ISSN 2181-8622

Manufacturing technology problems

Scientific and Technical Journal Namangan Institute of Engineering and Technology

INDEX COPERNICUS INTERNATIONAL

Google Scholar

Crossref doi

SLIB.UZ Scientific library of Uzbekistan

Volume 9
Issue 1
2024

UDC 661.635.68.

DETERMINATION OF THE INHIBITORY EFFICIENCY OF THE INHIBITOR SYNTHESIZED BASED ON MALEIC ANHYDRIDE BY THE ELECTROCHEMICAL METHOD

CHORIEV ILKHOM KENJAEVICH

Independent researcher of Namangan Termez State University, Termiz, Uzbekistan
E-mail: choriyevi@tersu.uz

TURAEV KHAYIT KHUDAYNAZAROVICH

Professor of Termez State University, Termiz, Uzbekistan
E-mail: hhturaev@rambler.ru

NORMURODOV BAKHTIYOR ABDULLAYEVICH

Associate professor of Termez State University, Termiz, Uzbekistan
E-mail: normurodovbakhtiyor@gmail.com

Abstract: In this article, study was conducted to determine the inhibition efficiency of the corrosion inhibitor synthesized on the basis of maleic anhydride, monoethanolamine, and phosphoric acid by electrochemical method. Studying the inhibition efficiency of this corrosion inhibitor was measured by the gravimetric method according to GOST 9.506-87 in 1M HCl + 200 mg/l NaCl and 0.5 HCl + 200 mg/l NaCl environments. The inhibition efficiency was 93.15% and 92.86%, respectively.

Keywords: maleic anhydride, corrosion inhibitor, electrochemical method, maleic anhydride, monoethanolamine.

Introduction. Corrosion is a reversible process, which converts pure metal to different chemical compounds[1]. Nowadays, corrosion is turning into a major issue in many industries, building materials, infrastructure, tools, ships, trains, vehicles, machines, and appliances [2]. Carbon steel experiences extensive corrosion during the cleansing process with acids. The NACE 2016 reported shows that at the world level about 2.5 trillion U.S. dollars economic fall caused by corrosion every year total of 10% of total metal of world is lost due to corrosion which influences the economy of the nation [3]. Corrosion is not only responsible for an economic loss but also associated with safety issues because it decreases the shelf life of steel[4]. This problem turns into a major issue for the entire world, so researchers are trying to address this issue in various ways[5]. An inhibitor is a substance which when added to an environment in small concentration[6]. In the following studies, corrosion inhibitors were obtained based on methyl methacrylate, poly(methyl methacrylate-maleic anhydride)P(MMA-MAH)s with different percentages methyl methacrylate and maleic anhydride were synthesized and the inhibitory potential of this inihitor on simple carbon steel in a 0.5 M HCl environment studied[7,8]. A new N-heterocyclic initiator N-[2-(8-heptadecenyl)-4,5-dihydro-1H-imidazole-1-ethyl]-2-bromoisobutyramide was synthesized[9,10].

Experimental part. Materials. 1M HCl + 200 mg/l NaCl for aggressive environments were used. Steel composition: Fe 97.755-97.215%, C 0.17-0.24%, Si 0.17-0.37, Mn 0.35-0.65%, Ni 0.3%, S 0.04 %, P 0.035 %, Cr 0.25 %, Cu 0.3 %, As 0.08 %. 2×2.5 cm2 samples of steel with this composition were taken, the surface was cleaned with sandpapers, washed several times in acetone and dried.

Methodology. Method of polarization curves. All electrochemical studies were carried out on CS-350 "Cossion test" device (Fig. 2.9). The effectiveness of inhibitors based on electrochemical measurements helps to determine what type of inhibitor it is. All experiments were carried out at a temperature of 298 K in the presence and absence of the inhibitor (in different concentrations).

Figure 1. Photo of CS-350 "Cossion test" device.

