ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025

Increasing Corrosion Resistance of Coatings for Gas Condensate Tanks Using Mineral Nano Fillers

U.Shaozimova, A. Djumabayev, A.Ibadullayev, E.Rakhmatov, J. Ziyamukhamedov, Sh.Abdurakhimov

Professor, Department of Material Science and Mechanical Engineering, Tashkent State Technical University, Tashkent, Uzbekistan
Professor, Department of Material Science and Mechanical Engineering, Tashkent State Technical University, Tashkent, Uzbekistan
Professor, Department of Material Science and Mechanical Engineering, Tashkent State Technical University, Tashkent, Uzbekistan
Associate professor, Department of Oil and Gas work, University of Economics and Pedagogy, Karshi, Uzbekistan
Associate professor, Department of Oil and Gas work, University of Economics and Pedagogy, Karshi, Uzbekistan
Doctoral student, Department of Material Science and Mechanical Engineering, Tashkent State Transport University, Tashkent, Uzbekistan

ABSTRACT: The article considers the problem of equipment corrosion in the oil and gas industry during storage and transportation of gas condensate. The results of the development of a composite anticorrosive coating based on an epoxy binder with natural mineral fillers (montmorillonite, wollastonite, kaolin AKF-78) are presented. The mechanical and chemical properties of the coatings are studied. It is established that coatings with montmorillonite have the best adhesion, impact strength and corrosion resistance. The development is aimed at extending the service life of metal structures exposed to aggressive environments.

KEY WORDS: Composite material, dispersed mineral filler, modification, polymer binder, kaolin, tribological properties, corrosion resistance, wear resistance

I.INTRODUCTION

Efficient use of natural resources plays a key role in shaping the economic development of countries with large energy reserves. Among the various types of raw materials, natural gas occupies a special place due to its wide range of applications - from household consumption to use as a raw material for the production of high-tech chemical products. The efficiency of converting hydrocarbons into commercial products depends not only on technological solutions, but also on the economic feasibility of the operation of processing plants.

Natural gas condensate, a valuable by-product of natural gas production, is of increasing interest due to its high commercial value and versatility of application. It is widely used as a component in the production of chemical reagents, as well as an additive in motor and industrial fuels. The high level of profitability makes natural gas condensate an important element in strategic planning of the energy complex.

II. LITERATURE SURVEY

This article examines the economic and strategic aspects of hydrocarbon processing, with an emphasis on the domestic market and export potential of natural gas and gas condensate. Current production and export volumes, as well as the infrastructure that ensures international gas transportation, are analyzed, which allows us to assess the role of this industry in the national economy.
To determine the direction of the study, it is important to study the problems arising from the action of raw materials on equipment and structures of the entire technological process from mining to the finished product. The main problem

arising in metals is corrosion and related problems with it. In world practice, there is no country where manufacturing enterprises would not face the problem of corrosion. This applies to both old enterprises operating obsolete equipment requiring major repairs and restoration, and new ones that have begun their operation. In both cases, metal structures are vulnerable to the effects of the external environment, which, under the influence of accompanying factors, lead to the destruction of the metal. Research conducted in this direction is known both abroad [1-7] and in our country [8-13]. The authors found that Our studies of statistical data on pipeline incidents showed that the majority of emergency situations occur from metal corrosion, especially from its abrasive mechanism [13]. Based on the conducted research, compositions were obtained based on natural minerals such as kaolin and vermiculite, and epoxy-diane compound was used as a binder in composite materials. (ED-20+PEPA+DBF).

But in the studies conducted by the authors, the use of the developed compositions was aimed at protecting tanks from abrasive corrosion that occurs during the filling and draining of crude oil as a result of electrochemical corrosion under the action of bottom water. But it should be noted that one of the global problems is mainly not only bottom water consisting mainly of mechanical inclusions and salt solutions, but the corrosion process in gas condensate collection tanks, since the chemical composition of gas condensate consisting of volatile alkanes enhances the process of peeling of the composite coating, which in many cases is multilayer [14].

