DrillBit

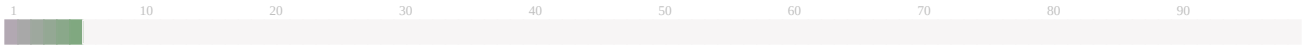
The Report is Generated by DrillBit Plagiarism Detection Software

Submission Information

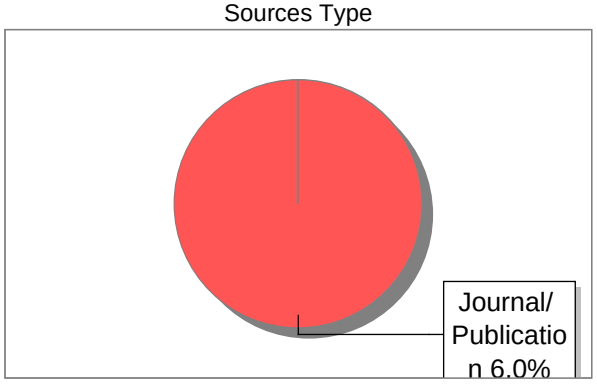
Author Name	I Gusti Ayu Arwatia,1*, Sagir Alvaa,2, Wahyu Irwansyaha,3, Ibdal Satarb,4
Title	HASIL CEK_I Gusti Ayu Arwatia,1*, Sagir Alvaa,2, Wahyu Irwansyaha,3, Ibdal Satarb,4
Paper/Submission ID	2281637
Submitted by	perpustakaan.similarity@uad.ac.id
Submission Date	2024-09-03 15:53:59
Total Pages, Total Words	6, 2515
Document type	Article

Result Information

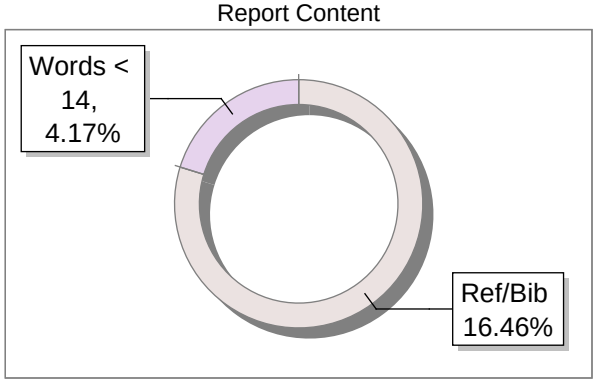
Similarity **6 %**



Sources Type



Report Content



Exclude Information

Quotes	Not Excluded
References/Bibliography	Excluded
Source: Excluded < 14 Words	Excluded
Excluded Source	**17 %**
Excluded Phrases	Not Excluded

Database Selection

Language	English
Student Papers	Yes
Journals & publishers	Yes
Internet or Web	Yes
Institution Repository	Yes

A Unique QR Code use to View/Download/Share Pdf File

DrillBit

DrillBit Similarity Report

6	9	A
SIMILARITY %	MATCHED SOURCES	GRADE

A-Satisfactory (0-10%)
B-Upgrade (11-40%)
C-Poor (41-60%)
D-Unacceptable (61-100%)

LOCATION	MATCHED DOMAIN	%	SOURCE TYPE
23	Effect of Microstructure and Heat Treatment on Resistance of Steels to by Zyryanov-2019	2	Publication
25	Effect of Microstructure and Heat Treatment on Resistance of Steels to by Zyryanov-2019	1	Publication
26	Effect of Microstructure and Heat Treatment on Resistance of Steels to by Zyryanov-2019	<1	Publication
27	Effect of Microstructure and Heat Treatment on Resistance of Steels to by Zyryanov-2019	<1	Publication
28	www.journal.uad.ac.id	1	Publication
29	www.journal.uad.ac.id	<1	Publication
32	www.atlantis-press.com	1	Publication
33	www.atlantis-press.com	1	Publication
35	www.atlantis-press.com	<1	Publication

EXCLUDED SOURCES

1	Corrosion resistance and cytotoxicity of AZ31 magnesium alloy with N by Li-2019	3	Publication
2	journal.uad.ac.id	2	Publication

