https://gospodarkainnowacje.pl
GOSPODARKA I INNOWACJE

LABORATORIUM WIEDZY Artur Borcuch

*Volume: 40 | 2023*
**Economy and Innovation**
**ISSN: 2545-0573**
For more information contact: editor@gospodarkainnowacje.pl

# RESEARCH OF DETERMINING THE EFFICIENCY OF ANTICORROSION COATING BASED ON VERMICULITE BY ELECTROCHEMICAL METHOD

**[1]Bakirov Zh. A., [2]Khalikova S. Dz., [3]Beknazarov Kh. S.**

*[1]Doctoral student, Tashkent Institute of Chemical Technology, Tashkent, Uzbekistan.*
*(ORCID: https://orcid.org/0009-0000-7634142X)*
*[2]Doctor of technical sciences, Tashkent Institute of Chemical Technology. Tashkent, Uzbekistan.*
*(ORCID: https://orcid.org/0000-0002-8736-1030)*
*[3]Doctor of technical sciences, professor. Tashkent Research Institute of Chemical technology, Tashkent, Uzbekistan.*
*(ORCID:* https://orcid.org/0000-0002-5070-4773*)*

**A R T I C L E I N F O.**

***Keywords:*** composite anti-corrosion coatings, vermiculite, 1 M chloride Acid, 1 M sulfuric acid, microphotographs, electrochemical methods.

**Annotation**

In this paper, composite anti-corrosion coatings based on vermiculite and polymer were obtained and an attempt was made to determine their inhibition efficiency by electrochemical methods. The experiments were mainly carried out in 1 M chloride, 1 M sulfuric acid and 3.7% sodium chloride solutions. According to the obtained results, the anti-corrosion coating obtained on the basis of vermiculite has a high degree of protection for salty environments, and it was also determined by microphotographs obtained after the experiment.



## Introduction.

There are two main methods of protecting metals and metal-based structures from corrosion, which include: mainly various anti-corrosion coatings and chemical pickling[1]. Today, various types of protective coatings are used to increase the corrosion resistance of the surfaces of steel parts. For the production of these protective coatings, it must be thermally stable and resistant to various mechanical and aggressive environments. This coating is becoming more and more popular due to its several advantages. These coatings are currently called anti-corrosion coatings. Organic (polymer, oligomer, etc.), inorganic, and metal-organic composite and hybrid anti-corrosion coatings are used as raw materials for these coatings[2].

Accelerated tests are an efficient and quick solution to assess organic coatings under controlled conditions[3]. A thoughtful examination of typical accelerated tests was made by Jacques, who described the main factors and the significance of each assay. Further modifications have been made in order to correct deficiencies in traditional tests. Combined tests and new types of chambers have been proposed to study the effects of different environmental factors on organic coatings[4].

In this paper, the behaviors of four anticorrosive organic coatings subjected to accelerated tests are analyzed using electrochemical impedance spectroscopy (EIS)[5]. The results obtained helped to establish an exponential relationship between the impedance module and the explanatory variables for each coating, being the response variable. This relationship allows assessing the performance of the coatings studied under the aforementioned conditions[6]. Also, it may be useful for weighing the effects of each factor, estimating the impedance modules of the coatings for extended periods, and establishing times of failure. A minimum value of is selected as criterion for protective performance, where a value in the range between $10^6$ and $10^7$ Ω $cm^2$ is generally accepted[7].

**Materials.** Vermiculite of the Tebinbulak deposit was used as a natural mineral. Before using vermiculite, acid treatment was carried out with a 1 M hydrochloric acid solution. Within two days. Then it was washed with distilled water until neutral and the resulting product was dried to a constant weight.

**Methods.** Infrared spectra were recorded using an IRAffinity-1S FT-IR spectrometer, Japan, between 600 and 4000 cm-1. The surface morphology of the coatings, as well as the morphology and size of the hybrid composite, were studied using a scanning electron microscope (SEM, leo1455vp-leq).

