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Corrosion Inhibition by Natural Extracts at 50°C

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Abstract

This work involves investigation on corrosion inhibition of steel 37-2 using Cinnamon, Ficus carica and Sweet clover extracts as natural inhibitors at 50oC by electrochemical measurements and AFM test. The data of polarization in blank electrolyte containing 3mL/L of each extract in electrolyte gave inhibition efficiencies equal to 86.051, 74.025 and 83.935% in presence 3mL/L of Cinnamon, Ficus carica and Sweet clover extract respectively. The data of AFM test shows the decreasing in roughness of surface after adding the natural inhibitor which equal to 0.631, 4.13 and 1.1nm corresponding to 3mL/L of Cinnamon, Ficus carica and Sweet clover extract respectively compared with the roughness Ra of polished and uninhibited surface as 8.39 and 44.7 nm respectively.

Keywords: Natural inhibitor, Roughness of inhibited surface.

Introduction

Corrosion is the deterioration of metal by chemical attack or reaction with its environment. It is a constant and continuous problem, often difficult to eliminate completely. Prevention would be more practical and achievable than complete elimination. Corrosion processes develop fast after disruption of the protective barrier and are accompanied by a number of reactions that change the composition and properties of both the metal surface and the local environment, for example, formation of oxides, diffusion of metal cations into the coating matrix, local pH changes, and electrochemical potential. Many authors were tried to use natural products and extracts to inhibit the corrosion of metals and alloys [1-9] instead of chemical compounds which have some toxicity for human and environment

The aim of present work involves extract three natural inhibitor using ethanol for cinnamon stems, ficus carica and sweet clover leaves in petroleum medium at 50°C using electrochemical measurements and AFM test to inhibit the corrosion of steel 37-2.

Procedure and methods

Materials

Steel 37-2 was used in this work (chemical composition wt%: 0.121 C, 0.22 Si, 0.44 Mn, 0.014 P, 0.016 S, 0.041 Cr, 0.002 Mo, 0.022 Ni, 0.02 Al, 0.002 Co, 0.055 Cu and Fe remain) obtained by SpectroMAX. Cubic steel (10x10x3mm) with a square surface area (1cm^2) was used in all experiments. The specimen was mounted by hot mounting using formaldehyde (Bakelite) at 138°C for 8 minutes to insulate all but one side and made a hole on one side for electrical connection and then the mounted specimens has been grinded with SiC emery papers in sequence of 400, 600, 1000, and 2000 grit. The base electrolyte was petroleum medium obtained from Iraqi oil refinery with contents of metals: 48.67% C, 8.73% H, 0.13% N, and 0.71% S. The pH of this medium is 5.25, electrical conductivity is 300 μS/cm, and TDS 296 mg/L.

Extraction of plants were achieved by washing with distilled water and then drayed and grounded and then identified by FTIR spectra Model Shimadzu using KBr. Ethanolic extract obtained by dissolving 5 gm of grounded leaves in 200 mL ethanol and then heated at 45°C. The obtained extract was filtered by using Whatmann filter paper and concentrated to 100 mL. 3mL/L of each extract was used as inhibitor concentration at 50°C.

Electrochemical Measurements

Electrochemical cell was composed of platinum counter electrode, prepared steel specimen as working electrode and saturated calomel electrode (SCE) as a reference electrode. The electrochemical behavior of steel in inhibiting and uninhibited solution

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was studied by WINKING M Lab potentiostat by recording anodic and cathodic galvanodynamic polarization curves. Measurements were carried out by changing the electrode current automatically from -15 to +15 mA at scan rate 1 mA.sec^{-1}. The linear Tafel segments of anodic and cathodic curves were extrapolated to the corrosion potential to obtain corrosion parameters.

Atomic Force Microscopy characterization (AFM)

The steel specimen immersed in blank and in the inhibitor solution for a period of 15 days was removed, rinsed with double distilled water, dried and subjected to the surface examination. Atomic force microscopy (Veeco dinnova model) was used to observe the sample's surface in tapping mode, using cantilever with linear tips. The scanning area in the images was 5 µm × 5 µm and the scan rate was 0.6 HZ /second.