3	apps.dtic.mil	2	Publication
4	Thesis Submitted to Shodhganga Repository	2	Publication
5	www.electrochemsci.org	2	Publication
6	Preparation and Electrochemical Behavior of Graphene-OxideZinc-Phosphate Compos by Sadawy-2020	1	Publication
7	qdoc.tips	1	Internet Data
8	coek.info	1	Internet Data
9	eprints.covenantuniversity.edu.ng	1	Publication
10	Characteristics of Al alloy surface after EDC with sintered Ti electrode and TiN by Chen-2014	1	Publication
13	www.mdpi.com	1	Publication
14	www.science.gov	1	Internet Data
16	Assessment of the durability of low-cost Al bipolar plates for High Temperature by Alegre-2019	1	Publication

CHEMICA : Jurnal Teknik Kimia
Vol. 8, No. 2, December 2021, pp. 74-79
ISSN 2355-8776

Performance of D-galactose for Protecting The Corrosion Rate of Aluminium Alloy 5052 (AA5052) in Acidic Environment

I Gusti Ayu Arwati[a,1*], Sagir Alva[a,2], Wahyu Irwansyah[a,3], Ibdal Satar[b,4]

[a]Faculty of Engineering, Universitas Mercu Buana, Jakarta, 11650, Indonesia.
[b]Departement of Food Technology, Faculty of Industrial Technology Universitas Ahmad Dahlan, Bantul 55191.
[1] ayuarwati@mercubuana.ac.id*; [2] sagiralva@mercubuana.ac.id; [3] irwansyah@yahoo.com; [4]ibdal@tp.uad.ac.id
* Corresponding author

ARTICLE INFO

Article history
Received November 08, 2021
Revised December 17, 2021
Accepted January 03, 2022

Keywords
Aluminium bipolar plate
Acidic condition
Corrosion rate
EPD technique
PEMFC

ABSTRACT

The PEMFC systems are generally operated in acidic environment conditions. Consequently, the metal bipolar plate in the system can easily be corroded. Therefore, the PEMFC performance is decreased along with long-term operation. Based on this fact, a mitigation approach is needed to prevent the corrosion issue in the metal bipolar plate to maintain the PEMFC performance. This work tries to evaluate the corrosion rate of the aluminium bipolar plate before and after being deposited with D-galactose. The electrophoretic deposition (EPD) technique was used to deposit D-galactose on the aluminum surface. To evaluate the effect of D-galactose on preventing the corrosion rate, it was deposited on the surface of the aluminium (AA5052) bipolar plate. The EPD processes were performed by using a potensiodimic in 0.5 M H_2SO_4. The results show that the optimum EPD process condition was obtained at 0.5 g/l D-galactose for 20 minutes of electrophoretic deposition time. This work indicated that the D-galactose could reduce the corrosion rate of aluminium bipolar plate with an efficiency of 90.7%.

1. Introduction

Fuel cell technology is one of the promising renewable energy innovations for the future [1]. Fuel cell technologies are gaining more attention because they may reduce fossil fuel depletion issues and environmental problems [2]. In addition, the efficiency of the fuel cell is relatively high, which can achieve 60% in the conversion of electrical energy and overall electrical and thermal co-generation [3]. The fuel cell can directly convert the chemical energy in hydrogen into electricity and heat and only water as a by-product [4].

One of the fuel cell types is the proton exchange membrane fuel cell (PEMFC) [5]. The PEMFC has four essential components, namely bipolar plates, cover plates, electrolyte assembly membrane (MEA), and current storage. Among the four components, bipolar plates are an essential component because it contributes 80% of PEMFC volume, 70% by weight, and 60% of costs [4, 6]. Therefore, the bipolar plates are interesting to investigate, particularly material performance and mass, durability, and cost.

Some bipolar plates are fabricated from aluminium alloy because aluminium is inexpensive, light material, and has high performance compared to other metals such as stainless steel (too heavy), graphite (fragile), titanium alloy (too expensive), and magnesium alloy (low performance) [7]. However, aluminium material faces the corrode issue due to the presence of dissolved cations in the cell and the long-term operation; consequently, the cell performance is dropped. To reduce

the corrosion rate of the biploar plate and improve the PEMFC perfromance, the biploar material can be tretaed with either chemical or organic substrates [8, 9].

