КОРРОЗИЯ И ЗАЩИТА ОТ КОРРОЗИИ – ОБЩИЕ ВОПРОСЫ

CORROSION AND CORROSION PROTECTION – GENERAL ISSUES

Тип статьи: научная, оригинальная

Articale type: original

https://doi.org/10.31615/j.corros.prot.2024.114.4-6

Анализ CO_2-коррозии в образцах воды из западной части Каспийского моря: выводы из Сумгаита, Нефтчалы, Бильгяха и Пираллахи

В.М. Аббасов, Д.Б. Агамалиева✉, Э.А. Айдынсой, З.З. Агамалиев

Институт Нефтехимических процессов имени Ю.Г. Мамедалиева
Министерства науки и образования Азербайджана,
Азербайджан, AZ 1025 г. Баку, пр-т Ходжалы, д. 30

e-mail: durna.agamaliyeva@mail.ru

Аннотация. Коррозия, вызванная углекислым газом (CO_2), представляет значительные проблемы для морской инфраструктуры, особенно влияя на нефтегазовую отрасль. Данное исследование посвящено изучению скоростей коррозии CO_2 в образцах воды, собранных из четырех ключевых мест в западной части Каспийского моря: Сумгаит, Нефтчала, Бильгях и Пираллахи. С использованием гравиметрического анализа мы измеряли скорости коррозии стальных пластин, погруженных в эти воды на пять часов при комнатной температуре. Результаты показали различную степень агрессивности коррозии, причем самые высокие показатели наблюдались в Сумгаите и Нефтчале. Эти данные подчеркивают географическую изменчивость химии воды и ее влияние на коррозию. Понимание этих закономерностей важно для разработки целенаправленных стратегий контроля коррозии, особенно в отраслях нефте- и газодобычи, где долговечность инфраструктуры является критически важной, таких как нефть, газ и транспорт. Данное исследование закладывает основу для будущих исследований ингибиторов коррозии и предоставляет ценные данные для улучшения защитных мер в промышленности Каспийского региона.

Ключевые слова: Каспийское море, коррозия углекислым газом, коррозия стали, морская среда

Для цитирования: Аббасов В.М., Агамалиева Д.Б., Айдынсой Э.А., Агамалиев З.З. Анализ CO_2-коррозии в образцах воды из западной части Каспийского моря: выводы из Сумгаита, Нефтчалы, Бильгяха и Пираллахи // Практика противокоррозионной защиты. – 2024. – Т. 29, № 4. – С. 53-59. https://doi.org/10.31615/j.corros.prot.2024.114.4-6

Статья получена 20.09.2024. Принята к публикации 06.11.2024. Опубликована 01.12.2024.

CO_2 Corrosion Analysis of Water Samples from the Western Caspian Sea: Insights from Sumqayit, Neftchala, Bilgah, and Pirallahi

Vagif M. Abbasov, Durna B. Agamalieva✉, Emil A. Aydinsoy, Zaur Z. Agamaliev

Institute of Petrochemical Processes, named after Yu.G. Mamedaliyev
Ministry of Science and Education of Azerbaijan,
Azerbaijan, AZ 1025, Baku, Khojaly Avenue, 30

e-mail: durna.agamaliyeva@mail.ru

Abstract. Corrosion caused by carbon dioxide (CO_2) poses considerable problems to infrastructure in maritime settings, significantly impacting the oil and gas industries. This study examines the CO_2 corrosion rates in water samples obtained from four significant sites in the western Caspian Sea: Sumqayit, Neftchala, Bilgah, and Pirallahi. We utilised gravimetric analysis to quantify the corrosion rates of steel plates submerged in these fluids for five hours at ambient temperature. The findings indicated differing degrees of corrosion aggressiveness throughout the locales, with Sumqayit and Neftchala demonstrating the most outstanding rates. This underscores the geographical variability in water chemistry and its influence on corrosion. Comprehending these patterns is vital for formulating tailored corrosion control strategies, especially in industries such as oil, gas, and transportation, where the durability of infrastructure is paramount. The work establishes a foundation for future investigations into corrosion inhibitors, providing insights for improving protective strategies in the industrial settings of the Caspian area.

