DOG ROSE OIL EXTRACT AS A POTENTIAL GREEN CORROSION INHIBITOR

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Abstract The inhibitory effect of the hydrophobic layer on the surface of copper in an acidic medium was studied by the classical potentiodynamic method and the impedance spectroscopy method. The hydrophobic character of the copper surface was achieved by immersing the sample in ethanolic octadecanoic acid with and without the addition of dog rose oil extract. The selected concentrations of the added dog rose oil extract were 0.5, 1.0, and 2.0 wt% in 0.05 molL-1 alcoholic solution of octadecanoic acid. Based on electrochemical measurements, an inhibition effect of ≈ 65% was obtained when the surface was modified by immersion in ethanolic octadecanoic acid only. With the addition of dog rose oil extract, this value increased to over 90%, depending on the concentration of dog rose oil extract added.

Keywords:
copper,
green corrosion inhibitor,
dog rose oil extract,
acid corrosion,
EIS

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1 Introduction

The existence of industry and related industrial processes is inconceivable without metallic materials. Despite all progress and research in the field of corrosion, it is still not possible to completely stop the deterioration of metallic materials by degrading corrosion reactions. By using various protective coatings, inhibitors acting through adsorption mechanisms, and intelligent materials, we can only slow down the corrosion processes more or less effectively. Progress has been made, but it is still far from complete success. More recently, "green orientation' and the circular economy have been added, prescribing both environmental protection and the sensible use and handling of raw materials and zero-waste production in the sense of 'every waste can be a raw material' (Abbasi, 2019) In other words: Products (food supplements) that have passed their expiration date can also be included in this group, but this expiration date is not necessarily mandatory in all areas. (Fuchs-Godec, 2021) (Patil, 2021). The hydrophobic properties of metals and alloys with high surface energy have recently attracted much attention from both researchers and academia, mainly because of their great importance in daily life and in various industrial and biological applications.

The present work focuses on the study of the inhibition properties of a dog rose oil extract added to the alcoholic solution of a fatty acid at a concentration of c = 50 mmol/L to form a self-assembled hydrophobic layer on the surface of copper. The selected concentrations of the added oil extract were 0.5, 1.0, and 2.0 wt%. Two electrochemical methods were used for the corrosion studies, namely a classical potentiodynamic method (PD) and electrochemical impedance spectroscopy (EIS). Measurements were performed in an acidic medium (acid rain), varying the pH (pH = 1, 3 and 5).

2 Experimental

For polarisation measurements, we chose a classical three-electrode system and a Tacussel type CEC/TH polarisation cell with a thermostatic sheath. All potentials were measured against an Ag/AgCl (3M KCl) reference electrode. The counter electrode was platinum and the working electrode was copper (99.9%).

The surface area of the sample affected by the test solution was approximately 0.875 cm^2. Polarisation curves were recorded from -0.4 V to a maximum of 0.3 V versus Ag/AgCl. The potential increased continuously at a scanning rate of 1 mVs^{-1}. Polarisation curves were recorded 30 minutes after sample immersion (stabilisation of the sample at the open circuit potential OCP occurred for 30 minutes). All measurements were performed at a temperature of 25°C ± 1°C. For the potentiodynamic and impedance measurements, we used a potentiostat/galvanostat/ZRA-Gamry Reference 600™ with the associated software to analyse the measurements.

Before etching, the metal surface was successively abraded using a grinding machine and SiC papers of grades 800, 1000, 1200 and 2400. Etching was performed in aqueous solutions of 10% HNO_3 for 1 minute and then washed in deionized water and dried with compressed air.

Subsequently, the etched sheets were immersed at room temperature for about two hours in a 50 mmol/L ethanolic solution of octadecanoic acid with and without the addition of various concentrations of dog rose oil extract.

3 Results and discussions

The polarization curves in Figure 1 show the voltage-current response of the untreated and modified copper surfaces in a simulated acid rain solution with different pH values = 5, 3, and 1. The surfaces of the copper samples were modified by immersion in an alcoholic solution of octadecanoic acid with and without the addition of the dog rose oil extract at different concentrations (0.5, 1.0, and 2.0 wt%).