Electrophoretic deposition (EDP) is one of the techniques that can be used to deposit the substrate on the material surface. Principally, the EPD technique is based on the deposition of charged particles dispersed in the suspension system due to the influence of the electric field. The EPD using organic substrate (i.e., chitosan, Arabic gum, D-galactose) is a new approach that can be used to reduce the corrosion rate [10, 11]. Based on our previous work, the corrosion rate (CR) and efficiency were obtained 10.70 mpy and 81.30%, respectively, using the Arabic gum with the concentration of 0.5 g/l in 0.5 M H_2SO_4 [12]. It is well known that D-galactose is one of the arabic gum monomers [13]; therefore it can also be used as organic substrate. D-galactose contains -COOH groups which may contribute to increasing the electron transfer as well as may facilitate the corrosion inhibition effect. This work is expected to show the higher efficiency for corrosion protection due to D-galactose containing more polar atoms compared to the Arabic gum. In this work, we try to use D-galactose with the same concentration and same time EPD processes.

2. Research Methodology

2.1. Materials

The aluminium material used in this work was aluminium with the type AA5052 (Sigma No. G9752-500 kg). Some sandpapers with types of 200, 400, 600, 1000, and 2000 grid and deionized water (DW) were purchased at the chemical shop nearby the campus of Universitas Mercu Buana Jakarta. Chemicals such as H_2SO_4 (98% purity) and D-Glucose (99.5% purity) were supplied by Sigma Aldrich.

2.2. Procedures

The material preparation was performed as described by Arwati [11]. The aluminium bipolar material used in this work was aluminium with the type AA5052 (SIGMA No. G9752-500 kg). The AA5052 sample was cut with 40 mm x 20 mm x 5 mm. Then, the AA5052 sample was cleaned using acetone to remove impurities that remained on the metal surface. To clean up the remaining dirt, the AA5052 sample was polished using sandpaper (200, 400, 600, 1000, and 2000 grids) in wet conditions.

The treatment on the AA5052 surface was priory performed using the ASTM method described by Arwati [11] before the EDP process was conducted. The AA5052 sample was rinsed trice using deionized water and then dried using a hairdryer. After that, the AA5052 sample was sterilized by dipping in 70% of alcohol and dried using a hairdryer.

D-galactose deposited on the AA5052 surface was performed using the electrophoretic deposition (EDP) technique. A total of 5.0 g/l of D-galactose solution was used as substrate in the EDP and applied voltage of 8.0 V (DC power supply) for 20 minutes [11]. All experiments were conducted in triplicate. After the EDP process was finished, the AA5052 deposited with D-galactose was labeled as G-AA5052 while the AA5052 as a control.

The EIS tests for AA5052 and G-AA5052 were conducted by using a Potentiostat (Autolab PGSTAT128N, Netherlands). The EIS analyses were performed at the frequency range of 100 kHz to 5 MHz, AC amplitude of 10 mV as described by Arwati [11]. The EIS data were then presented in Nyquist curves for AA5052 and G-AA5052.

Corrosion testing on the AA5052 control and G-AA5052 were evaluated by using potentiodynamic polarization electrochemical (Potentiostate CS-350). The corrosion rate was denoted in mils per year (mpy). The corrosion inhibition efficiency (η) was measured by using Equation 1 as described by Shen et al. [10] as follow;

$$\eta = \frac{i^0_{corr} - i_{corr}}{i^0_{corr}} \times 100\ \% \quad (1)$$

where the i^0_{corr} and i_{corr} are the corrosion current density (A/m^2) before and after coated with inhibitor. Meanwhile, the corrosion rate (CR, mpy) was calculated by using Equation 2 and Equation 3 based on the measured polarization resistance.

Chemica: Jurnal Teknik Kimia
Vol. 8, No. 2, December 2021, pp. 74-79
ISSN 2355-8776

$$CR = \frac{0.13 \times i_{corr} \times EW}{\rho} \quad (2)$$

$$i_{corr} = \frac{R_p x \beta_A x \beta_C}{2.3 \times A \times (\beta_A + \beta_C)} \quad (3)$$

Where EW is the equivalent weight (g/mol) of metal, ρ is density (g/cm³), βA and βC are the anodic and cathodic Tafel constants (mV/dec), Rp is polarization resistance of material after being coated with inhibitor (Ω.cm²), and A is the surface area or metal (cm²).

Arwati [11] described the surface morphology of G-AA5052 can be analyzed using scanning electron microscopy- energy-dispersive X-ray spectroscopy (SEM-EDX, Carl Zeiss Evo machine, model MA10 type).