Keywords: Caspian Sea, Carbon Dioxide Corrosion, Steel Corrosion, Marine Environment

For citation: Abbasov, V. M., Agamalieva, D. B., Aydinsoy, E. A. & Agamaliev, Z. Z. (2024). CO_2 Corrosion Analysis of Water Samples from the Western Caspian Sea: Insights from Sumqayit, Neftchala, Bilgah, and Pirallahi. *Theory and Practice of Corrosion Protection, 29(4),* 53-59. https://doi.org/10.31615/j.corros.prot.2024.114.4-6

Received September 20, 2024. Accepted for publication November 06, 2024. Published December 12, 2024.

Introduction

Carbon dioxide (CO_2) corrosion is critical for infrastructure exposed to marine environments, particularly in regions rich in oil and gas resources like the Caspian Sea. The Caspian Sea's western shores, where industrial activities are concentrated, are subject to environmental conditions that accelerate corrosion processes. Understanding the specific corrosion dynamics in this region is crucial for developing effective mitigation strategies to protect pipelines, storage tanks, and other critical infrastructure [1, 2].

CO_2 corrosion, often referred to as "sweet corrosion," occurs when CO_2 dissolves in water to form carbonic acid (H_2CO_3), which then dissociates into hydrogen ions (H^+) and bicarbonate ions (HCO^{3-}). The hydrogen ions contribute to the cathodic reactions that result in metal corrosion, such as steel. Several studies have highlighted the impact of CO_2 corrosion on metals in different environments. For instance, research on the corrosion aggressiveness of oilfield waters has shown that local water chemistry, temperature, and pressure significantly influence corrosion rates [2, 3]. However, there is limited data on CO_2 corrosion specific to the Caspian Sea, particularly in the western regions. This study aims to fill this gap by comparing corrosion rates in four key locations: Sumqayit, Neftchala, Bilgah, and Pirallahi.

Recent research has shown that elevated levels of CO_2 can speed up the pace of corrosion in pipeline systems. This emphasises the significance of comprehending the chemical interactions in various water compositions and pressures. This observation is especially pertinent to our investigation of CO_2 corrosion in the Caspian Sea, as varied environmental variables may influence the corrosion rates at various places.

Materials and Methods

Sample Collection and Preparation: Water samples were collected from four key locations on the western shores of the Caspian Sea: Sumqayit, Neftchala, Bilgah, and Pirallahi. Each location represents a unique environmental and industrial condition that could influence corrosion rates. The samples were stored in clean, airtight containers to prevent contamination and transported to the laboratory for analysis.

Sumgayit, the second-largest city in Azerbaijan, is a significant industrial hub with a multitude of factories that may release industrial pollutants into its coastal waterways. On the other hand, Bilgah is a well-liked beach destination close to Baku, where the water composition is influenced by tourism and the discharge of urban waste. Pirallahi, situated at the extremity of the Absheron Peninsula, is distinguished by substantial petroleum drilling operations, which have a notable effect on the adjacent waterways by releasing hydrocarbons and industrial waste products. Neftchala, a little city situated at the point where the Kura River and the Caspian Sea meet, has a distinctive salty environment. This environment is impacted by the inflow of freshwater and the fishing activities carried out by the locals. As a result, it provides unique circumstances for conducting corrosion studies. Experiment locations can be seen on the figure.

Corrosion Testing Procedure: Steel plates were used as the test material to simulate the typical construction materials exposed to these environments. The plates were cleaned and weighed (initial mass: m_1, m_2), and then submerged in the collected water samples for five hours at room temperature. The gravimetric analysis technique was employed to measure the percentage of metal loss due to corrosion. After the exposure period, the plates were cleaned to remove any corrosion products, dried, and reweighed (final mass: m_1', m_2') [3].