## Experimental part

Vermiculite of the Tebinbulak deposit was used as a natural mineral. Before using vermiculite, an acid treatment was carried out with a 7% hydrochloric acid solution. Within two days. Then it was washed with distilled water until neutral and the resulting product was dried to a constant weight.

***Hybrid coatings were prepared as follows:*** first, crotonaldehyde (a secondary raw material in the synthesis of acetaldehyde) was treated with ammonia, after which epoxy resin ED-20 was used to obtain the coating, the epoxy resin was mixed with treated crotonaldehyde with ammonia, and acid-treated vermiculite. Substrate preparation. Steel plates with dimensions of 150×100×0.6 mm were manufactured according to the following steps[8].

## Results and Discussion

**Electrochemical measurements** were carried out under extreme environmental conditions, including exposure to an aqueous solution of sodium chloride (3.5% NaCl) in air. Each sample was sealed with waterproof tape to prevent premature corrosion along the edges of the substrate. A 1cm×1cm ear at the center of each specimen was exposed to the solution during testing. Corrosion analysis of bare and coated substrates was performed using a CS350 potentiostat system connected to corrosion analysis software[9].

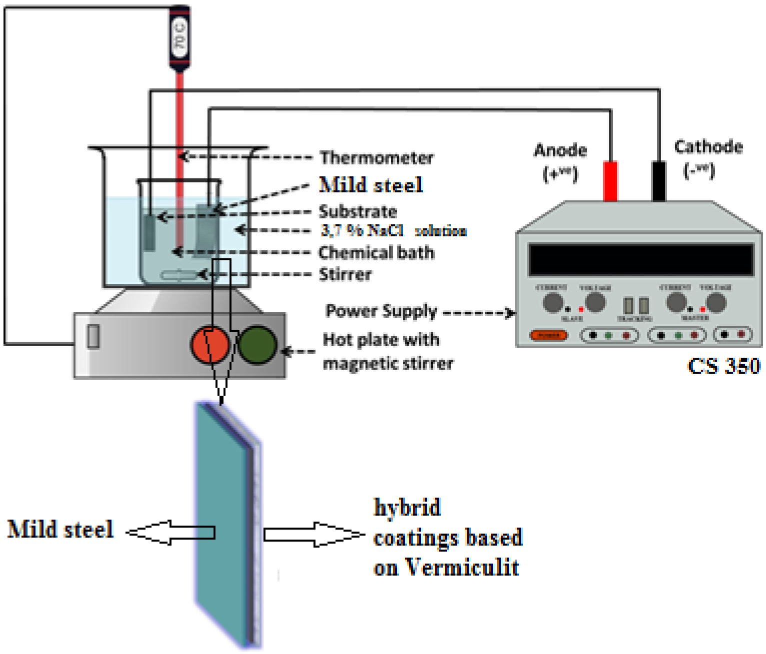


**Figure-1.** Electrochemical method for determining the degree of protection of hybrid composite coatings

Polarization measurements were made potenciostatically at room temperature using an Ag/AgCl/Cl- (0.222 V) and a platinum electrode. Potentiodynamic measurements were carried out in the range from 2000 to 10000 mV relative to Ag/AgCl/Clat at a rate of 5 Vs.

