

In order to improve the complex properties of the adhesive composition based on epoxy oligomer, we have prepared an adhesive composition based on ED-20 / MFFO / SKN-18-1 oligomer mixtures in various proportions. In order to improve its location and technological, physical-mechanical properties, MFFO and SKN-18-1 oligomers are added to the epoxide oligomer in several variants, and an adhesive composition is prepared [5-8].

6. Research results

A test bottle with a volume of 100 ml is taken and 0.1-0.5 g of the substance to be analyzed is added to it. Then this substance is mixed well in 5 ml of solution. Then, with a special tool, this prepared solution is poured onto 10-15 ml of hydrochloric acid in an acetone mixture. , kept at room temperature for 30 minutes. Pour 2 or 3 drops of indicator (methyl red) into the test bottle and shake with 0.1 n NaOH solution until the red color disappears [6-12].

The mass fraction (in %) of the oligomer shown by the following formula is calculated:

-

$$x = \frac{(V1 - V2)f \cdot 0{,}0043 \ \cdot 100}{g}, \%$$

Here; V1-0.1 n NaOH alkaline solution is the amount used for titration in the determination of the analyzed substance, ml; V2- the amount of 0.1 n NaOH alkaline solution allocated for titration without the analyzed substance, ml; m-substance weight g; 0.0043- is the loss of epoxide per 1 ml of n NaOH alkaline solution. We performed the analysis with the same rule and got the following result.

V1 = 48.7 ml; V2 = 28.5 ml; m = 0.458 g.

And we calculate as follows:

$$x = \frac{(48{,}7 - 28{,}5) * 1 * 0{,}0043 * 100}{0.458} = 18.9\%$$

So, the amount of epoxy resins is 18.9%.

7. Prospects for further research development

Infrared spectroscopy:

They analyze organic compounds by the infrared (IR) spectroscopy method. It is one of the most important and modern methods. The infrared field of the spectrum is studied in the range of 4000-625 cm-1. This method allows to determine both solid, liquid and vapor substances, and as a solvent chloroform (CCl4), acetone (C3H6O) or carbon disulfide (CS2) are taken. In IR spectroscopy, pellets of KCL and KBr are used, in which approximately 300 mg of KBr is mixed with 1 mg of weighed sample and then compressed under high pressure to form a pellet. And the spectrum of the studied compound is compared with a compound whose spectrum is known in advance. When the spectra overlap, it means that the substances are similar to each other. And we separately recorded the spectrum of SKN-18-1, ED-20, SKN-18-1+ED-20. And then we compare the received spectra.

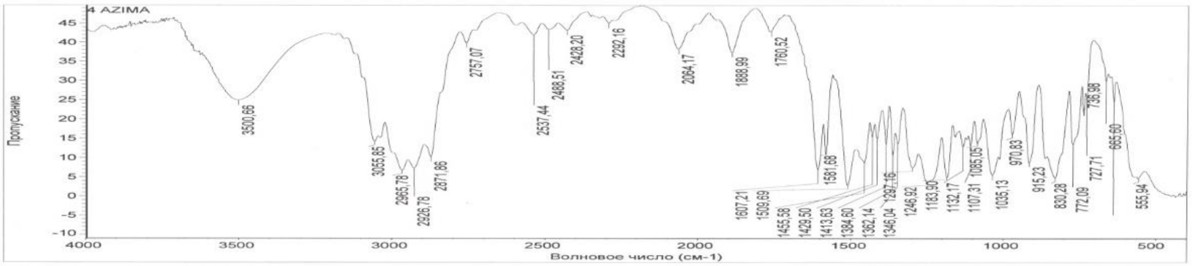


Figure 1. IR spectrum of ED-20 branded epoxide oligomer.

3055, 3030 cm^{-1} for the absorption band of deformation titration of CH bonds in ED-20 oligomer;

The absorption band of CH bonds in CH_2 units is 2965, 2926, 2871 cm^{-1} and the valence titration absorption band of CH bonds in the aromatic core is 1607, 1509, 1413 cm^{-1};

δCH =1455,1384,1362,727cm^{-1} absorption band of CH bonds and deformation vibrations in CH_2 units;

δCH = 970,915,830,772 valence titration bands of CH bonds connected to 2-fold vrabite in the aromatic nucleus;

8. Conclusions

Epoxy oligomer (ED-20), aniline-modified oligomer phenol-formaldehyde (MFFO), oligomer SKN-18-1, rubber SKN-40.