3. Results and Discussion

3.1. Analysis of polarization curves

The Polarization curves for AA5052 and G-5052 are presented in Fig.1. Based on the previous work, the optimum condition in the EDP process using Arabic gum was obtained 0.5 g/l in 0.5 M H_2SO_4. Similarly, this work was performed at a similar condition using 0.5 g g/l D-galactose in 0.5 M H_2SO_4. Table 1 shows the corrosion rate (CR) of G-AA5052 was much lower than AA5052. This fact means the deposited D-galactose on the AA5052 surface can reduce the CR from 1.5585 mpy to 0.1445 mpy (90.7 %).

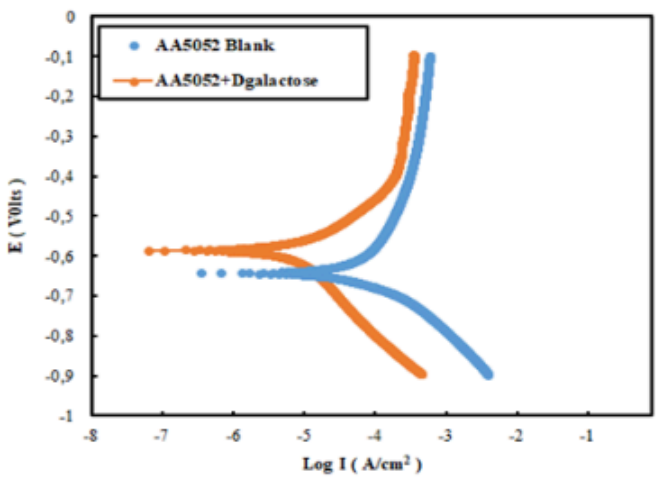


Fig. 1. Potentiodinamic polarization curves for AA5052 (blue line) and G-AA5052 (red line)

Furthermore, Table 1 shows the effect of D-galactose on the I_{corr} (A/m²) and E_{corr} (V) of AA5052. Based on Table 1, the corrosion potentials (E_{corr}) of G-AA5052 and A5052 were obtained - 0.611 V and – 0.585 V, respectively. Meanwhile, the corrosion current density (I_{corr}) of AA5052 and G-AA5052 were observed 1.4 x 10^{-4} A/m² and 1.3 x 10^{-5} A/m² respectively. Similarly, the effect of D-galactose on the corrosion rate in which the D-galactose may also reduce the potential and current density.

Table 1. Effect of D-galactose on the corrosion potential (E_{corr}) and corrosion current density (Icorr) of AA5052

Metal	I_{corr} (A/cm²)	E_{corr} (V)	Corrosion rate (mpy)	Impedance (Ω)
AA5052	1.4 x 10^{-4}	-0.611	1.585	365.31
G-AA5052	1.3 x 10^{-5}	-0.586	0.144	439.72

3.2. Analyst of Nyquist Curves

The effect of D-galactose on the AA5052 was illustrated in Fig. 2 at where the deposited D-galactose on the AA5052 surface increases the electrical impedance (Z) of the material. This fact was indicated by increasing material resistance from 365.31 Ω to 439.72 Ω. It is well known that the material with lower resistance allows a faster current flow. Otherwise, the material with the higher resistance resulted in a slow current flow, and consequently, the current density was low. Hence, based on the polarization curves above, the effect of deposited D-galactose on the AA5052 material may reduce the corrosion potential and corrosion current density.

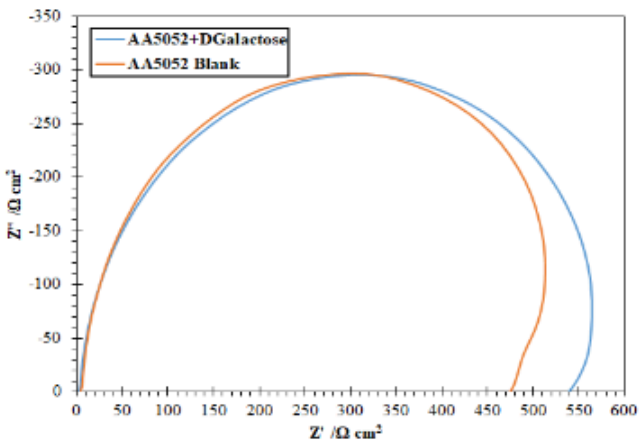


Fig. 2. Nyquist curves for AA5052 (red line) and G-AA5052 (blue line)