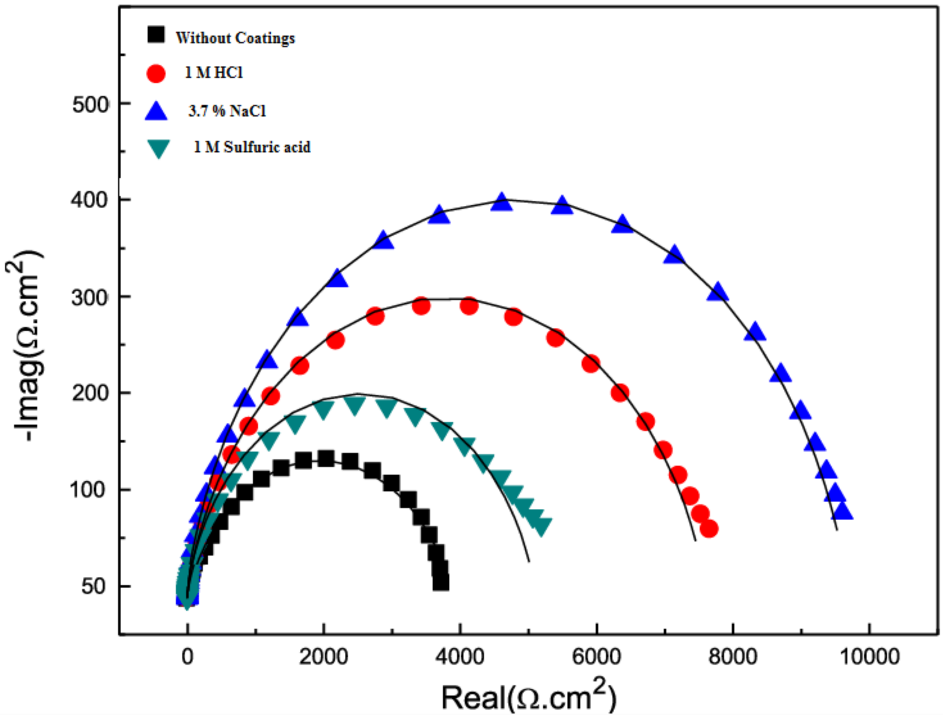


**Figure-2. Typical Nyquist plots of impedance diagrams of coatings**

The corrosion protection level of this Vermiculite-based anti-corrosion coating on steel materials in different solutions of 1 M hydrochloric acid, 3.7% sodium chloride solution and 1 M sulfuric acid solution was evaluated using Nyquist plots of impedance diagrams for up to 500 hours. studied[10].

From this we can see that the corrosion rate of the uncoated steel material in normal water for 50 hours and aging at 400 resistance is very high. The degree of protection of this coating gave good resistance to both sulfuric and hydrochloric acids, but the best degree of protection was achieved in the 3.7% solution.
These cases provide the most reliable information about the corrosion protection properties of these coatings based on the low-frequency modulus of the electrochemical impedance.

**Study of the surface of anti-corrosion coatings.**

The substrate is covered with dense layers consisting of many small particles, and the surface roughness increases after processing. With an increase in the content of vermiculite, cracks do not appear on the surface of the films. The introduction of hybridity into the vermiculite composite changes the microstructure of the resulting coating and forms many microholes on the surface, which may be associated with the formation of a solid solution between the organic parts and metal oxides in vermiculite[11].

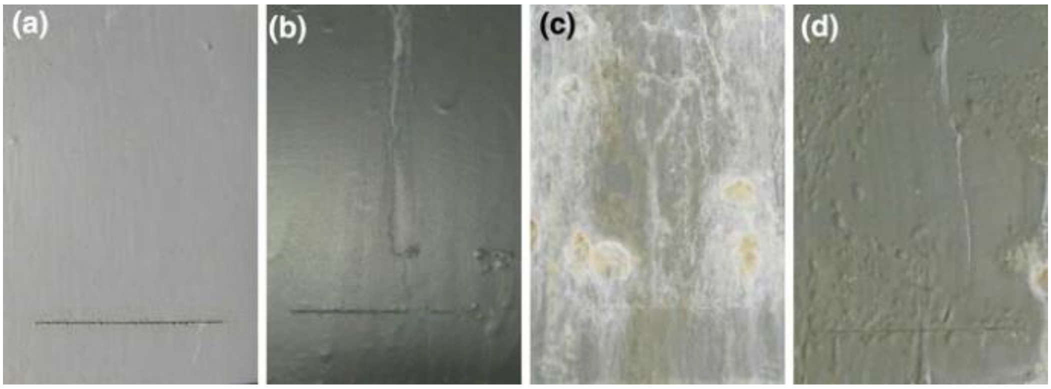


**Figure-2. Photographs of vermiculite-based coatings tested in various aggressive environments over a period of 500 hours.**

