

**Ukrainian Scientific  
and Practical  
Conference**

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**SRM**

**«Scientific Research  
Methodology – 2024»**



**November, 2024**

# Proceedings

## Ukrainian Scientific and Practical Conference

# Scientific Research Methodology – 2024



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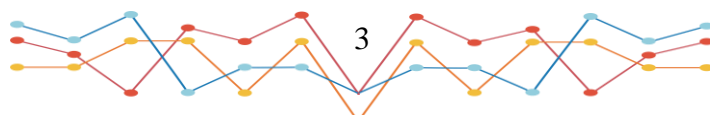
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## QUALITY CONTROL SYSTEM FOR ANTICORROSIVE COATINGS OF STEEL PRODUCTS

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**Abstract.** *As a result of the research, it was found that adding zinc oxide nanoparticles to acrylic lacquers can effectively retard corrosion of Fe37-3FN and UA10 steels in acidic concentrated and dilute environments. It has been established that when the chemical reaction retarder is applied, a predominantly dense phase of ferric metahydroxide is formed on the surface of steels, and the content of ferric carbide is not detected on the surface. It has been shown that nanoparticles cause better adhesion of the varnish to the surface.*

**Key words:** *zinc oxide nanoparticles, corrosion chemical reaction retarder, low alloy steel, high carbon steel, acrylic varnish.*

**Introduction.** Metals are widely used in our daily lives, and they are essential in all spheres of life. However, the surface of metal materials and the environment enter into chemical or electrochemical interactions, causing degradation or damage to the material (corrosion). Chemical reaction retarders for corrosion can be pre-applied to the metal or introduced directly into the aggressive environment. Due to the variety of aggressive environments, the first type of corrosion protection coating is easier to implement in practice. Corrosion protection by means of coatings is attractive because it is one of the most effective, flexible, cost-effective and simple strategies.

The characteristics of polymer coatings are often affected by their inherent porosity and defects that create pathways for aggressive substances, leading to mechanical and corrosion damage. One way to solve this problem is to use nanomaterial additives to polymer matrices.

The **aim** of the work is evaluation of the protective properties of chemical reaction retarders based on zinc oxide nanoparticles obtained by spray drying and acrylic varnish on the example of U10A and Fe37-3FN steel.

To achieve the set goal, the following tasks need to be addressed:

- Evaluation of the stability of chemical reaction retarders based on zinc oxide nanoparticles by gravimetry in a mixture of concentrated nitric and hydrochloric acids.
- Study of the morphology of steels with a chemical reaction retarder before and after corrosion by optical microscopy.
- Evaluation of the phase composition of the surface of steels with a chemical reaction retarder before and after corrosion.
- Construction of a mathematical model of the degree of corrosion of the damaged layer of steels.

### Methods and Materials.

**Preparation of nanoparticles.** In the master's thesis, zinc oxide nanoparticles obtained by nanospray drying were used. Spray drying is a method of obtaining a dry powder from a liquid or suspension by rapid drying with hot gas. We used the NanoSprayDryer B-90 to obtain particles

from 300 nm to 10  $\mu\text{m}$  in size from solutions or suspensions by drying or encapsulation with a yield of up to 90%. The particle size at the output depended on the selected spray nozzle.

The following spray drying parameters were used in the experiment: gas flow rate 103-105 l/min, relative spray intensity 45-59 %,  $T = 80\text{ }^{\circ}\text{C}$ ,  $P = 31\text{ Pa}$ . The nanopowders were collected from the cylinder and annealed at  $250\text{ }^{\circ}\text{C}$  for 1 hour.

**Preparation of a chemical reaction retarder.** A commercial dispersion of acrylic varnish was chosen as a polymer matrix for zinc oxide nanoparticles. The composition of the acrylic varnish mainly included a liquid polymer, an acrylic dispersion (polymers of prop-2-enoic and 2-methylprop-2-enoic acids and their derivatives).

The chemical reaction retarder was prepared and applied to the steel surface in two ways. First, acrylic varnish was mixed with zinc oxide (10 ml of acrylic varnish + 0.015 g of zinc oxide nanoparticles (0.15 wt. %)), then applied to the steel surface. The second method involved first applying zinc oxide nanoparticles (25 ml of water + 0.0375 g of zinc oxide nanoparticles (0.15 wt%)) from an aqueous suspension, drying at room temperature for 15 minutes, and then applying acrylic varnish.

The evaluation of the phase composition during the etching process was performed by obtaining X-ray phase diffractograms of the steel before and after etching (Shimadzy XRD-7000S X-ray diffractometer). X-ray tube: Cu, voltage 40 (kV), current 30 (mA). Diffraction was recorded in the range from 20 to 90 degrees ( $2\theta$ ) at a speed of  $1^{\circ}/\text{min}$ , step  $0.03^{\circ}$ .

The modeling results show the convenience of using two measures of corrosion: by the depth of damage to the structural material  $h$  and by the loss of its specific gravity  $m$ . The value of  $m$  is a measure of corrosion of the specific area of the surface layer of the product, and the value of  $h$  is a local characteristic of the depth of damage. These measures provide an objective assessment of the corrosion damage to the product based on modeling using systematized research data. The material functions included in the model relations and determined on the basis of systematized research data made it possible to obtain reliable results for assessing the damageability of Fe37-3FN and UA10 steels.

**Conclusions.** As a result of the study, it was found that adding zinc oxide nanoparticles to acrylic lacquers can effectively slow down the corrosion of Fe37-3FN and U10A steels in acidic concentrated dilute media. It has been established that when chemical reaction retarders are applied, a predominantly dense phase of ferric metahydroxide is formed on the surface of steels, and the content of ferric carbide is not detected on the surface. It is shown that nanoparticles cause better adhesion of the varnish to the surface.

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