The corrosion rate (p) It was calculated using the formula:

$$p = \frac{\Delta m}{S \cdot t} .$$

Where

- Δm Is the average mass loss,
- S Is the surface area of the steel bar,
- t Is the time of exposure in hours?

The corrosion aggressiveness is expressed in grams per square meter per hour (g/m^2·h).

This work uses weight loss measurements to ascertain the corrosion rates of Iron in various water samples, following a methodology similar to the ones described in [5]. These methods are generally acknowledged for their dependability and efficiency in measuring the deterioration of metals in settings saturated with CO_2.

Results

The corrosion rate data for the four locations is summarised in *Table 1*.

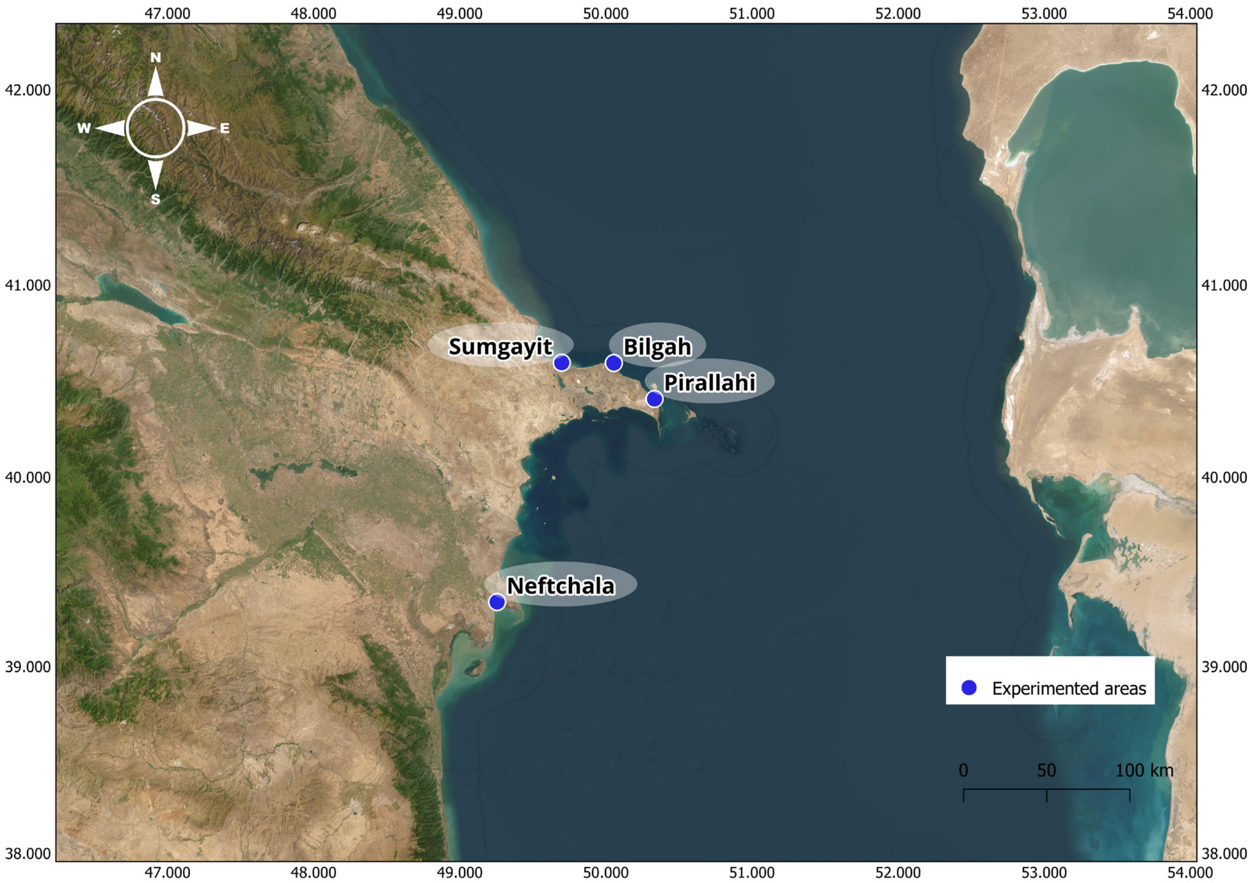

Рис. Места исследований в Каспийском море

Fig. Study Locations in the Caspian Sea

As *Table 1* shows, the corrosion aggressiveness was calculated to be 0.8345 g/m^2 h. The water sample turned yellowish after the experiment, indicating the potential formation of iron oxide or other corrosion products, which aligns with observations made in other studies [1,7]. Neftchala, Bilgah, and Pirallahi exhibited higher corrosion rates of 1.3586, 1.3448, and 1.3724 g/m^2 h, respectively, suggesting a more aggressive corrosive environment.

This study utilised the ASTM G31-21 standard, officially known as the 'Standard Guide for Laboratory Immersion Corrosion Testing of Metals,' to evaluate the corrosive nature of water samples. ASTM G31-21 is a well-regarded standard that offers extensive instructions for laboratory immersion tests to assess the corrosion characteristics of metals and alloys

Таблица 1. Результаты коррозии CO_2 для исследованных мест

Table 1. CO_2 Corrosion results for experimented locations

Location	Initial Mass (g)	Final Mass (g)	Mass Loss (g)	Corrosion Aggressiveness (g/m^2·h)
Sumqayit	13.0730, 12.8788	13.0660, 12.8737	0.0070, 0.0051	0.8345
Neftchala	12.5799, 13.7486	12.5703, 13.7385	0.0096, 0.0101	1.3586
Bilgah	13.9850, 13.6386	13.9754, 13.6287	0.0096, 0.0099	1.3448
Pirallahi	12.8613, 13.4228	12.8511, 13.4131	0.0102, 0.0097	1.3724

