The Investigation of the Effect of Epoxide Resins Thermal Destruction Products on Epoxide Compounds Electrical Ageing

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ABSTRACT

Thermal destruction of epoxide diane resin is conducted in inert media at 300 °C for 180 min. Then the alcohol extract of the thermodestruction light products is obtained. After the ethyl alcohol distillation, the product is obtained in the quantity of 18 wt.% on the starting resin. Using the method of infrared spectroscopy, it is established that the obtained resin product of thermodestruction is a mixture of complex dioles.

The effect of 0.5-2 wt.% of this product as the additive on the electrical ageing of epoxide compounds is studied. It is established that the additive has the stabilizing effect on the ageing of epoxide compound. After the introduction of 2% of the additive the rate of the decrease of electrical strength of these compounds lessens 1.5 times, and the lifetime increases 3 times on the starting compounds.

Key Words: epoxide compounds, electrical ageing, thermal destruction, stabilizing

INTRODUCTION

Epoxide diane resins-based potting compounds have found wide application in high voltage equipment. They are used in the production of high voltage insulators, switches, power transformers, etc. Power transformers with potted insulation of windings, according to their processing parameters, surpass transformers of other construction. The potted windings have high heat and weather resistance, mechanical strength and they are water-proof.

But during the processing, insulating epoxide materials used in the said equipment are subject to electrical ageing as the result of the effect of electrical discharges. It is known, that the main reason of product characteristics degradation is the changes of the structure, resulting in the destruction processes flowing inside. In this connection, the development of methods for improving the epoxide compounds resistance to the electrical ageing is very urgent.

On studying various composition materials on the basis of epoxide resins, we found that the compounds obtained from the over-heated epoxide resins have higher electrical resistance, than the compounds obtained according to the existing technology. Thermodestruction kinetics of epoxide compounds were studied previously [1-4], where it was shown, that epoxides are not stable at temperature above 300 °C. Taking into account these factors, we conducted this investigation, the aim of which was the separation of the resin (ЭD-20) thermodestruction products and determination of the component, which effect electrical ageing processes.

EXPERIMENTAL

The stabilizer of interest was obtained by thermal treatment of epoxide-diane resin (ЭD-20) in inert helium media at 300 °C during 180 min. After cooling to 20-25 °C in the reaction vessel acetone was added in the quantity of 200 wt% according to the weight of starting resin. After complete dissolution, ethyl alcohol was also added in the quantity of 100 wt%. On heating and stirring acetone was extracted. Heavy products of destruction precipitated and the light products remained dissolved in ethyl alcohol. Then ethyl alcohol was distilled at 80-85 °C under normal pressure. As a result, a viscous product of yellow colour in the quantity of 18 wt.% was obtained.

The determination of the product was accomplished by infrared spectroscopy using UR-20 spectrometer in the range of 700-3700 cm^{-1}.

Epoxide compounds were prepared by vacuum mixing of ЭD-20 resin and phthalic anhydride (in a weight ratio of 3:1) with the addition of the obtained product (stabilizer) in the volume of 0.5-2 wt.% at 80 °C during 30 min. To prepare epoxide compound plates, the mixture was poured out on brass disks with recesses. The hardening was conducted in the following order: at 100 °C for 60 min., at 120 °C for 180 min., and at 140 °C for 900 min.

The electrical ageing of epoxide compounds was conducted in the testing cell, consisting of the grounded electrode (brass plate) with the tested sample, glass plate above with thickness of 1.5 mm and a clearance of the same thickness between plates. The layer of silver sprayed on the external surface of the glass plate was the high voltage electrode. High voltage of 9 kV of industrial frequency was supplied to the cell. The temporary electrical strength was determined as a result of 20 independent calculations of U_{Bz}/h relationship, where U_{Bz} is the break-down voltage and h is the arithmetic mean of five calculations of thickness around the break-down place. For the sample break-down, brass electrodes were used: upper electrode diameter-6 mm, the lower-25 mm, and high voltage was supplied to them with the rate of 2 kV/sec.

The lifetime (τ), or the time between the voltage supply and the sample break-down was determined according to the methods described in ref. [5].

RESULTS AND DISCUSSION

In Figures 1 and 2, respectively, the infrared spectra of the ЭD-20 resin of the obtained stabilizer are presented. The stabilizer indicates the considerable (2 and 1.6 times, respectively) increase of absorption band intensity of OH-groups (3450 cm^{-1}) and CH_2-groups (2851 cm^{-1}), and the absorption bands intensity of epoxide groups decrease (830, 920, 1240-1260 cm^{-1}).

It is supposed, that at thermal destruction of

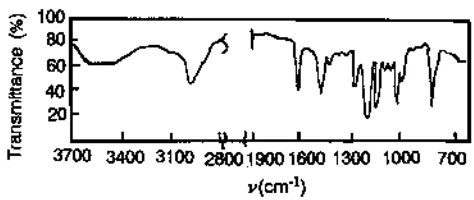


Figure 1. Infrared spectrum of the starting ЭD-20 epoxide-diane resin.