Our research was aimed at the problem of the oil and gas industry, in particular, at developing a wear-resistant anti-corrosion coating on a polymer base used in aggressive well conditions of oil and gas production, complicated by corrosion factors, to protect tanks and reservoirs for storing gas condensate and oil. We set the goal of using composite coating compositions in the form of an independent coating of surfaces subject to corrosion, for example, as a result of exposure to climatic factors, including an industrial atmosphere containing aggressive vapors and gases. The composite coating is intended for application to steel, aluminum surfaces and surfaces made of ferrous metals in order to protect them from corrosion and aggressive environments.

One of the most frequently used nanofillers in various fields today is montmorillonite - a purified processed mineral obtained from bentonite clays [15]. This mineral filler is currently a component for polymer composite materials with enhanced physical and mechanical properties, increasing the material's resistance to combustion and protective properties. It is also used as a thickener for drilling fluids and as a component of various protective coatings. In connection with the above, the purpose of the research in this article was to study the mechanical properties and develop a composition of composite polymer materials based on thermosetting plastic and natural mineral fillers for protective coatings of gas condensate reservoirs.

III. MATERIALS AND METHODS OF RESEARCH

The research was carried out using a compound based on ED-20, which also included a hardener in a ratio of 1:10. Gassipol resin from the waste soapstock of an oil processing plant (TU 6-08-200-85) was used as a plasticizer. Montmorillonite, wollastonite, and kaolin AKF-78 were used as a filler. The physicochemical properties of the fillers are given in Table 1.

Table 1. Physicochemical properties of fillers

Property	Montmorillonite	Wollastonite	Kaolin AKF-78
Chemical formula	$(Na,Ca)_{0.33}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$	$CaSiO_3$	$Al_2Si_2O_5(OH)_4$
Color	Gray, beige	White to grey	White
Density, g/cm³	2.0–2.7	2.8–3.1	2.6
Specific surface area, m²/g	200–800	1–2	10–20
Particle size, mkm	0.1–2	5–30 fibers up to 100 mkm)	1–5
Degree of swelling in water	High	Almost absent	Low
Adsorption capacity	Very high	Low	Average
Acid resistance	Average	High	Average

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025

Heat resistance, °C	Up to 600	Up to 1000	Up to 600
Electrochemical resistance	High	Average	Low
Purpose in coatings	Barriers, sorbent, thickener	Strengthening, thermal insulation	Filler, matting agent

Impact strength was determined according to GOST 4765 on the U-1A device. The operating principle of this device is based on determining the resistance of samples to the impact of a 1 kg load from the maximum height from which the load falls onto the film.

The X-shaped notch method was used to determine the adhesive strength according to GOST 32702.2-2014 by measuring the coating thickness with a magnetic thickness gauge**.**. The technique is based on making X-shaped cuts from 40 to 60 mm with their intersection in the middle at an angle of approximately 400. The adhesion index was assessed by inspection and was evaluated as follows: 5A points, when there was no peeling; 4A points, when the coating was difficult to peel off in small particles, 3A points, when the coating was peeled off in larger parts, 2A points, when the coating was peeled off without crushing and without resistance; 1A point - peeling off of a large part of the X-shaped cut; 0A - when peeling was observed completely outside the X-shaped cut.

Corrosion resistance tests were carried out in distilled water for water resistance, in various aggressive chemical environments.

Determination of the modulus of elasticity.
The elastic modulus of organ mineral heterocomposites was determined using the “Universal Pendulum” and calculated using the standard formula:

$$G'' = \frac{I}{F}\left(\frac{4\cdot\pi^2+\lambda_k^2}{T_k^2} - \frac{4\cdot\pi^2}{T_0^2}\right) \quad (1)$$

I - moment of inertia, *F* - sample form factor, λ*k* - logarithmic decrement, *Tk* - period of oscillation of the system with the sample, *T0* - period of oscillation of the system without a sample, π = 3.1426.