in controlled environments. The standard replicates different environmental conditions in a controlled laboratory environment to measure the rate of corrosion and gain insight into the underlying causes.

The ASTM G31-21 standard provides guidelines for preparing test specimens, selecting corrosive media, and conducting immersion testing. It specifies the duration of the test and the ambient parameters, such as temperature and flow that need to be controlled. The guideline highlights the significance of maintaining uniform test circumstances to guarantee the reproducibility and comparability of outcomes. Additionally, it offers techniques for determining the corrosion rate by analysing the mass lost, measured in millimetres per year (mm/year). This information can be utilised to classify the level of corrosiveness in the tested surroundings.

ASTM G31-21 categorises corrosion rates into four distinct levels: low, moderate, high, and extremely high. These levels are determined by the amount of material lost over a given period. These categories aid in assessing the necessity for corrosion mitigation measures, such as implementing coatings, utilising corrosion inhibitors, or selecting appropriate materials. For the sake of our research, we translated the corrosion rate categories from millimetres per year to grams per square meter per hour ($g/m^2{\cdot}h$), which is the unit of measurement employed in our experiments. This conversion allows for a direct comparison between the two. The following table summarises the corrosion rate categories defined by ASTM G31-21 and their corresponding equivalents in grams per square meter per hour for Iron 3. This conversion enables a significant evaluation of the corrosiveness of the water samples from the Caspian Sea by the rules of the standard. The ASTM G31-21 standards are displayed in *Table 2*.

The ASTM G31-21 standard is essential in corrosion studies. It establishes a structure for assessing the corrosive nature of various environments and their effects on materials. This standard assists engineers and researchers in choosing suitable corrosion control measures and materials for specific applications.

