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EFFECT OF 5-NITRO-2-FURALDEHYDE ON CORROSION OF CARBON STEEL

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Abstract: Evaluation of corrosion inhibitors for carbon steel in chlorinated environments is very important for some industrial plants. For this purpose, the inhibitory effect of 5-nitro-2-furaldehyde on the corrosion of carbon steel in aqueous solutions of 0.1 M NaCl and 0.1 M HCl was investigated. Cyclic voltammograms were taken to determine the electrochemical behavior of carbon steel in non-inhibitory and inhibitory environments. The corrosion rates of carbon steel in the presence of 5-nitro-2-furaldehyde in different concentrations (10, 20, 50 and 100 ppm) were measured by the Tafel Polarization method. As the inhibitor concentration increased, no significant change was detected in the 0.1 M HCl medium. In the 0.1 M NaCl environment, the corrosion potential has shifted to values that are more positive and the corrosion current has been reduced. This indicates that the inhibitors form a film on the surface of metal in this environment and create resistance to corrosion. The best inhibitory activity was achieved with an inhibitor concentration of 100 ppm in 0.1 M NaCl medium.

Keywords: Corrosion, Inhibitor, Tafel Polarization, Carbon Steel.

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INTRODUCTION

Corrosion of metals and alloys can lead to pollution of the environment and loss of economy (1-3). Carbon steel is a widely used construction material in many industrial areas due to its low cost and excellent mechanical properties (4, 5). Carbon steel is used in exchangers, boilers, reactors, storage tanks, gas and oil transportation industry, etc. However, carbon steel is particularly vulnerable to corrosion in oil and gas production systems (6, 7). Although inhibitors are highly effective in corrosion and oil and gas production systems, the selection and application of inhibitors due to variable corrosive environments is complex (6, 8-10). However, in the event of corrosion of the steel in corrosive environments; studies to increase the corrosion resistance of the environment by applying inhibitor cataracts, cathodic protection, adding coating element, alloying element or changing corrosive environment. This method does not require change in the system and can be easily controlled (11-14). Corrosion inhibitors are mixtures used to protect metallic materials against corrosion, which can be applied to closed systems and generally prepared in certain formulas. The active ingredients are selected according to the conditions in the mixtures. The formula of the mixture is mostly patented. What is important, however, is the type and concentration of the active substance in the mixture. The researchers carry out the selection of active substances. Many investigators have found that compounds with have a non-paired electron such as sulfur, nitrogen, and oxygen have a very good inhibitory candidates (15-18).

The inhibitor property of the 5-nitro-2-furaldehyde compound, whose structure was given in Figure 1, is firstly investigated by this study.

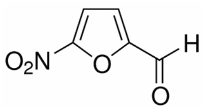

Figure 1. Structural formula of 5-nitro-2-furaldehyde.

EXPERIMENTAL

In the experiments, a 250 mL three-necked corrosion cell was used. Chemical composition of carbon steel given in Table 2 was placed in the middle neck of the cell as the working electrode. The working electrode is prepared by embedding it in a polyester resin with an open area of 1.0 cm^2. Before each test, the working electrode surface was polished with 2000-inch sandpaper under water. The electrode was washed with distilled water and placed in the experimental apparatus after treatment with ethyl alcohol. For measurement of the electrode potential, saturated calomel electrode (SCE) was used as the reference electrode. A platinum plate with 1.0 cm^2 surface area was used as the counter electrode for current measurement. In order to allow time for interaction between the working electrode and the inhibitor, working electrode was kept for 30 minutes in inhibitor contained solution before each electrochemical polarization. Tafel Polarization curves and cyclic voltammograms were obtained by using Ivium Technologies De Regent 178 5611 HW Eindhoven Ivium Compact Stat.

Table 1. Chemical Composition of Carbon Steel.

C	**Mn**	**P**	**Si**	**Cr**	**Al**	**Cu**	**Fe**
0.08	0.17	0.01	0.05	0.05	0.04	0.20	Rest

Inhibition Efficiency was calculated according to the following equation.

$$\text{Inhibition Efficiency } \% = \frac{CR(without\, inhibitor) - CR(with\, inhibitor)}{CR(without\, inhibitor)} \times 100$$

RESULTS AND DISCUSSION

The CV voltammogram of carbon steel obtained in 0.1 M NaCl medium is given in Figure 2. In anodic polarization with a scanning speed of 100 mV / s in the range of -1.5 V to 0.0 V, the anodic current passes in -1.2 V and ends at very low current at about -0.3 V. Carbon steel is passive until this potential. However, after this potential, the current is rapidly increasing and passivation occurs. The anodic current at 0.0 V is approximately 12 mA.