Results and discussion

Figure (1) shows the Tafel plot of steel in petroleum medium in absence and presence of three plant extracts with 3mL/L as concentration and 50ºC temperature. By Tafel extrapolation method, corrosion parameters have been measured. These parameters indicate that corrosion potential became either more active or more noble, while corrosion current density was lower compared with uninhibited electrolyte. Cathodic and anodic Tafel slopes were decreased as shown in Table (1). From the corrosion current densities in absence and presence inhibitors, inhibition efficiencies IE% can be calculated according to eq. (1). The data of IE% indicate that the plant extracts act as good inhibitors for steel 37-2 in petroleum medium as listed in Table (1).

$$IE\% = \frac{(i_{corr})_a - (i_{corr})_p}{(i_{corr})_a} \times 100 \quad .....(1)$$

Where $(i_{corr})_a$ and $(i_{corr})_p$ are the corrosion current density (µA.cm^{-2}) in the absence and the presence of the inhibitor, respectively.

Figure (2) displays the surface topography of un-corroded metal surface. The value of Ra for the polished carbon steel surface (reference sample) is 8.39 nm. The slight roughness observed on the polished steel surface is due to atmospheric corrosion. Figure (3) displays the corroded metal surface with few pits in the absence of the inhibitor immersed in petroleum medium. The Ra for the carbon steel surface is 44.7 nm. These data suggests that steel surface immersed in petroleum medium has a greater surface roughness than the polished metal surface, which shows that the unprotected steel surface is rougher and was due to the corrosion of the steel in petroleum medium. Figures (4) to (6) display the steel surface after immersion in petroleum medium containing 3mL/L of Cinnamon extract, Ficus carica extract and Sweet clover extract, and the Ra values for the steel surface are 0.631, 4.13 and 1.1 nm respectively. These parameters confirm that the surface is smoother. The smoothness of the surface is due to the formation of a compact protective film of Fe^{2+} − natural extract complex thereby inhibiting the corrosion of steel [10]. These results were agreement with the results of Khaled and Ebenso [11] and Sangeetha et al. [5] when they used the AFM technique for corrosion inhibition measurements.

Conclusion

In this work, we used three natural extracts as inhibitors for steel 37-2 in petroleum medium and they proved their activity with good efficiencies when they used with 3mL/L as concentration at 50ºC in petroleum medium using electrochemical measurements and AFM test.

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Table (1): Corrosion parameters for polarization of steel in petroleum medium in the absence and presence of 3mL/L alcoholic extracts at 50ºC.

Extract	*E_{corr} mV*	*i_{corr} µA.cm^{-2}*	*$-b_c$ mV.dec^{-1}*	*$+b_a$ mV.dec^{-1}*	*IE%*	*Ra*
Petroleum medium only	-759.8	497.68	1095.3	1087.7	-	
Cinnamon	-1609.7	69.420	276.5	185.8	86.05128	0.631
Ficus carica	-733.0	129.27	652.8	588.4	74.02548	4.13
Sweet clover	-360.6	79.950	330.0	373.1	83.93546	1.10

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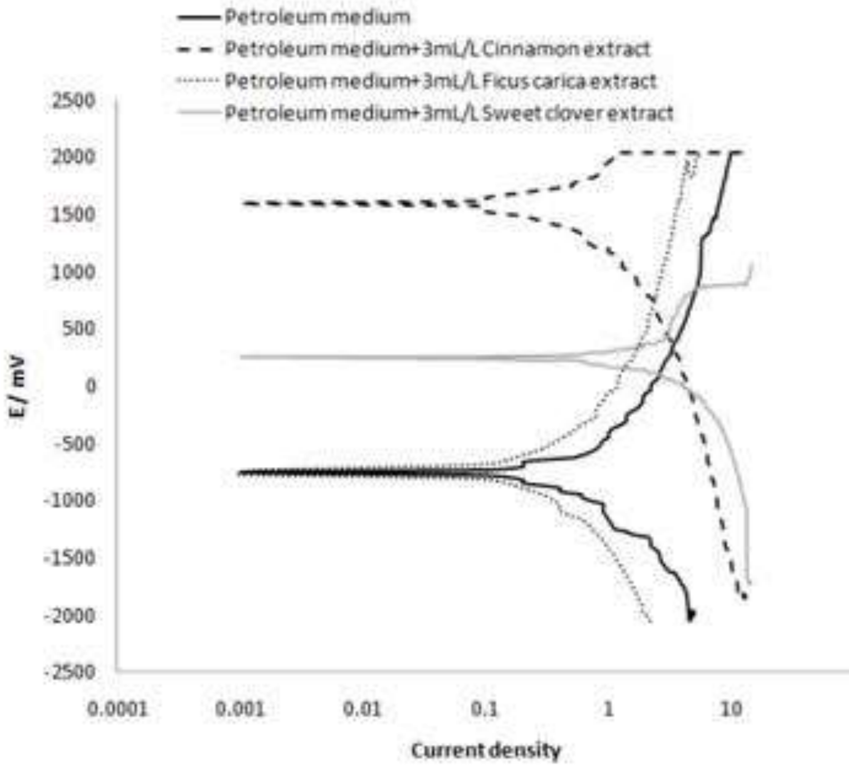

Figure 1: Tafel plot of steel in petroleum medium in absence and presence three natural inhibitors at 50°C.