Discussion

The results indicate significant variability in CO_2 corrosion aggressiveness across the different locations in the western Caspian Sea. The yellowish discolouration of the water post-experiment may be due to the formation of ferrous or ferric hydroxides, which can occur under certain pH and oxygen conditions [2, 9].

Conversely, the higher corrosion rates result in more corrosive conditions, potentially due to higher dissolved salts, oxygen, or other corrosive agents. The aggressive nature of these environments aligns with findings from previous studies that highlight the impact of water chemistry on CO_2 corrosion rates [8,10]. For example, chloride ions accelerate corrosion by breaking down passive oxide layers on steel surfaces, facilitating further metal dissolution [4,11].

Although primarily studied in the context of biocorrosion caused by sulfate-reducing bacteria, recent research on inhibitors such as alkylamine complexes and oligomethylene aryl sulfonates demonstrates their potential for broad-spectrum corrosion protection, which may inform future strategies for mitigating CO_2-induced corrosion [12,13].

According to ASTM G31-21 standards, the experimental results for the four coastline locations (Sumqayit, Bilgah, Pirallahi, and Neftchala) indicate corrosion rates classified as 'Very High Corrosion Rate'. More precisely, the cor-

Таблица 2. Категории скоростей коррозии по ASTM G31-21

Table 2. ASTM G31-21 Corrosion Rate Categories

Corrosion Rate Category	Range (mm/year)	Equivalent ($g/m^2{\cdot}h$)
Low Corrosion Rate	< 0.1	< 0.000896
Moderate Corrosion Rate	0.1...0.5	0.000896...0.00448
High Corrosion Rate	0.5...1.0	0.00448...0.00896
Very High Corrosion Rate	> 1.0	> 0.00896

rosion rates varied between 9.31 mm/year for Sumqayit and 15.32 mm/year for Pirallahi. All of these values were considerably higher than the threshold of 1.0 mm/year, which is used to classify an environment as having a very high level of corrosion. These findings indicate that Iron 3 will likely undergo rapid deterioration unless appropriate corrosion prevention methods are used. The significant levels of corrosion witnessed at Bilgah, Pirallahi, and Neftchala, specifically, highlight the immediate necessity for effective mitigation techniques, such as employing improved coatings, corrosion inhibitors, or alternative materials that possess more resistance to CO_2 and maritime corrosion. The results emphasise the significance of consistent surveillance and upkeep to avert structural collapse and guarantee prolonged resilience in such hostile surroundings.

Understanding these differences is crucial for infrastructure management and planning. The high corrosion rates in Neftchala, Bilgah, and Pirallahi highlight the need for enhanced corrosion protection measures in these regions. Future research should focus on the application of corrosion inhibitors, as previous studies have shown their effectiveness in reducing CO_2 corrosion in similar environments [3].

Conclusion

The analysis reveals significant differences in CO_2 corrosion aggressiveness across the four studied locations in the western Caspian Sea, with Sumgayit showing the lowest corrosion rates and Pirallahi experiencing the highest. The findings indicate that all examined areas are subject to extreme corrosion conditions, underscoring the urgent need for developing advanced corrosion inhibitors and other mitigation technologies. These results highlight the critical importance of tailored, location-specific corrosion management strategies to protect infrastructure and promote sustainable development in this region. Future research should focus on innovating effective solutions to counteract the severe corrosion aggressiveness identified in these environments.

Литература

1. Набиева Н.Д., Агамалиева Д.Б., Исмайылов Т.А., Маммадалиев Я.Х. Изучение ингибирующих и бактерицидных свойств побочного продукта производства белого масла против демульгатора и коррозии // Процессы нефтехимии и нефтепереработки. – 2021. – Т. 22, № 4. – С. 546-551.