The purpose and character of the study: in order to obtain a high-quality composite material based on an epoxy oligomer that meets the requirements of the test conditions, research work was conducted in this direction in the dissertation to obtain compositions with new high-quality modified properties. Based on the modification of the epoxy oligomer with different oligomers. Therefore, the properties of highly filled compositions based on butadiene-nitrile rubber modified with oligomers and mixtures of oligomers such as ED-20 / MFFO-96/4, ED-20 / SKN-18-1-96/4, ED-20 / MFFO were developed and studied. / SKN-18-1-96/2/2, MFFO, SKN-18-1, MFFO / SKN-18-1 and MFFO / SKN-18-1 / ED-20.

Dolomite (CaO -29.6%; MgO -19.5%; Fe2O3 -0.5%; Al2O3 - 0.14%; CoO - 0.15%; MnO - 0.10%; NiO - 0.11% ; ZnO – 0.13% ; SiO2 – 2.14% ; CO2 – 46.72%) is a solid substance with a unique pearly luster. Dolomites can have several colors, but mostly there are colorless, pink and white forms. The hardness of dolomite is 3.5-4, and its density is 2.85-3.00.

Zinc oxide (ZnO) is a white, odorless, powdery solid substance with high electrical conductivity, insoluble in water. Zinc oxide along with stearic acid is used in rubber vulcanization and also protects rubber from UV light.

Obtained results: A number of properties of these obtained adhesive compositions increased in relation to the properties of compositions obtained on the basis of ED-20. For example, the strength limit at the moment of destruction, the strength of contact with metal when sliding, the strength of contact with wood, resistance to aggressive environments, etc. The influence of adhesive compositions on the physical and mechanical properties of fillers (ZnO and dolomite) was studied and their optimal amounts were determined. Studies have shown that the action of ZnO is more effective than that of dolomite.

References:

1) Movlaev I.G., Ibragimova S.M., Mamedova G.M. Analysis of local raw materials , use instead of traditional raw materials in various fields. Science, technology and education. 2017, No. 10(40), pp.6-11

2) Younis A.A Evaluation of the flammability and thermal properties of a new flame retardant coating applied on polyester fabric. Egyptian Journal of Petroleum, 2016, Vol.25, No.2, pp.161-169

3) Ibrahim Movlayev Gumbat, Telli Guliyeva Ali, Aynur Mammadova Fazil. Studying the rheological properties of ternary ethylene-propylene and copolymer modified with polybutadiene-styrene.The 22th International scientific and practical conference "Modern theories and improvement of world methods"(June 06–09, 2023), Helsinki, Finland. International Science Group. 2023. 543 p.

4) Ibrahim Movlayev Gumbat, Telli Guliyeva Ali, Aynur Mammadova Fazil. Preparation and study of compositions based on ternary ethylene-propylene copolymer mechano-chemically modified with polybutadien styrene.The 16th International scientific and practical conference"Methods of solving complex problems in science"(April 25–28, 2023) Prague, Czech Republic. International Science Group. 2023. 541 p.

5) Fariz Amirli, Ibrahim Movlayev, Gulnara Aliyeva, Aynur Mammadova. Compositions based on modified and filled epoxy oligomer. PPOR, Vol. 24, No. 4, 2023, pp.689-696

6) Teytelbaum B.Ya. Termomehanicheskiy analiz polimerov. M.: Nauka, 2015, 236, p.15.

7) Vshivkov SA, Safronov AP, Rusinova EV, et al. Metodyi issledovaniya polimernyih sistem. Ekaterinburg. Izd. Uralskogo universiteta, 2016, pp.232

8) Nigmatullina A.I., Pavlova A.A., Dementev A.D., et al. Issledovanie termostoykosti i ognestoykosti termoplastichnyih vulkanizatov, soderzhaschih sloistyie glinyi. Vestnik tehnologicheskogo universiteta, 2017, Vol. 20, No.14, pp. 51-53

9) Vshivkov S.A., Safronov A.P., Rusinova E.V., et al. Metodyi issledovaniya polimernyih sistem. Ekaterinburg. Izd. Urals University, 2016, pp. 232

10) Lu J., Yan F., Texter J. Advanced applications of ionic liquids in polymer science. Progress in Polymer Science, 2009, Vol.34, No. 5, pp. 431-448.

11) Bilalov Y.M., Movlaev I.G., Ivanov A.V., Ibragimov A.D. Rheological properties of mixtures of ternary ethylene-propylene and chlorine-containing polymers. Matt. Methods and equipment for processing them into products. Moscow, 1982, December 21-23, 1982, p. 6

12) Novakov I.A., Sidorenko N.V., Vaniev M.A. Phase stability and rheological characteristics of thermoplastic-polymerization-capable compound systems in the conditions of application of a mechanical field // Vestnik of Bashkir University. 2008. T.13. №. 4. p. 911–915