3 types of electrodes were mainly used for electrochemical measurements. The St20 steel sample itself performs the task of the working electrode in the process, the surface of the electrode is cleaned with different grades of sand paper, washed in distilled water, dried, and then cleaned again by washing with acetone. Ag/AgCl was used as the reference electrode. Platinum was used as the counter electrode. For the experiment, only 1.2 cm2 of each electrode was immersed in the corrosive medium. Each electrode was placed parallel to each other at a distance of 1 cm, and the Ag/AgCl electrode was placed between the other two electrodes. These three types of electrodes were placed in solutions without inhibitors and with different concentrations of inhibitors.

The measurements were made using a sine wave with an amplitude of 10 mV at a frequency from 10 kHz to 0.01 Hz at an open-circuit electronic potential. Polarization curves were performed from -160 mV to +160 mV at a scan rate of 1 mV s-1.

The electrochemical initial input range was 2.5 V, with a maximum potential resolution of 760 mV and a potential accuracy of 300 mV with an apparatus containing a noise module. The data recorded by this device was edited and summarized using the "ORIGIN LAB" program.

Electrochemical studies. One of the most reliable methods for determining the inhibition efficiency of corrosion inhibitors is the electrochemical method. As a result of the absorption of inhibitors on the surface of the steel electrode, there is a change in the potential difference and the amount of corrosion current in the electrodes. The process of polarization occurs because the potentials at the cathode and anode do not have a constant value.

Electrochemical studies of these MMF-2 brand corrosion inhibitors were studied in Fon-1 corrosion environments at a temperature of 20 0C. Inhibition efficiency of Fon-1(1M HCl+200 mg/l NaCl) without inhibitor at different (50, 100, 150 and 200) concentrations of St2 steel o studied.

In general, when the Tafel curves are studied in the medium with and without the inhibitor, the amount of corrosion current is higher in the medium without the inhibitor, which increases the formation of hydrogen and chloride ions in the solution and stimulates the acceleration of the dissolution of the cathode and anode. However, in environments where corrosion inhibitors are added to the corrosive environment, the Tafel curves show that the amount of corrosion current decreases, that is, the corrosion inhibitors reduce the melting of steel to a maximum level due to the slowing down of the cathode and anode dissolution[11].

Results and discussions. It is known from the results of the research that the concentration of the inhibitor depends on the change of the Tafel curves, which shows how much of the inhibitor molecules cover the steel surface.