2. Аббасов В.М., Агамалиева Д.Б., Исмайылов Т.А., Гусейнова Г.Х. Ингибирующее действие сульфатного продукта амидов подсолнечного масла на коррозионную агрессивность карабахской глины // Процессы нефтехимии и нефтепереработки. – 2024. – Специальный выпуск №1. – С. 94-102. https://doi.org/10.62972/1726-4685.si2024.1.94

3. Аббасов В.М., Агамалиева Д.Б., Афандиева Л.М., Агамалиев З.З., Алиева Н.М., Пашаева З.Н., Гурбанова Ф.Дж. Исследование влияния комплексов алкилгалогенидов амидоамина кукурузного масла на кинетику коррозии CO_2 // Процессы нефтехимии и нефтепереработки. – 2024. – Т. 25, № 2. – С. 313-322. https://doi.org/10.62972/1726-4685.2024.2.313

4. Эзизбейли А.Р., Талыбов Г.М., Агамалиева Д.Б., Мехтизада У.С. Хемо- и региоселективное алкоксигалогенирование аллилметакрилата насыщенными C_7-C_{10} -алканолами-1 и исследование коррозии металлов в среде CO_2 и биокоррозии // Процессы нефтехимии и нефтепереработки. – 2021. – Т. 22, №1. – С. 159-171.

5. Чой Ю., Нешич С. Определение коррозионного потенциала трубопровода для транспорта CO_2 в условиях системы высокого $P(CO_2)$ – водной среды // Международный журнал по контролю парниковых газов. – 2010. – Т. 5, № 4. – С. 788-797. https://doi.org/10.1016/j.ijggc.2010.11.008

6. Афандиева Л.М., Аббасов В.М., Агамалиева Д.Б., Мурсалов Н.И., Жабраилзаде Ш.З., Мамедова Н.М., Сеидахмадова Ф.Н., Тагизаде З.Ю. Исследование производных имидазолина, полученных из синтетических нефтяных кислот, в качестве ингибиторов коррозии // Журнал продвинутой химии. – 2016. – Т. 11, №1. – С. 3372–3381. https://doi.org/10.24297/jac.v11i1.2225

7. Мурсалов Н.И., Жабраилзаде Ш.З., Аббасов В.М., Гулиев А.А., Гулузаде А.Г., Бадалова Г.Н., Дуздабан Х.Р. Исследование влияния производных имидазолина на сероводородную коррозию // Химические проблемы. – 2015. – Т. 13, №2. – С. 159–164. (На азербайджанском языке).

8. Аббасов В.М., Мамадбейли Э.Х., Агамалиева Д.Б., Маммудова Л.А., Тахирова Ф.Ф., Бабаева В.Г., Аббасова Х.А. Влияние неорганических комплексов имидазолина на основе синтетических нефтяных кислот и триэтилентетрамина на коррозию диоксида углерода // Химические проблемы. – 2017. – №4. – С. 364-369.

9. Аббасов В.М., Алиева Л.И., Эфендиева Л.М., Нуриев Л.Г., Агамалиева Д.Б., Гаджиева С.Я., Мамедова Н.М. Влияние производных имидазолина на основе синтетических нефтяных кислот на кинетику коррозии стали в среде CO_2 // Процессы нефтехимии и нефтепереработки. – 2016. – Т. 17, №1. – С. 3-8.

10. Аббасов В.М., Агамалиева Д.Б., Гурбанова Ф.Дж., Талыбов А.Г., Эфендиева Л.М., Айюбов И.Х., Кахраманова К.А., Сеид-заде Р.Х. Изучение пентилбромидного комплекса амидоамина подсолнечного масла как ингибитора коррозии // Zenodo (CERN). – 2023. – № 50, – С. 5-6. https://doi.org/10.5281/zenodo.7647349

11. Исмайылов И. Адсорбционные и ингибирующие свойства новых сурфактантов на основе жирных кислот пальмового масла на углеродистой стали в среде, содержащей CO_2 // Международный исследовательский журнал чистой и прикладной химии. – 2014. – Т. 4, №3. – С. 299-314. https://doi.org/10.9734/irjpac/2014/4524