Tribological studies of composite materials based on thermosetting plastic ED-20 with various fillers were tested for fretting wear using a universal tribometer (Rtec Instruments, USA) with a ball counterbody made of Si3N4. The Si3N4 counterbody balls had a purity of 92-95%, a diameter of 10 mm, and a density of 3.20-3.30 g/cm3. The selected process parameters were a frequency of 10 Hz, a stroke of 100 µm, and a constant load of 10 N. The schematic diagram of the tribotest setup for the composite discs and the Si3N4 ball is shown in Fig. 1. The system automatically measured and recorded the data. The surface area of each 2D profile (obtained from different positions on the 3D profile) was integrated over the distance to measure the wear volume, wear scar, disc, and ball. From the calculated wear volume, the Archard equation (2) was used to measure the specific wear rate.

$$\text{Wear rate} = \frac{\text{wear volume}}{\text{load * sliding distance}} \quad (2)$$

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025

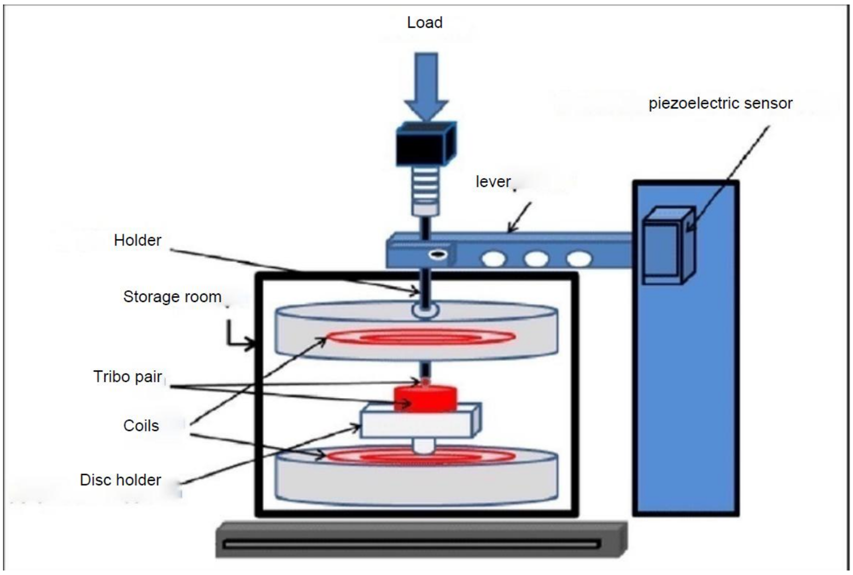


Fig. 1. Tribological testing setup diagram

Physical and mechanical properties were determined using well-known standard methods.

IV. EXPERIMENTAL RESULTS

Each component of any composite material performs a specific function, which is established based on operational requirements. In this regard, our studies included experiments on the effect of a modifier in the composition of a composite coating material on the structural properties of heterocomposites based on ED-20 using a montmorillonite nanofiller. Impact strength tests conducted according to GOST 4765 on a U-1A device showed that the highest impact strength values are observed for composite coatings with montmorillonite (Fig. 2). While coatings containing wollastonite demonstrate moderate results, and compositions with AKF-78 kaolin have the lowest strength characteristics.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025