3.3. Analysis of Surface Morphology

The morphology of AA5052 and G-AA5052 surfaces was characterized by SEM-EDX analysis. As shown in Fig. 3(a), the SEM image of the AA5052 surface before being tested in H_2SO_4 was clearer and smoother. At this stage, no chemical reactions occurred between metal and strong acid. Meanwhile, SEM images of AA5052 (Fig. 3 (b)) and G-AA5052 (Fig. 3(c)) after testing in H_2SO_4 were slightly rough and damaged. The chemical reactions may occur between a strong acid and metal resulting from the oxide layer; hence, their surfaces become defects. In certain concentrations, the strong acids can easily oxidize the metal surface [14], dan hence decreasing the duty life of bipolar plate in the PEMFC system. The defective pattern on the G-AA5052 surface was thinner and more uniform than the AA5052. In addition, the G-AA5052 surface has no deposits as a result of, local breakdown of the oxide layer on the surface. Based on these results, G-AA5052 shows better corrosion reaction protection in acidic conditions than AA5052.

As discussed above, the coated D-galactose inhibitor on the metal surface can reduce corrosion. D-galactose's presence on the metal surface was indicated by the decrease in aluminum (Al) composition. Based on the EDX analysis, Al composition on the AA5052 (before coated with D-galactose) was obtained 95.45% while 77.27% for G-AA5052 (after coated with D-galactose). In addition, the uniform layer on the G-AA5052 describes the presence of D-galactose. The use inhibitor on the metal surfaces is not only for reducing the corrosion rate but also for minimizing the metal loss and acid consumption [15].

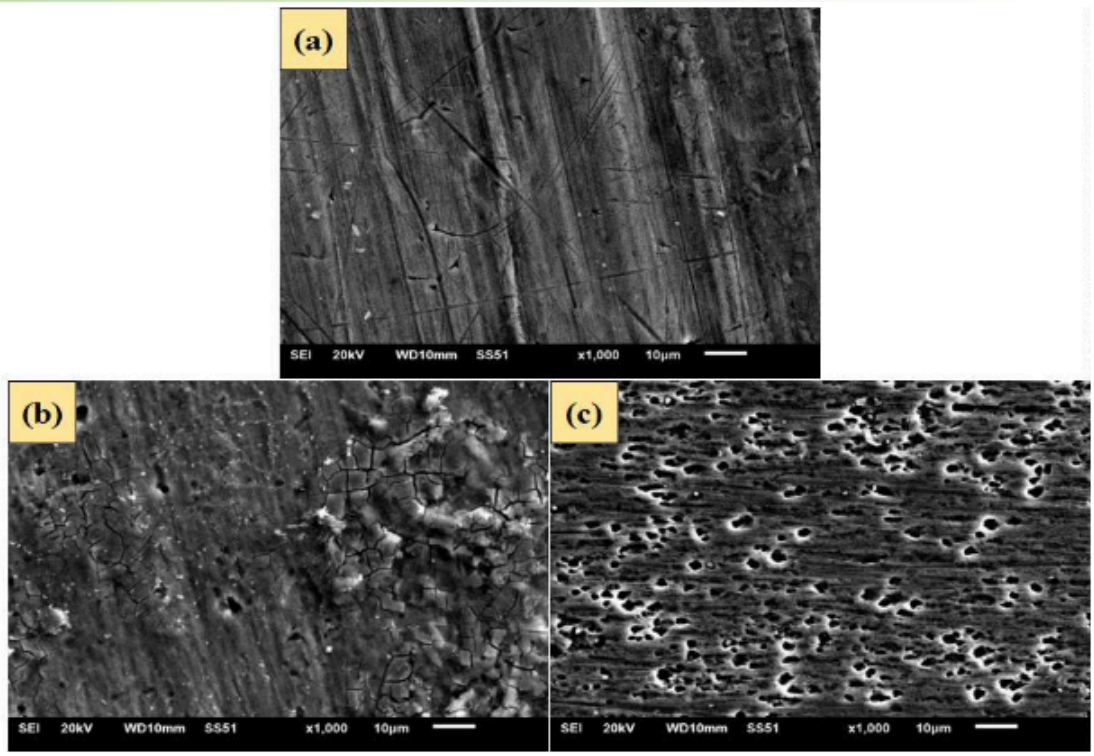


Fig. 3. SEM images of (a) AA5052 before tested in H_2SO_4, (b) AA5052 after tested in H_2SO_4 and (c) G-AA5052 after tested in H_2SO_4