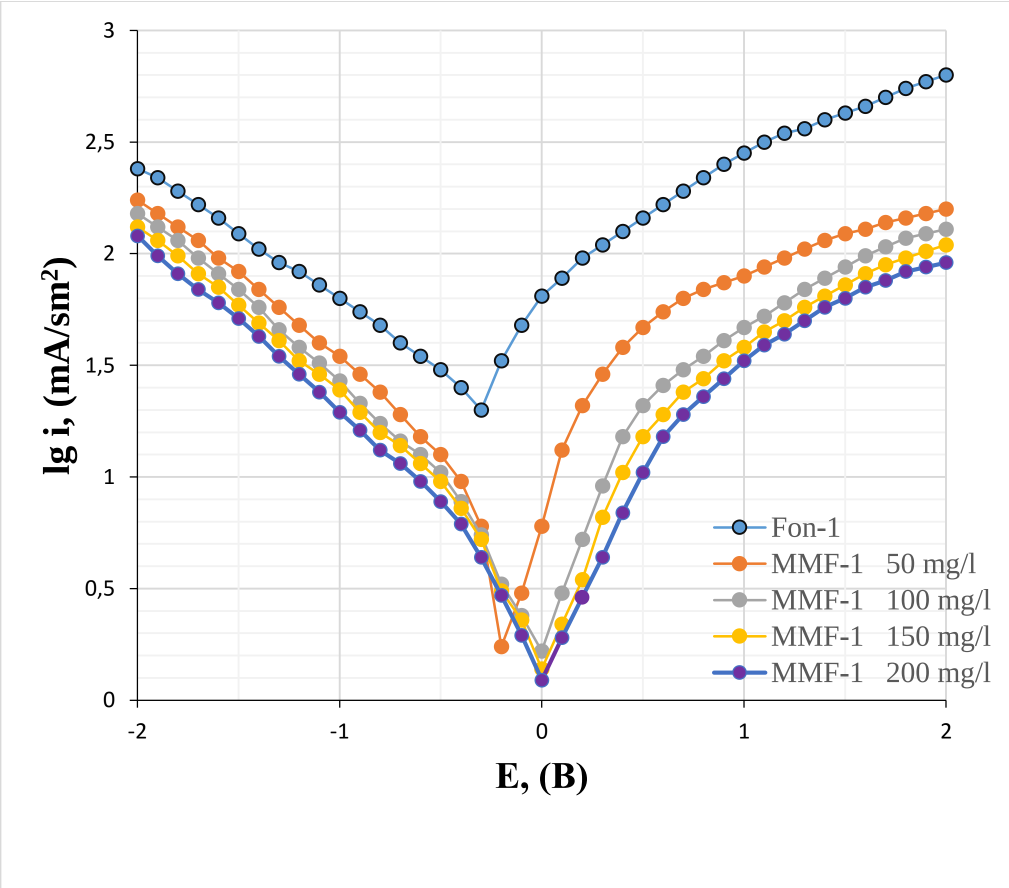

Figure 3.1. Polarization curves of the steel electrode in the Fon-1 solution in the presence of solutions without and with inhibitors

Tafel curves (Fig. 3.12) of corrosion current density (i_{corr}), corrosion rate (CR_{PDP}), corrosion potential (E_{corr}), β_a and $\beta_c$slopes were obtained (Table 3.1).

Table-3.1. The efficacy of the inhibitor is determined by the method of polarization curves in solution with inhibitor (MMF-1) and without inhibitor.

Inhibitor	**C,** (mg/l)	*i*, (*m*A/cm²)	γ	θ	**η,** (%)
Fon-1	-	56,1	–	–	–
MMF-1	50	8,63	5,06	0,821	82,1
	100	6,22	5,83	0,837	83,7
	150	4,13	7,24	0,861	86,1
	200	2,21	11,81	0,915	91,5

From Table 3.1, we can see that the amount of corrosion current is high (56.1 mA/cm²) in solutions without inhibitor, but the amount of corrosion current decreases accordingly with the introduction of an inhibitor into the system and the increase of the concentration of the inhibitor. For example: 8.63 mA/cm² at 50 mg/l, 6.22 mA/cm² at 100 mg/l, 4.13 8.63 mA/cm² at 150 mg/l and 2.21 at 200 mg/l reduced to mA/cm².

Due to the formation of a complex with Fe^{2+} ions, this MMF-1 brand corrosion inhibitor blocks cathodic reactions, reduces the release of hydrogen and prevents anode and cathode melting. Inhibition efficiency was 91.5% at 200 mg/l.

When smaller concentrations of the inhibitor are effectively adsorbed on the metal surface in a straight direction, its inhibition efficiency can be even higher. In conclusion, it can be said that the adsorption mechanism depends on the concentration, and with the increase in the concentration, the electrostatic repulsion and the forces between the inhibitor molecules increase with the increase of the concentration, which leads to the adsorption mechanism of a straight direction along the metal surface.

Conculusion. According to the results of the research, the inhibition efficiency of this corrosion inhibitor was studied by electrochemical polarization curves. The electrical conductivity of the system without the inhibitor was 56.1 (mA/cm2). gradually decreased to 2.21 i, (mA/cm2) and its inhibition efficiency was 91.5%. According to the obtained conclusions, this inhibitor can be recommended for corrosion protection.

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