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THE STUDY OF THE ELECTRIC STRENGTH OF COMPOSITE MATERIALS BASED ON A POLYMER MATRIX

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The results of studies of polymer-based composite materials are presented. The characteristics of electrical resistivity and strength are measured. Recommendations on the practical application of the investigated materials are given.

The development of modern technology has led to the emergence of materials that have exceptional performance. Polymeric materials can have a molecular weight of from several thousand to several million.[1]

Distinctive properties of polymers are :

– Low rate of thermal conductivity. That is why some polymers can be used as insulation during some work;

– A high coefficient of LTEC is caused by a relatively high mobility of the bonds and a constant change in the strain coefficient;

– Despite the high rate of thermal expansion coefficient, polymer materials are ideal for spraying. Recently, it is often possible to meet a situation where the polymer is applied to the surface in the form of a thin layer to give the metal and other materials anti-corrosion properties. Modern application technologies make it possible to obtain a thin protective film;

– The specific gravity can vary in a rather wide range depending on the specific composition;

– A fairly high tensile strength from a part is caused by increased ductility. The resistivity can vary over a fairly wide range. An example of such polymers is hard PVC, which has 10^{17} Ohm × cm;

– The coefficient of linear expansion is from 70 to 200×10^{-6} per degree Celsius;

– To enhance the rigidity and strength of polymeric materials, various reinforcing fillers are introduced into their composition: fiberglass, carbon fibers, carbon -containing nanoparticles, metal - carbon nanocomposites, etc.

– Good dielectric properties allow the use of polymeric material without fear of electric shock. That is why polymers are often used to create tools and equipment designed to work with electricity.

The interest in polymeric materials is caused by the fact that every year the share of polymers accounts for an increasing number of products. Products from composite materials are used in everyday life, electronics, agriculture, construction. Today, polymeric materials are found in various states of aggregation such as glue, grease, sealant, paint, some solid polymeric materials. Solid composites are widely used in the production of a wide variety of equipment. As previously noted, composites based on a polymer matrix have high elasticity, due to which silicone, rubber, foam rubber and other similar polymeric materials were obtained .[2]

Of particular interest is the material that is used to seal the housings of devices, electronic components. An important characteristic for such materials is the electrical resistance .

It is known, that there are two paths of current flow of solid dielectrics: through the insulator and on its surface. Therefore, to assess the ability of a dielectric to conduct electric current in these directions, the concepts of volume and surface resistances are used. [3]

By volumetric (ρ_v) is meant the resistance that a dielectric possesses when direct current flows through its volume. The bulk resistance depends, besides other things, on the structure and composition of the material.

Surface (ρ_s) is the resistance that a dielectric possesses when direct current flows over its surface. Surface resistance depends on the state of the surface of the material through which current flows.

The article presents the results of studies of composite materials based on polymer matrix. Silicone and acrylic were chosen as matrix materials .

The methodology for determining the specific volume and surface electrical resistance was carried out according to GOST 6433.2-71 [4]

The results of the studies are presented in table 1.

Table 1. - Specific surface and volume resistance

Material	ρ_s Ohm * m	ρ_v Ohm * m
Acrylic Sealant		
Clean	$13.5 * 10^8$	$5 * 10^9$
Fiberglass (Fiber)	$1.6 * 10^6$	$11.4 * 10^7$
Fiberglass (Canvas)	$1.0 * 10^6$	$8.4 * 10^9$
Coal 10%	$1.0 * 10^6$	$1.7 * 10^9$
Coal 20%	$1.2 * 10^6$	$2.1 * 10^9$
Soot 10%	$1.2 * 10^6$	$11.1 * 10^7$
Soot 20%	$1.0 * 10^6$	$10.2 * 10^8$
PC10%	$3.09 * 10^8$	$4 * 10^8$
PC20%	$1.3 * 10^6$	$24 * 10^9$
Material	ρ_s Ohm * m	ρ_v Ohm * m
Siliconesealant		
Clean	$13.5 * 10^8$	∞
Fiberglass (Fiber)	$2.3 * 10^{10}$	∞
Fiberglass (Canvas)	$2.3 * 10^{10}$	∞
Coal 10%	$1.0 * 10^6$	∞
Coal 20%	$0.9 * 10^6$	∞
Soot 10%	$0.8 * 10^6$	∞
Soot 20%	$0.8 * 10^6$ ($34 * 10^6$)	∞
PC10%	$0.9 * 10^6$	∞
PC20%	$0.8 * 10^6$	∞

From the analysis of the results shown in table 1, the material based on silicone matrix with filler in the form of fiberglass has the highest surface electrical resistivity. Materials with silicone matrix with filler in the form of 20 % RS-5402 have the smallest surface electrical resistivity, and the material with filler in the form of 20 % carbon black has the same resistance.