4. Conclusion

Based on the results of this work, the EPD method was successfully used to deposit D-Galactose on the AA5052 surface. This fact was proved by SEM-EDX analysis in which the aluminium (Al) composition on the AA5052 surface was decreased from 95.45% to 77.27%. This work also shows D-galactose could inhibit and reduce the CR of AA5052 from 1.585 mpy to 0.144 mpy. It means the efficiency of D-galactose to protect the AA5052 bipolar plate from corrosion reaction was around 90.7 %. D-galactose could be used as an alternative organic inhibitor to protect the AA5052 bipolar plate from the corrosion reaction in an acidic environment.

Acknowledgment

Thank you to the Mercubuana University academic community, especially to the UMB Research Center and Lab team, Mechanical Engineering, which has provided facilities to complete this research well.

References

[1] A. Scha¨fer, J.B. Heywood, M.A. Weiss, Future fuel cell and internal combustion engine automobile technologies: A 25-year life cycle and fleet impact assessment, Energy 31 (2006) 2064–2087.

[2] O. Erdinc, M. Uzunoglu, Recent trends in PEM fuel cell-powered hybrid systems: Investigation of application areas, design architectures and energy management approaches, Renew Sust Energ Rev 14 (2010) 2874-2884.

[3] Z. Xu, D. Qiu, P. Yi, L. Peng, X. Lai, Towards mass applications: A review on the challenges and developments in metallic bipolar plates for PEMFC Pro Nat Sci-Mater 30(6) (2020) 815-824.

[4] J. Liu, Key materials and technologies for fuel cells, Pro Nat Sci-Mater 30 (2020) 719-720.

[5] S. Latorrata, R. Pelosato, P.G. Stampino, C. Cristiani, G. Dotelli, Use of electrochemical impedance spectroscopy for the evaluation of performance of pem fuel cells based on carbon cloth gas diffusion electrodes, J Spectrosc (2018) 1-13.

[6] A.G. González-Gutiérreza, M.A. Pech-Canul, G. Chan-Rosado, P.J. Sebastian, Studies on the physical and electrochemical properties of Ni-P coating on commercial aluminum as bipolar plate in PEMFC, Fuel 235 (2019) 1361-1367.

[7] S.A. El-Enin, O.E. Abdel-Salam, H. El-Abd, A.M. Amin, New electroplated aluminum bipolar plate for PEM fuel cell, J Power Sources 177 (2008) 131-136.

[8] C.-H. Lin, S.-Y. Tsai, An investigation of coated aluminium bipolar plates for PEMFC, Appl Energy 100 (2012) 87-92.

[9] F. Madadi, A. Rezaeian, H. Edris, M. Zhiani, Improving performance in PEMFC by applying different coatings to metallic bipolar plates Mater Chem Phys 238 (2019) 121911.

[10] C. Shen, V. Alvarez, J.D.B. Koenig, J.-L. Luo, Gum Arabic as corrosion inhibitor in the oil industry: experimental and theoretical studies, Corros Eng Sci Technol 54(5) (2019) 444-454.

[11] I.G.A. Arwati, Effect of chitosan on the corrosion protection of Aluminum in H_2SO_4 medium, WCEJ 2(1) (2018) 1-5.

[12] O. Sanni, O.S.I.F. Fayomi, A.P.I. Popoola, Eco-friendly Inhibitors for corrosion protection of stainless steel: an overview, J Phys Conf Ser 1378 (2019) 042047.

[13] Y. Dror, Y. Cohen, Y.-R. R, Structure of gum arabic in aqueous solution, J Polym Sci B Polym Phys 44 (2006) 3265–3271.

[14] A.A. Al-Amierya, L.M. Shaker, A.A.H. Kadhum, M.S. Takriff, Corrosion inhibition of mild steel in strong acid environment by 4-((5,5-dimethyl-3-oxocyclohex-1- en-1-yl) amino)benzenesulfonamide, Tribology in Industry 42(1) (2020) 89-101.

[15] G. Palanisamy, Corrosion inhibitors, in: G. Palanisamy (Ed.), Corrosion inhibitors, IntechOpen, India, 2019, pp. 1-24.