Tafel polarization method was used to determine the corrosion rate of carbon steel in 0.1 M NaCl medium containing 5-nitro-2-furaldehyde. Tafel Polarization curves were obtained with a scan rate 2 mV/s in the range of -1.5 V to 0.0 V. Tafel Polarization curves obtained in 0.1 M NaCl medium containing 10, 20, 50 and 100 ppm inhibitor and without inhibitor were overlapped and given in Figure 3.

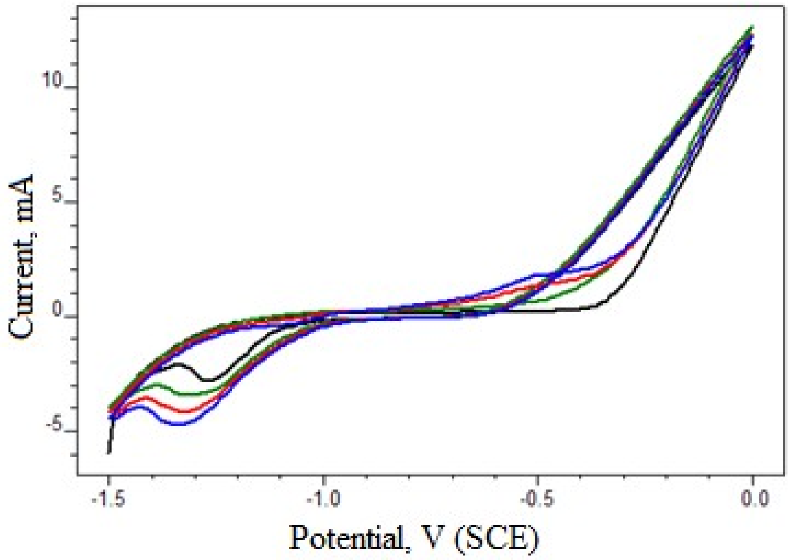

Figure 2. Cyclic voltammogram of Carbon Steel in 0.1 M NaCl.

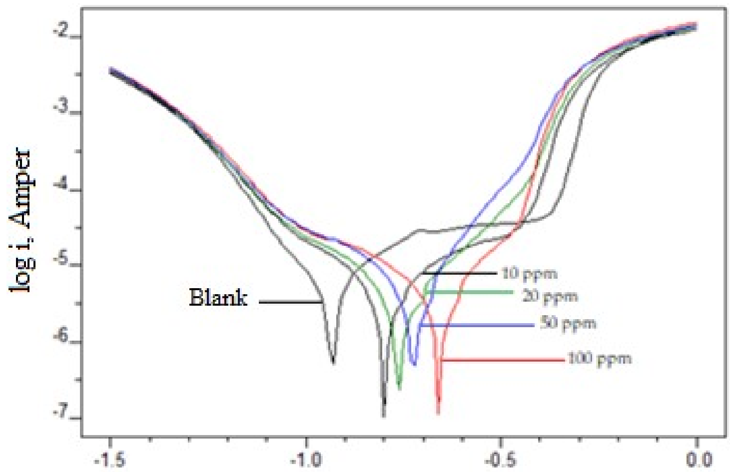

Figure 3. Tafel Polarization Curves of carbon steel in 0.1 M NaCl solution with and without inhibitor in different concentrations.

In all inhibitor concentrations, the corrosion potential of the steel was increased while the corrosion potential of the steel increased compared to the medium without inhibitor. As the inhibitor concentration increases, the corrosion potential of the corrosion potential is further reduced. This shows that the inhibitor slows down both the anodic reaction and the cathodic reaction. It was understood that 5-nitro-2-furaldehyde behaves as a mixed inhibitor for carbon steel in this medium.

The polarization curves of the carbon steel obtained in 0.1 M HCl solution were given in Figure 4. The anodic current occurs at about -0.7 V. There was a large increase in the anodic current after a very small increase of about 100-200 mV. It is understood that there is no passivity on the surface.