Since the test material can be used for sealing the enclosure, a very important characteristic is electric strength. Strength in the broad sense is understood as the ability of the body to withstand the destruction that occurs as a result of external forces. The destruction of the polymer material takes place under the influence of electrical forces that determine the electrical resistance.

$$E_{пр} = \frac{U_{пр}}{d},$$

where U $_{CR}$ - breakdown voltage between conductors, V; d is the thickness of the dielectric layer, microns.

Having determined the value of EPr, it is possible to choose the optimal thickness of electrical insulating coatings with a margin of electrical strength.

It is known, that the electrical strength of the material depends on the composition, structure, concentration and type of filler material, thickness. This allowed us to determine the parameters of the study of the dielectric strength. [2]

Table 2 shows the results of tests of silicone and acrylic samples for electrical strength.

Table 2. - The results of the test for the electric strength of silicone sealants

Filler	VoltagekV	The thickness of the material, microns	Breakdown	E_{ol}, V / cm V / cm
Silicone sealant				
Clean	25.5	1.735	not	$1.4 * 10^8$
Fiberglass (Fiber)	27.3	1.713	not	$1.6 * 10^8$
Fiberglass (Canvas)	26.5	1.395	thereis	$1.89 * 10^8$
Coal 10%	26.5	1.705	not	$1.55 * 10^8$
Coal20%	26.5	1.842	not	$1.43 * 10^8$
Soot 10%	26.8	1.751	not	$1.53 * 10^8$
Soot 20%	26.8	1.893	not	$1.41 * 10^8$
PC10%	26.5	1.802	not	$1.47 * 10^8$
PC20%	26.5	1.827	not	$1.45 * 10^8$

Filler	VoltagekV	The thickness of the material, microns	Breakdown	E_{ol}, V / cm
Acrylic sealant				
Clean	10.4	0.867	thereis	$1.19 * 10^8$
Fiberglass (Fiber)	21.5	1.313	not	$1.63 * 10^8$
Fiberglass (Canvas)	8.7	0.988	thereis	$8.8 * 10^7$
Coal 10%	9.3	1.015	thereis	$9.16 * 10^7$
Coal 20%	10.4	1.010	thereis	$1.02 * 10^8$
Soot 10%	11.4	0.942	thereis	$1.2 * 10^8$
Soot 20%	9.8	0.856	thereis	$1.14 * 10^8$
PC10%	11.5	1.066	thereis	$1.07 * 10^8$
PC20%	7.8	1.332	thereis	$5.8 * 10^7$

From the analysis of table 2, we can conclude: silicone sealants have greater electrical strength than acrylic.

Composites based on a silicone matrix had the greatest electric strength .

Our research allows us to establish the dependence of E_{pr} composites on the type and amount of filler. The highest dielectric strength was found in materials based on a silicone matrix filled with fiberglass (in fiber). The conducted studies will allow us to propose composite materials as sealants for electronic components.

REFERENCES

1. Фетисов Т.П. Материаловедение и технология металлов: Учебник для студ. высш. техн. учеб. заведений / Т.П. Фетисов, М.Г. Карпман, В.Л. Матюнин и др. : под. Ред. Т.П. Фетисова. - М.: Высшая шк., 2007. - 639 с.
2. Евстифеев, В.В. и др. Электротехнические материалы, пластмассы, резины, композиты: Учебное пособие/ В.В. Евстифеев, М.С. Корытов. – Омск: Изд-во СибАДИ, 2009. – 36 с.
3. Волков Г.М. Материаловедение: Учебник Г. М. Волков, В.М. Зуев. - М.: Издательский центр «Академия», 2008. – 400 с.
4. ГОСТ 6433.2-71 (СТ СЭВ 2411-80) Материалы электроизоляционные твердые. Методы определения электрического сопротивления при постоянном напряжении Сб. ГОСТов. -М.: Издательство стандартов, 1994