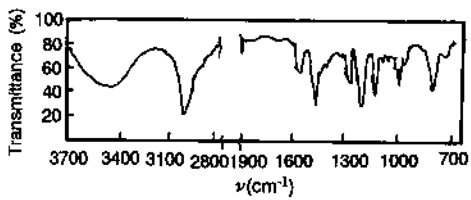
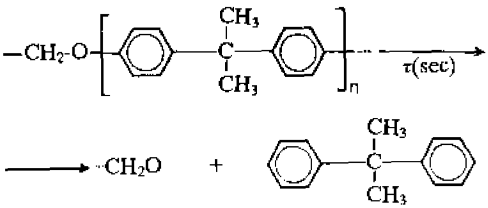
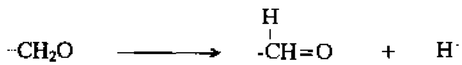


Figure 2. Infrared spectrum of the thermal destruction product (stabilizer).

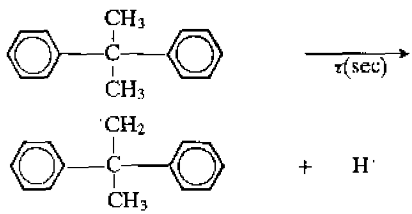
ЭD-20 the processes of tensed epoxide rings opening and ethers bonds destruction occur:



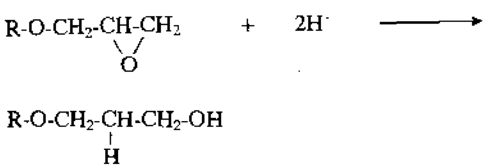
then the newly formed CH_2O radical is isomerized:



Hydrogen atoms are obtained as the result of the radical isomerization and the breakage of methyl group according to the following reaction:



and act like reducers breaking the tensed epoxide ring:



As a result, the complicated aromatic diole is formed: $(CH_3)_2C[C_6H_4O(CH_2)_nOH]$, where n=2, 3, which is used as the stabilizer for ЭD-20 resin-based epoxide compounds.

The values of temporary electrical strength of epoxide compounds, both stabilized and unstabilized, are practically the same, but the rate of their decrease under the effect of electrical discharge differs. Though E_s for stabilized and unstabilized samples decreases according to the linear low (Fig. 3), the rate of decrease for the stabilized sample

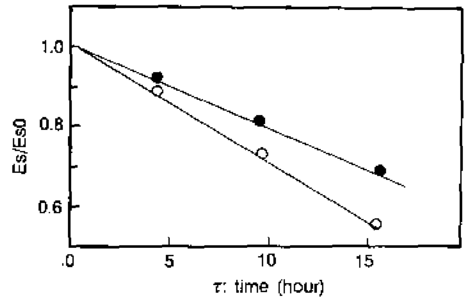


Figure 3. The dependence of the relative electrical strength on the electrical ageing time.

Es_0 - electrical strength of the starting samples.

Es - electrical strength of the samples being subject to electrical ageing.

o - compounds without stabilizer.

• - compounds containing 2 wt.% of the stabilizer.

is 1.5 times lower than for the unstabilized one.

The lifetime curve of both samples in the range of electric field tensions of 20-100 kV/mm is presented by a straight line (Figure 3) and is described by the following expression:

$$\tau = B\exp(-\beta E)$$

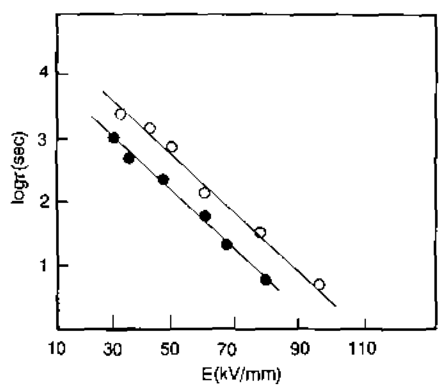


Figure 4. The dependence of the compounds lifetime on the voltage.

o - compounds without stabilizer.

• - compounds comprizing 2 wt.% of stabilizer.

where B and β are definite parameters depending on the electrical nature and test conditions. The straight line for stabilized samples [log τ = f(E)] lies higher, and the lifetime value after the stabilizer introduction increases by a factor of three.

So by the method of thermal destruction of ЭD-20 resin in vacuum we obtained the complicated aromatic diol, which is suggested as the stabilizing additive for epoxide compounds. After the introduction of 2% of the stabilizer the lifetime increases by a factor of three and the rate of temporary electrical strength decreases 1.5 times.

CONCLUSION

The mixture of complex aromatic dioles produced as a result of thermal destruction of ЭD-20 epoxide resin with addition of epoxide compounds in the quantity of 2 wt.% increases the lifetime of the compound during its electrical ageing. This investigation shows this diole mixture to be a good stabilizers of electrical ageing of epoxide compounds used in the production of high voltage equipment.

SYMBOLS

E: electrical strength (kV/mm).
τ: time (sec).
B and β: factors depending on the dielectric nature.
h: sample thickness.
U_{Br}: break-down voltage.

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