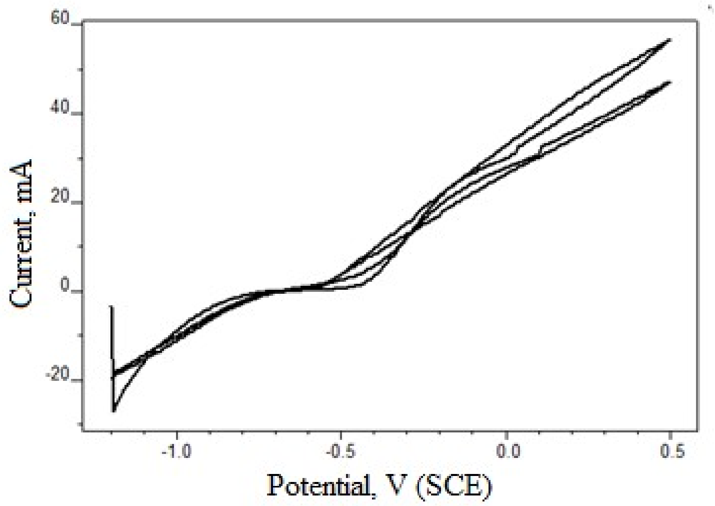

Figure 4. Cyclic voltammogram of Carbon Steel in 0.1 M HCl.

Tafel polarization curves obtained in 0.1 M HCl medium without inhibitor and containing inhibitor at different concentrations were overlapped and given in Figure 5. The curves in the hydrochloric acid medium without inhibitor and containing 10, 20, 50 ppm inhibitors are almost coincident. The curve obtained in the solution containing only 100 ppm inhibitor has a small increase in steel potential and a decrease in current.

In both corrosive environments, the corrosion parameters obtained by extrapolation of Tafel Polarization curves and the calculated inhibitor activity results were summarized in Table 2.

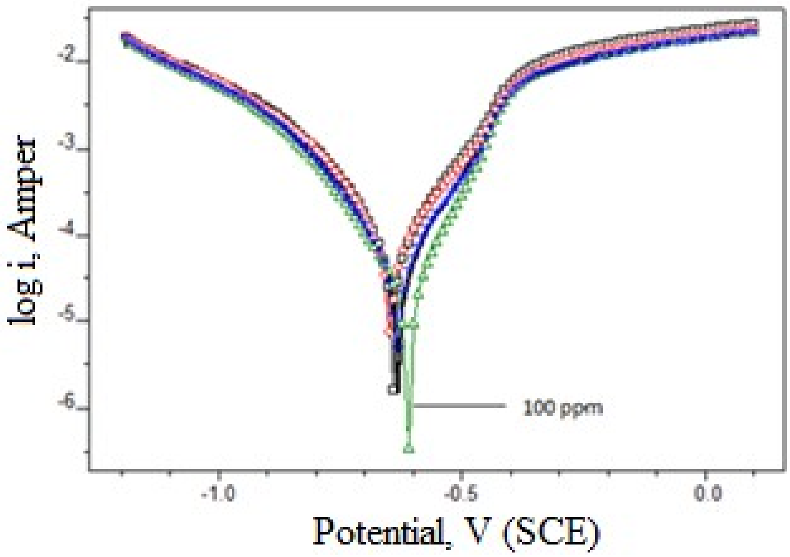

Figure 5. Tafel Polarization Curves of carbon steel in 0.1 M HCl solution with and without inhibitor in different concentrations.

Table 2. Carbon steel corrosion parameters in corrosive environments.

	Concentration (ppm)	Ecor (mV)	Rp (ohm)	Corrosion Rate (mm/y)	Inhibition Efficiency%
0,1 M NaCl	without	-950	9088	0.071	-
	10	-811	12050	0.032	54.9
	20	-774	12180	0.014	80.3
	50	-742	12750	0.011	84.5
	100	-683	13124	0.010	85.9
0,1 M HCl	without	-665	643	0.5023	-
	10	-661	647	0.5009	0.3
	20	-658	648	0.5010	0.3
	50	-657	651	0.4995	0.5
	100	-619	687	0.4321	7.0

As a result, while 5-nitro-2-furaldehyde did not provide significant inhibition efficiency in acidic medium, which is a corrosive environment, it has provided significant activity in the saline environment. The best inhibition efficiency was found to be 85.9% in 0.1 M NaCl medium containing 100 ppm inhibitor.

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