12. Агамалиева Д.Б., Аббасов М.М., Аббасов В.М., Алиева Х.Х. Синтез комплексов алкиламинов на основе малеиновых кислот и исследование их бактерицидных свойств // Практика противокоррозионной защиты – 2022. – Т. 27, №1. – С. 42-48. https://doi.org/10.31615/j.corros.prot.2022.103.1-4

13. Ибрагимова М.Д., Мамедханова С.А., Абдулазаде А.Б., Агамалиева Д.Б., Сеидова С.А., Мамедова Н.М. Влияние олигометиленарилсульфонатов, полученных на основе легкого газойля каталитического крекинга, на процесс биокоррозии // Практика противокоррозионной защиты. – 2020. – Т. 25, №4. – С. 18-25. https://doi.org/10.31615/j.corros.prot.2020.98.4-2

References

1. Nabiyeva, N. D., Aghamaliyeva, D. B., Ismayilov, T. A., & Mammadaliyev, Y. H. (2021). Study of inhibitory-bactericidal properties of the byproduct of white oil production against deemulsifier and corrosion. *Processes of Petrochemistry and Oil-Refining (PPOR), 22(4),* 546-551.

2. Abbasov, V. M., Aghamaliyeva, D. B., Ismayilov, T. A., & Huseynova, G. H. (2024). The inhibitory effect of sunflower oil amide sulfate product on the corrosion aggressiveness of Karabakh clay water. *Processes of Petrochemistry and Oil-Refining (PPOR), Special Issue 1*, 94-102. https://doi.org/10.62972/1726-4685.si2024.1.94

3. Abbasov, V. M., Aghamaliyeva, D. B., Afandiyeva, L. M., Aghamaliyev, Z. Z., Aliyeva, N. M., Pashayeva, Z. N., & Gurbanova, F. C. (2024). The study of the effect of alkylhalogenide complexes of amidoamine of corn oil on the kinetics of CO_2 corrosion. *Processes of Petrochemistry and Oil-Refining (PPOR), 02,* 313-322. https://doi.org/10.62972/1726-4685.2024.2.313

4. Ezizbeyli, A. R., Talybov, G. M., Aghamaliyeva, D. B., & Mehtizada, U. S. (2021). Chemo- and regio-selective alkoxyhalogenation of allylmethacrylate with saturated C_7-C_{10} - alkanol-1 and investigation on CO_2 corrosion of metals and biocorrosion. *Processes of Petrochemistry and Oil-Refining (PPOR), 22(1)*, 159-171.

5. Choi, Y., & Nešić, S. (2010). Determining the corrosive potential of CO_2 transport pipeline in high $P(CO_2)$–water environments. *International Journal of Greenhouse Gas Control, 5(4)*, 788–797. https://doi.org/10.1016/j.ijggc.2010.11.008

6. Afandiyeva, L. M., Abbasov, V. M., Agamaliyeva, D. B., Mursalov, N. I., ShZ, J., Mammadova, N. M., Seyidahmadova, F. N., & Tagizade, Z. Y. (2016). Investigation of imidazoline derivatives obtained from synthetic petroleum acids as corrosion inhibitors. *Journal of Advances in Chemistry, 11(1)*, 3372–3381. https://doi.org/10.24297/jac.v11i1.2225

7. Mursalov, N. I., Jabrailzadeh, Sh. Z., Abbasov, V. M., Guliyev, A. A., Guluzadeh, A. G., Badalova, G. N., & Duzdaban, Kh. R. (2015). Research into effect of imidazoline derivatives on hydrogen sulfide corrosion. *Chemical Problems, 13(2)*, 159-164. (In Azerbaijani).