Considering the untreated surface, significant changes are observed in both the cathodic and anodic regions. The cathodic and anodic current density decreases. In the case where the surface of Cu was modified in the mixture with added dogrose oil extract, its values decrease by almost three orders of magnitude in all selected corrosion media. This is particularly effective in the most aggressive medium, namely in the case where the pH of the corrosion medium was pH = 1. In this case, the surface protection is significantly lower when the protective hydrophobic coating consists only of octadecanoic acid. The corrosion current density is only slightly lower than the corrosion current density of the untreated surface. However, the corrosion current density decreases by two orders of magnitude when the dog rose oil extract is added at all three selected concentrations. The decreasing trend is from the lowest concentration chosen to the highest.

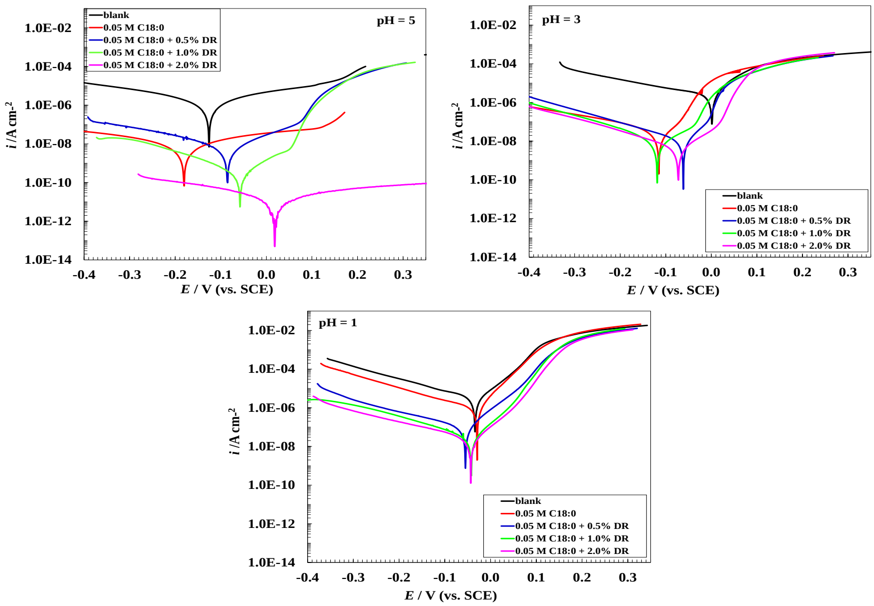

Figure 1: Potentiodynamic polarisation curves (1 mVs^{-1}) of Cu for the bare and modified surfaces of the 'acid rain' solutions (pH =5, 3 and 1) at 25°C. The modified surface was prepared by the immersion of the sample in 0.05 M alcoholic solution of octadecanoic acid with and without the addition of dogrose (DR).

Source: own.

Table 1: The inhibition efficiency η determined based on the kinetic parameters for the corrosion of Cu from the potentiodynamic polarisation curves for the bare and modified surfaces of the 'acid rain' solutions (pH =5, 3 and 1) at 25°C. The modified surfaces were prepared by immersing Cu in 0.05 M stearic acid in ethanol with and without the addition of Dog Rose (DR).

Corrosive media acid rain, pH = 5	wt% DR	% η_{icorr}	% η_{Rp}
modified surface of Cu	**0***	97.8	97.4
	0.5	98.5	98.7
	1.0	99.3	99.4
	2.0	99.7	99.8

Corrosive media acid rain, pH = 3	wt% DR	% η_{icorr}	% η_{Rp}
modified surface of Cu	**0***	95.2	94.1
	0.5	97.5	97.7
	1.0	99.5	99.6
	2.0	99.8	99.8

Corrosive media acid rain, pH = 1	wt% DR	% η_{icorr}	% η_{Rp}
modified surface of Cu	0*	65.2	66.4
	0.5	92.3	93.1
	1.0	98.0	96.4
	2.0	99.1	99.2