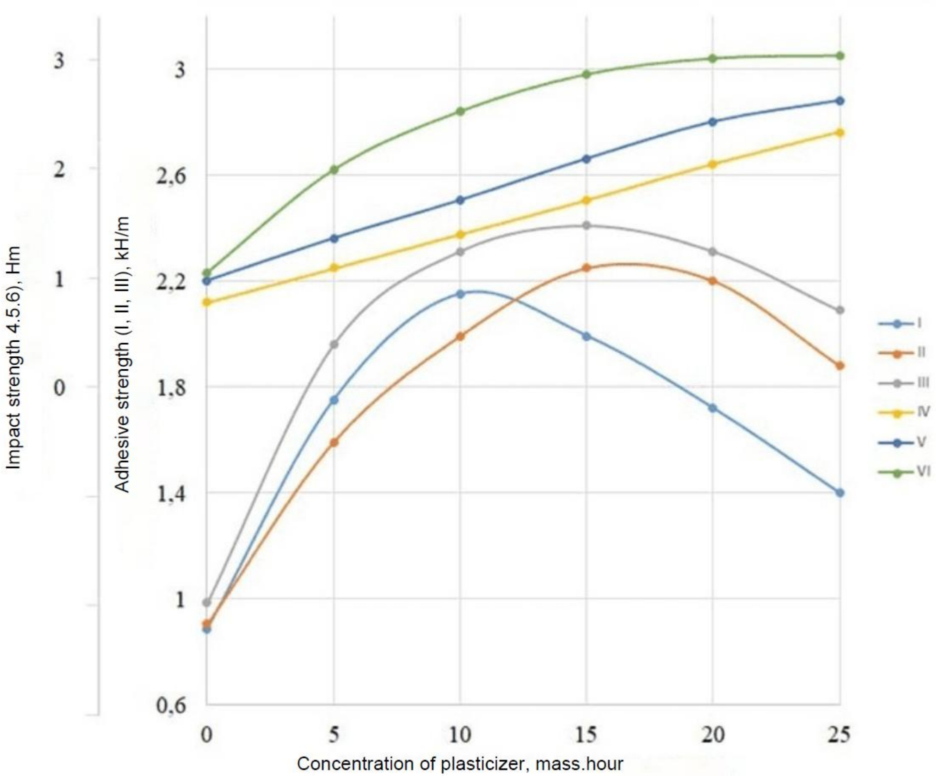


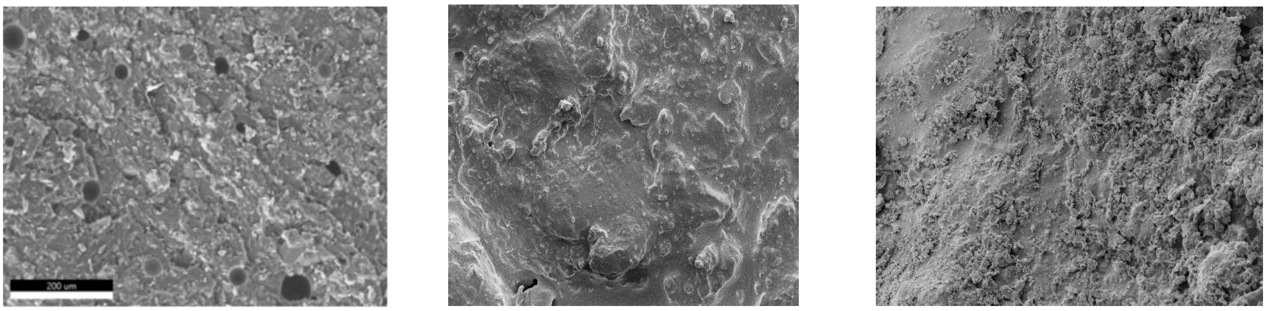
Fig. 2. Dependence of impact and adhesive strength of composite materials for coatings plasticized with gassipol resin, with a content of mineral filler montmorillonite (IV)(III), wollastonite (V)(II) and kaolin AKF-78 (VI)(I) %

The results of these experiments confirm the hypothesis that montmorillonite particles, due to their porous structure at the nanoscale, significantly improve the interaction between the polymer matrix and the filler. This improves the mechanical properties of the material, allowing it to withstand higher loads under mechanical impact.

Montmorillonite coatings exhibit good adhesion to the metal surface, which minimizes the likelihood of material peeling, even under high temperature and mechanical loads. On the contrary, compositions with AKF-78 kaolin show a significant decrease in adhesion, which is due to less effective interaction.

