UDC 621.316.89

ANALYSIS OF THE DIELECTRIC CHARACTERISTICS OF COMPOSITE MATERIALS BASED ON A POLYMER MATRIX

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Currently, polymeric materials are widely used in every branch of industry and human activity. On the basis of high molecular weight compounds, rubbers, fibers, plastics, films and paint coatings are manufactured. Polymers are the basis for the production of composite materials.

Polymers belong to the class of high molecular weight compounds and are characterized by chemical structure, molecular weight, molecular weight distribution, polarity, conformational flexibility of the chain, the ability to form supramolecular structures, etc.

The widespread use of polymeric materials is due to their *unique properties,* including: low density, high plasticity, elasticity, thermal and wear resistance, chemical and radiation resistance, low electrical and thermal conductivity, crack resistance under high-intensity loads, etc.

The properties of polymers, in turn, depend on the chemical nature of the monomer, production technology, the arrangement of molecules in space and the degree of their branching, as well as external conditions (pressure, temperature).

Composite materials are compositions, i. e. in their composition, in addition to the main component, called the matrix, other components (fillers) that differ from it in properties are included in certain ratios. The peculiarities of polymers are determined primarily by the properties of the binder. The filler usually imparts these characteristics [2]. The characteristics and properties of the produced material also depend on the choice of technology for their connection with the filler. After different components are combined, the resulted material has conductive property set, which reflects not only the initial characteristics of the generators of its components, but new properties which starting components do not possess. This makes it possible to create materials with predetermined or improved properties, which is an *undoubted advantage of composites* over traditionally used materials.

Previously we had conducted research that helped 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 glass fiber (fiber). This will make it possible to use composite materials as sealants for electronic components.

The relative permittivity of a dielectric material is defined as the ratio of the capacitance of a capacitor, in which the space between and around the electrodes is completely filled with the dielectric material under test, to the capacitance of the same positioned electrodes in a vacuum.

$$\varepsilon = \frac{C_x}{C_0} (1)$$

When determining the relative dielectric constant of a dielectric material according to formula (1), the interelectrode capacitance can be replaced with practically sufficient accuracy in vacuum with the interelectrode capacitance in airC_0 , since the relative dielectric constant of dry air$C_в$, under normal atmospheric conditions is close to unity ($\varepsilon_в$ =1.00053).

The dielectric constant depends on the presence of polar impurities and moisture in the polymer.

Permittivity is related to polarization, i.e. with the occurrence of certain electric moment in the unit. Electric point volume is the geometric sum unit - IU dipole moments which are included in this volume.

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

Samples for testing the dielectric constant were made in accordance with GOST 22372-77 [1].

Sample making technology:

1.We took silicone and acrylic sealant as a matrix.
2.The required amount of silicone and acrylic sealant used as a matrix is determined by weighing.
3.The percentage of fillers was calculated.
4.We combine the calculated filler with the matrix by stirring.
5.Apply the prepared mixture on a round-shaped substrate according to GOST 22372-77. [1]
6.After 24 hours, the samples were ready for measurements.

Samples shall meet the following requirements:

1. Samples for testing solid dielectric materials should be made in the form of round, square plates or cylindrical tubes.

2. The surface of the sample should be flat, smooth, without cracks, folds, dents, scratches, foreign inclusions and other defects. If necessary, the surface of the sample should be cleaned with a solvent that does not affect the properties of the material.

3. The thickness of the sample should be determined as the results of its measurements at not less than five points evenly spaced along the surface of the sample.

4. Measurement of the dielectric constant of the material should be made on the same sample.

The method for determining the dielectric constant was carried out in accordance with GOST 22372-77 [1].

The capacitance was measured on an E 7-8 installation that meets the requirements of GOST 22372-77 [1].

Arrangement of electrodes in a sample using a two-electrode system.

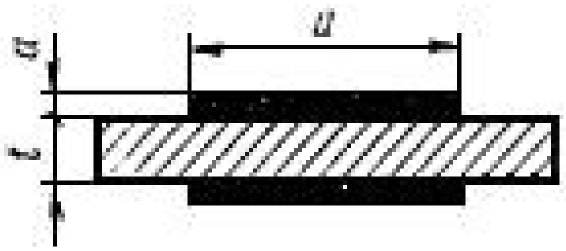

Figure 1. - Arrangement of electrodes in a sample using a two-electrode system

Formula for calculating C_0 interelectrode capacitance

$$C_0 = 0{,}0695\frac{d^2}{t} \quad (2)$$

The results of these studies are presented in Tables 1-4.

Table 1. - Test results for interelectrode capacitance and dielectric constant on the E7-8 device

Silicone newsealant		
	ε	C_0
PC 10%	2.594	15.216
PC 20%	3.286	15.419
Fiberglass (Fiber)	5.217	15.334
Fiberglass (Canvas)	2.609	25.273
Coal 10%	5.447	14.686
Coal 20%	1.727	23.167
Soot 10%	2.969	16.838
Soot 20%	3.314	15.088

Table 2. - Test results for interelectrode capacitance and dielectric constant on the E7-8 device

	Acrylic sealant	
	ε	C_0
PC 10%	0,48	29.030
PC 20%	0,71	20.871
Fiberglass (Fiber)	0,61	21.173
Fiberglass (Canvas)	0,42	28.138
Coal 10%	0,37	31.663
Coal 20%	0,633	25.249
Soot 10%	0,44	29.512
Soot 20%	0,46	32,477

Using the analysis of tables 1 and 2, we can conclude that silicone sealants have a higher relative permittivity of the dielectric material than acrylic.

Table 3. - Test results for interelectrode capacitance and dielectric constant on a laboratory bench

	Siliconesealant	
	ε	C_0
PC 10%	0.195	15.419
PC 20%	0.197	15.216
Fiberglass (Fiber)	0.261	15.334
Fiberglass (Canvas)	0.189	25.273
Coal 10%	0.265	14.686
Coal 20%	0.086	23.167
Soot 10%	0.178	16.838
Soot 20%	0.199	15.088

Table 4. - Test results for interelectrode capacitance and dielectric constant on a laboratory bench

	Acrylic sealant	
	ε	C_0
PC 10 %	0,24	29.030
PC 20 %	0,43	20.871
Стекловолокна (Волокна)	0,42	21.173
Стекловолокно(Полотно)	0,35	28.138
Уголь 10%	0,18	31.663
Уголь 20 %	0,35	25.249
Сажа 10%	0,37	29.512
Сажа 20%	0,307	32.477

Using the analysis of tables 3 and 4, we can conclude that silicone sealants have a higher relative permittivity of the dielectric material than acrylic ones.

Output:

Studies have been carried out on the dielectric characteristics of composites based on silicone and acrylic. The result of studies show that most are samples of silicone excipient where the carbon makes up 10% as measured on the instrument E 7-8. The least important are the samples made of silicone, the filler of which is 20% carbon, which was determined on a laboratory bench.

This information will be used for a comprehensive assessment of the properties of composites in the selection of their performance characteristics.

REFERENCES

1. GOST 22372-77 Dielectric materials. Methods for determining the dielectric constant and the tangent of the dielectric loss angle in the frequency range from 100 to $5 \cdot 10^6$Hz. By the termination of the State Committee of Standards of the Council of Ministers of the USSR dated February 18, 1977 N 424, the validity period was established from 01.01 1978 to 01.01 1983 - URL: https://docs.cntd.ru/document/1200016160. –Text: electronic.