8. Abbasov, V. M., Mamadbayli, E. H., Agamaliyeva, D. B., Mahmudova, L. A., Tahirova, F. F., Babayeva, V. H., & Abbasova, Kh. A. (2017). Effect of inorganic complexes of imida-

zoline based on synthetic petroleum acids and triethylentetramin against carbon dioxide corrosion. *Chemical Problems Journal, 4*, 364-369.

9. Abbasov, V. M., Aliyeva, L. I., Efendiyeva, L. M., Nuriyev, L. G., Agamaliyeva, D. B., Gadzhiyeva, S. Ya., & Mamedova, N. M. (2016). Influence of imidazoline derivatives of synthetic oil acids on kinetics of process of CO_2-steel corrosion. *Processes of Petrochemistry and Oil-Refining (PPOR), 17(1)*, 3-8.

10. Abbasov, V. M., Agamaliyeva, D. B., Gurbanova, F. J., Talybov, A. H., Efendiyeva, L. M., Ayyubov, I. H., Kahramanova, K. A., & Seidzade, R. Kh. (2023). Study of pentyl bromide complex of amidoamine of sunflower acids as a corrosion inhibitor. *Zenodo (CERN European Organization for Nuclear Research), 50*, 5-6. https://doi.org/10.5281/zenodo.7647349

11. Ismayilov, I. (2014). Adsorption and corrosion inhibitive properties of novel surfactants in the series of fatty acids based on palm oil on carbon steel in CO_2-containing solution. *International Research Journal of Pure and Applied Chemistry, 4(3),* 299-314. https://doi.org/10.9734/irjpac/2014/4524

12. Agamalieva, D. B., Abbasov, M. M., Abbasov, V. M., & Alieva, Kh. Kh. (2022). Synthesis of alkylamine complexes based on maleic acids and investigation of bactericidal properties. *Theory and Practice of Corrosion Protection, 27(1),* 42-48. (In Russ). https://doi.org/10.31615/j.corros.prot.2022.103.1-4

13. Ibragimova, M. D., Mamedkhanova, S. A., Abdulazade, A. B., Agamalieva, D. B., Seidova, S. A., & Mamedova, N. M. (2020). Influence of oligomethylenaryl sulphonates based on the light gas oil of catalytic cracking on the process of biocorrosion. *Theory and Practice of Corrosion Protection*, 25(4), 18-25. https://doi.org/10.31615/j.corros.prot.2020.98.4-2

Информация об авторах

Аббасов Вагиф Магеррам, академик, генеральный директор, Институт нефтехимических процессов имени Ю.Г. Мамедалиева, Баку, Азербайджанская Республика

Агамалиева Дурна Бабек, доктор философии по химическим наукам, доцент, заведующая лабораторией, Институт нефтехимических процессов имени Ю.Г. Мамедалиева, Баку, Азербайджанская Республика

Айдынсой Эмиль Айдын, аспирант, младший научный сотрудник, Институт нефтехимических процессов имени Ю.Г. Мамедалиева, Баку, Азербайджанская Республика

Агамалиев Заур Забил, доктор технических наук, доцент, заведующий лабораторией, Институт нефтехимических процессов имени Ю.Г. Мамедалиева, Баку, Азербайджанская Республика

Information about authors

Vagif M. Abbasov, Academician, director general, Institute of Petrochemical Processes named after Yu.G. Mamedaliyev, Baku, Republic of Azerbaijan

Durna B. Aghamaliyeva, Doctor of philosophy on chemical sciences, assistant professor, head of the laboratory, Institute of Petrochemical Processes named after Yu.G. Mamedaliyev, Baku, Azerbaijan Republic

Emil A. Aydinsoy, postgraduate, junior scientific staff, Institute of Petrochemical Processes, named after Yu.G. Mamedaliyev, Baku, Azerbaijan, Baku, Azerbaijan Republic

Zaur Z. Aghamaliyev, Doctor of technical sciences, assistant professor, head of the laboratory, Institute of Petrochemical Processes named after Yu.G. Mamedaliyev, Baku, Azerbaijan Republic