As we can see from the above pictures, picture a is the original sample, picture 2b is the one in 1 M sulfuric acid environment, picture 2 c is the one under the influence of 1 M chloride, and picture 2d is the practical one when it is exposed to 3.7% sodium chloride. photos from the experience.
The existence of an active hydroxyl in the composites forms large aggregates and makes the coating resistant to scratches. With increasing vermiculite content, the surfaceturned out to be porous with an uneven arrangement of particles and an uneven particle size distribution.

**Conclusion**

When the effectiveness of anti-corrosion coating based on vermiculite mineral was studied using Nyquist plots of impedance diagrams, the level of protection of steel materials in 3.7% NaCl solution showed the highest indicator. In addition, it was determined based on practical experiments that the corrosion in saline solution is less than that in acidic solutions when analyzing photos of plate samples from test processes in various aggressive environments.

**References.**

1. Pritzl M.D., Tabatabai H., Ghorbanpoor A. Laboratory Evaluation of Select Methods of Corrosion Prevention in Reinforced Concrete Bridges // Int. J. Concr. Struct. Mater. Korea Concrete Institute, 2014. Vol. 8, № 3. P. 201–212.

**2.** Galedari, S.A., Mahdavi, A., Azarmi, F. *et al.* A Comprehensive Review of Corrosion Resistance of Thermally-Sprayed and Thermally-Diffused Protective Coatings on Steel Structures. *J Therm Spray Tech* **28**, 645–677 (2019).

3. Bierwagen, GP, et al., "Studies of a New Accelerated Evaluation Method for Coating Corrosion Resistance—Thermal Cycling Testing." *Prog. Org. Coat.*, **39** 67–78 (2000)

4. Brunner, S, et al., "Accelerated Weathering Device for Service Life Prediction for Organic Coatings." *Polym. Test.*, **24** 25–31 (2005).

5. Shreepathi, S, et al., "Service Life Prediction of Organic Coatings: Electrochemical Impedance Spectroscopy vs Actual Service Life." *J. Coat. Technol. Res.*, **82** 191–200 (2010).

6. Gray, LGS, Appleman, BR, "EIS: Electrochemical Impedance Spectroscopy A Tool to Predict Remaining Coating Life?" *J. Prot. Coat. Linings*, **30** 66–74 (2003).

7. Scully, JR, Hensley, ST, "Lifetime Prediction for Organic Coatings on Steel and a Magnesium Alloy Using Electrochemical Impedance Methods." *Corrosion*, **50** 705–716 (1994).

8. Shreepathi, S, Bajaj, P, Mallik, BP, "Electrochemical Impedance Spectroscopy Investigations of Epoxy Zinc Rich Coatings: Role of Zn Content on Corrosion Protection Mechanism." *Electrochim. Acta*, **55** 5129–5134 (2010).

9. Hammouda, N, Chadli, H, Guillemot, G, Belmokre, K, "The Corrosion Protection Behaviour of Zinc Rich Epoxy Paint in 3% NaCl Solution." *Adv. Chem. Eng. Sci.*, **1** 51–60 (2011).

10. Amirudin, A, Thierry, D, "Application of Electrochemical Impedance Spectroscopy to Study the Degradation of Polymer-Coated Metals." *Prog. Org. Coat.*, **26** (1) 1–28 (1995).

11. Gebhardt F, Seuss S, Turhan MC, Hornberger H, Virtanen S, Boccaccini AR (2012) Characterization of electrophoretic chitosan coatings on stainless steel. Mater Lett 66:302 – 304.