The inhibition efficiency η was calculated via the kinetic parameters measured during corrosion processes, as well as the polarisation resistance R_p, the corrosion current density i_{corr}, In the case of the polarisation resistance, η was calculated via Equation (2), where while Equation (1) was used in connection with the corrosion current density (Table 1).

$$\eta\% = \left[1 - \frac{i'_{corr}}{i_{corr}}\right] \cdot 100 \quad (1)$$

$$\eta\% = \left[1 - \frac{R_p}{R_p'}\right] \cdot 100, \quad (2)$$

where the notations i_{corr}, R_p, were used for those measurements without inhibition action, whilst the primed quantities i_{corr}', R_p' were applied when measurements were performed on the modified surfaces of copper in simulated solution of acid rain with pH = 1, 3 or 5.

The Nyquist diagrams confirm the results of the potentiodynamic measurements. In the case of the unprotected surface, depressed semicircles appear at all selected pH values of the corrosion medium, followed by a straight line with a slope of about 45° in the low-frequency region, indicating diffusion processes in the formed oxide layer of the untreated copper sample. As expected, this is least pronounced when the pH of the corrosion medium is 5 and most pronounced at pH=1. The diffusion tail does not appear at pH=5 in the case of the surface modified with both octadecanoic acid alone and with the addition of dog rose oil extract. In the case of 2% addition of DR, a polarisation resistance of 12.5 MΩcm2 is obtained, which places the resulting self-assembled layer among the stable layers.

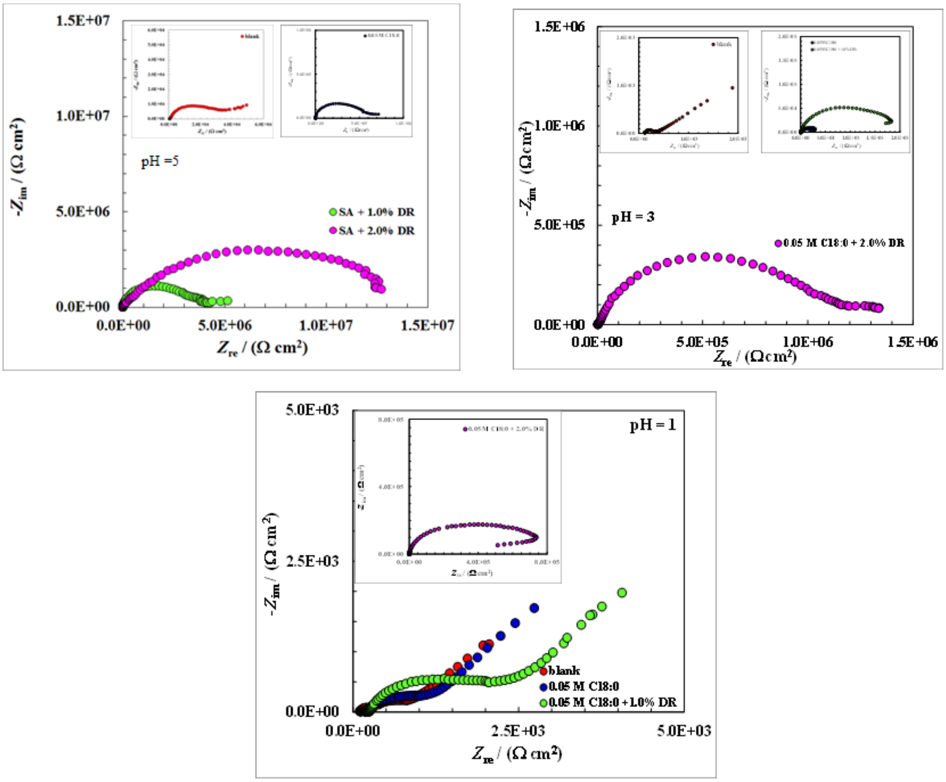

Figure 2: Nyquist diagrams of Cu for the bare and modified surfaces in the 'acid rain' solutions (pH =5, 3 and 1) at 25ºC.

Source: own.

Acknowledgments

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