The obtained results are explained by the fact that montmorillonite particles having a porous structure at the nanolevel play the role of channels - conductors of the plasticizer in the interstructural areas of the macromolecules of the mesh thermosetting plastic, where the polyfunctional plasticizer gossypol resin in the process of structural interaction in the interlayer spaces is located both in the interlattice area and in the pores of the nanofiller - montmorillonite. Satisfactory results were also shown by the compositions with wollastonite, which can be explained by the needle structure of the filler, which has a weak reinforcing effect. Compositions with AKF-78 filler have lower mechanical properties relative to montmorillonite and wollastonite, which is explained by the structural structure of the filler (Fig. 3) in the composite material.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025



a b c

Fig. 3 Structure of composite material with mineral fillers:
a-montmorillonite, b-wollastonite; c-kaolin AKF-78

Analysis of the results of activated dispersed components obtained on the FE-SEM 5000 scanning microscope revealed the presence of channels in the form of sorption bags capable of absorbing a viscous plasticizer, which will exhibit a lubricating effect during abrasive friction.

To prove this statement, the results of a study of the tibological properties of composite materials were obtained (Fig. 4).

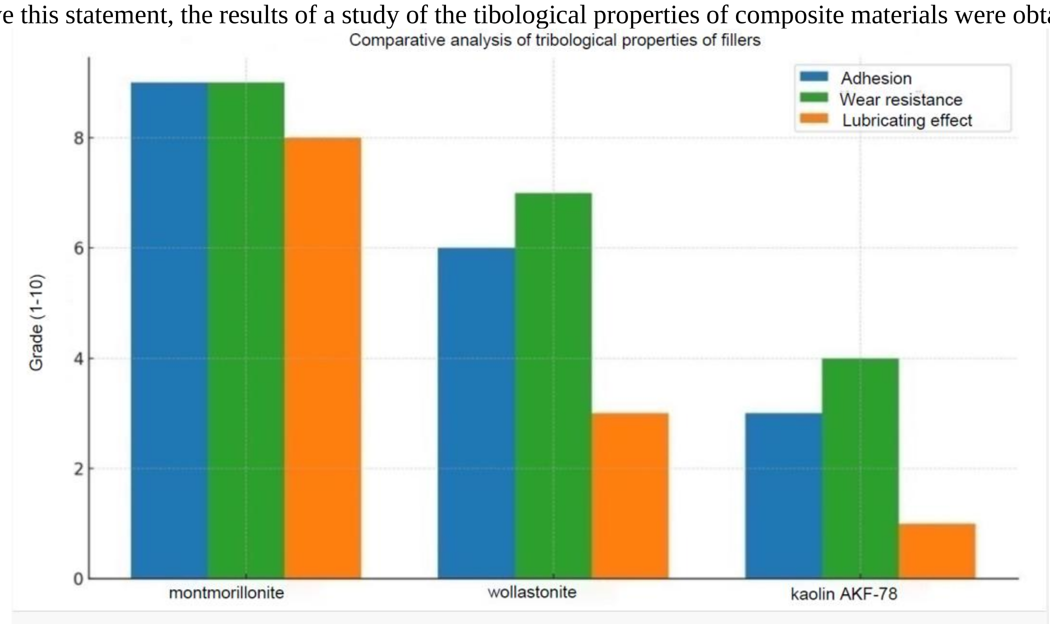


Fig.4 Tribological properties of composite coatings depending on the type of filler

Based on the application area, the main indicator of operational reliability of the developed composite material compositions is corrosion resistance. The study of corrosion resistance showed that coatings with montmorillonite significantly exceed compositions with wollastonite and AKF-78 kaolin under conditions of exposure to aggressive chemical environments (for example, salt water and acid solutions). These coatings are resistant to electrochemical corrosion, which is confirmed by the results of tests carried out in distilled water and in aqueous solutions with the addition of NaCl (Fig. 5).

