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OPTIMIZATION OF POLYMER COATING COMPOSITION USING STATGRAPHICS SOFTWARE

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ОПТИМІЗАЦІЯ СКЛАДУ ПОЛІМЕРНОГО ПОКРИТТЯ З ВИКОРИСТАННЯМ ПРОГРАМНОГО ЗАБЕЗПЕЧЕННЯ STATGRAPHICS

Introduction. To improve the performance characteristics of epoxy coatings, carbon fillers are used [1–3]. However, using carbon fillers cannot always provide a comprehensive improvement in the properties of coatings. In particular, improving crack, wear, and chemical resistance often requires multidirectional approaches to modifying compositions. To solve this problem, it is advisable to use combined filling systems that involve the simultaneous introduction of several fillers of different natures and sizes into the epoxy matrix [4]. In particular, a combination of micro- and nano-additives is effective, which allows the creation of a multi-level spatial structure of the polymer. This approach contributes to the rational distribution of mechanical stresses in the volume of polymer coatings and effectively prevents the initiation and propagation of micro- and macro-cracks. Developing mathematical models is relevant to achieving a relationship between polymer coatings' structure and performance characteristics. Mathematical models allow for predicting the behavior of multicomponent systems, optimizing the ratio of different types of fillers in the matrix, and ensuring the required functional properties of the created polymer coatings.

Mathematical planning of the experiment was carried out using the Statgraphics application software package to increase the adhesion strength of protective coatings. The influence of fillers of different dispersions introduced into the epoxy matrix was considered when developing the experimental model. The use of mathematical planning made it possible to assess the impact of various factors on the characteristics of the coatings, minimize the number of experiments, and simultaneously obtain reliable results. In this case, the variation in the content of various components of the composition is significant since maintaining a rational ratio of epoxy resin, hardener, and fillers significantly affects the operational characteristics of the coating. Generalized data on the concentration of components are given in Table 1.

Table 1

Variable levels in nominal and natural scales

Components	Factor	Variable parameter values (wt. %)		
		-1	0	+1
Trimethoprim, 5...10 μm	x_1	5.0	10.0	15.0
Fullerene-carbon black mixture, 30…40 nm	x_2	0.025	0,050	0.075

The mathematical model of the dependence of the properties $y = f(x_1, x_2)$ was sought as a regression equation [4]. Thus, when analyzing the adhesion strength, the following regression equation was obtained:

$$y_1 = 40{,}67 - 1{,}65\,x_1 - 0{,}82\,x_2 - 0{,}35x_1^2 - 3{,}45x_2^2 + 0{,}37x_1x_2 \quad (1)$$

For statistical processing of the obtained experimental results, the reproducibility of the experiments was checked using the Cochrane criterion (G), using the method described in [4]. It was established that the condition $G_{res} = 0.208 \leq G_{table} = 0.478$ is fulfilled, i.e., the reproducibility of the

experiments was confirmed.

The significance of the regression equation coefficients was determined using the Student's test, using the method described in [4]. Fisher's test [4] established that the presented equations adequately describe the composition.

Further, transformations were performed to obtain regression equations with natural values of the variable parameters:

$$\sigma_a = 31{,}9 - 0{,}2q_1 + 489{,}333q_2 - 0{,}014q_1^2 + 3{,}0q_1q_2 - 5520{,}0q_2^2 \quad (2)$$

Using equations presented in natural values, the main effects were constructed depending on the content of heterogeneous additives (Fig. 1).

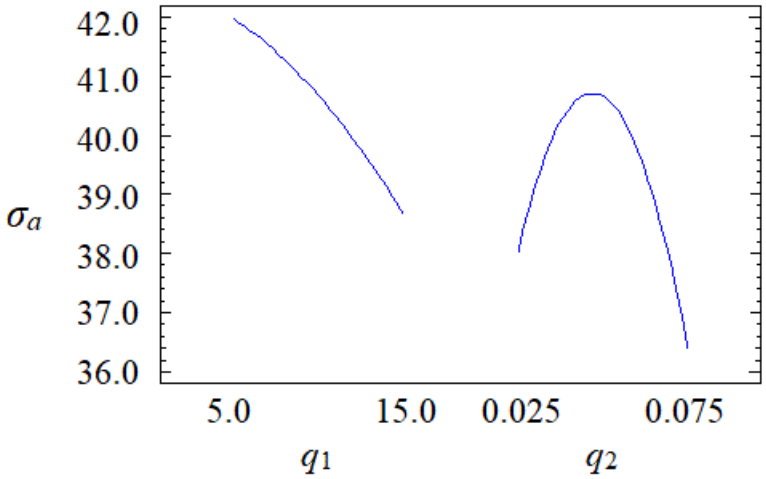

Fig. 1. Main effects of the influence of heterogeneous fillers $\sigma_a = f(q_1, q_2)$

Based on the analysis of the presented graph (Fig. 1), it can be stated that to ensure the maximum value of the adhesive strength, the optimal composition of the protective coating should contain 5.0 wt.%. Parts of trimethoprim and 0.050 wt.%. Parts of the fullerene-carbon black mixture.

Conclusions. The content of additives of different physicochemical nature in the epoxy binder was optimized using the method of mathematical planning of the experiment using the Statgraphics software, and an increase in the value of the adhesive strength was ensured from σ_a = 24.4 MPa to σ_a = 42.0 MPa.

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