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025

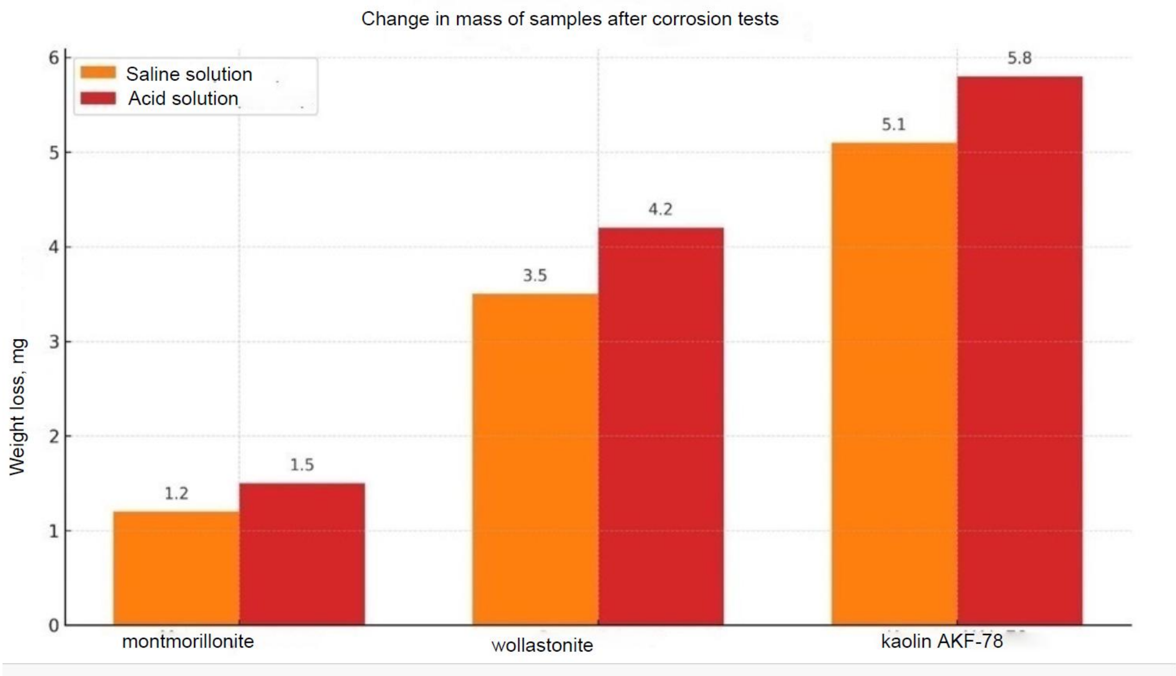


Fig. 5. Change in mass of samples after corrosion tests in aggressive chemical environments.

When tested in salt solutions, coatings with montmorillonite demonstrated a significantly smaller decrease in weight compared to coatings based on other fillers. This indicates high anti-corrosion properties of montmorillonite, which prevents aggressive substances from penetrating deep into the coating and increases its durability. For a more detailed analysis, tests were conducted to determine the elastic modulus using a universal pendulum. As shown by the results of the study (Table 2), compositions with montmorillonite have better elasticity indicators, which confirms their ability to withstand large deformations without destruction.

Table 2. Mechanical properties of composite materials with different fillers.

Filler	**Impact strength, MPa**	**Adhesive strength, points**	**Modulus of elasticity, GPa**
Montmorillonite	7.2	5A	3.4
Wollastonite	5.5	4A	2.8
Kaolin AKF-78	4.1	2A	2.1

Thus, the improved performance characteristics of coatings with montmorillonite are explained by the developed porous structure of the nanofiller, which promotes stronger adhesion to the substrate and uniform distribution of the plasticizer. Wollastonite, having a needle-like structure, showed a moderate reinforcing effect. Kaolin AKF-78, due to its dense morphology, demonstrated the lowest values. The use of montmorillonite can significantly increase the anti-corrosion resistance of coatings, especially under conditions of exposure to condensate vapors and salt solutions.

V. CONCLUSION

The developed composite coatings with montmorillonite are effective for protecting tanks from corrosion caused by aggressive components of gas condensate. The coatings have high impact strength, adhesion and resistance to chemical action. The use of natural fillers improves the environmental and economic characteristics of protective materials. The data obtained allow us to recommend the developed coatings for wide application in the oil and gas industry.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025

REFERENCES

[1] M.M. Stack. Mapping tribo-corrosion processes: some new directions for the new millennium, Tribology International.2002, 35, 679-687
[2] A.Grossman. Corrosion of Aboveground Fuel Storage Tanks // Material Per- formance, 2005, September, p. 44.
[3] A. Gandihi. Storage Tank Bottom Protection Using Volatile Corrosion Inhibitors // CORTEC CORP. Supplement to Material Performance. Jenuary 2001, p. 28-30.
[4] E. Lyulinski, Y. Vaks. Corrosion Protection of Oil Tank Double Bottoms. Eurocorr 2010.p.146.
[5] R. Heidersbach. Metallergy and Corrosion Control in Oil and Gas Produc- tion. AjohnWiley&sons, inc. publication, 2011, 280 p.
[6] Medvedeva M.L. Corrosion and Protection of Equipment in Oil and Gas Processing.-"Oil and Gas" Gubkin Russian State University, 2005.- 311 p.
[7]Medvedeva M.L., Muradov A.V., Prygaev A.K. Corrosion and Protection of Main Pipelines and Reservoirs: A Textbook for Universities of Oil and Gas Profile. - Moscow: Publishing Center of the Russian State University of Oil and Gas named after I.M. Gubkin: - Moscow,2013.- 250 p.
[8] Turabjanov S.M., Li M.S., Ziyamukhamedova U.A., Miradullaeva G.K. Increasing the corrosion resistance of the coating in the process of the electrochemical mechanism. Technical Sciences and Innovations, 2019.-No 4-P. 257-262.
[9] Li M.S., Miradullaeva G.B., Ziyamukhamedova U.A. Development and application of anti-corrosion coatings based on local modified Angren kaolins and epoxy compound operating in highly aggressive acid environments. Uzbek Chemical Journal, 2019.-No5. – P.28-35.
[10] Ziyamukhamedova, U., Evlen, H., Nafasov, J., Jalolova, Z., Turgunaliyev, E., & Rakhmatov, E. (2023). Modeling of the process of mechano activation of filler particles in polymer composites. In *E3S Web of Conferences* (Vol. 401, p. 05027). EDP Sciences..
[11] Khalimov, S., Nishonov, F., Begmatov, D., Mohammad, F. W., & Ziyamukhamedova, U. (2023). Study of the physico-chemical characteristics of reinforced composite polymer materials. In *E3S Web of Conferences* (Vol. 401, p. 05039). EDP Sciences.
[12] Ziyamukhamedova, U., Bakirov, L., Donaev, S., Miradullaeva, G., & Turgunaliev, E. (2023). Study of structure formation processes in matrices of mixed components with reinforcing natural fillers. In *E3S Web of Conferences* (Vol. 401, p. 05074). EDP Sciences.
[13] Ziyamukhamedova, U., Rakhmatov, E., Dustqobilov, E., Nafasov, J., & Ziyamukhamedov, J. (2023, June). Development of protective coating compositions for process tanks. In *AIP Conference Proceedings* (Vol. 2789, No. 1). AIP Publishing.
[14] Rakhmatov E.A. Properties and Technology of Polyfunctional Coatings for Technological Equipment Based on Local Organomineral Components. PhD. Tashkent State Transport University. -Tashkent. -2020. - 110 p.
[15] GOST 28177-89. Bentonite molding clays. Interstate standard. Moscow, 1991