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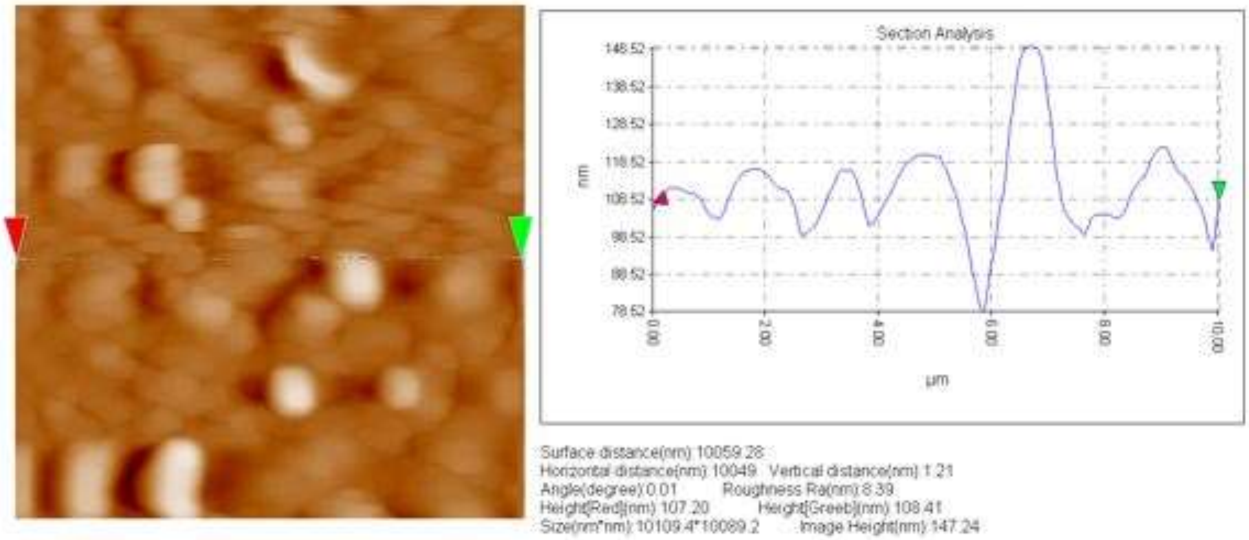

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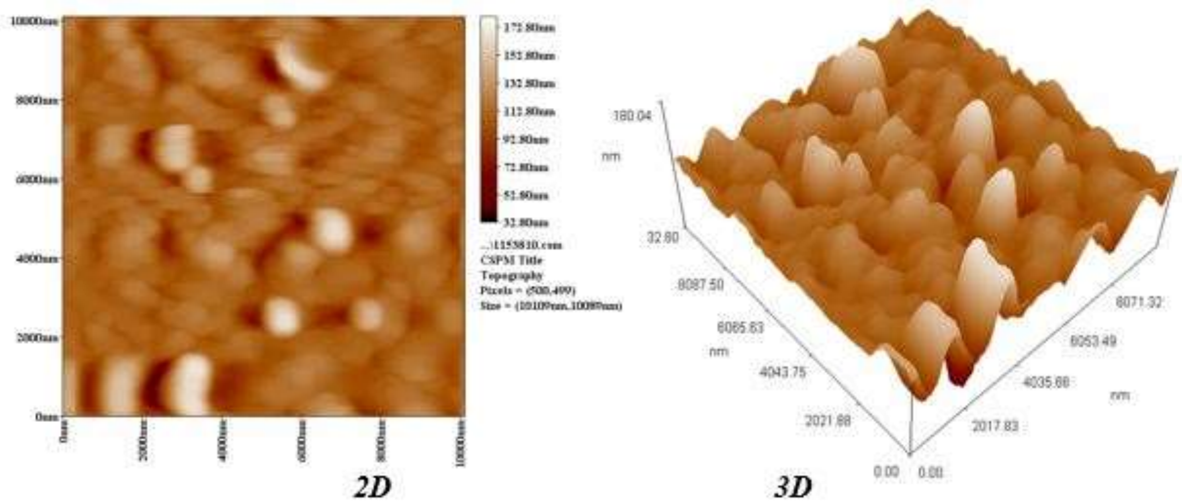

Figure 2: AFM images of the surface of as polished steel.

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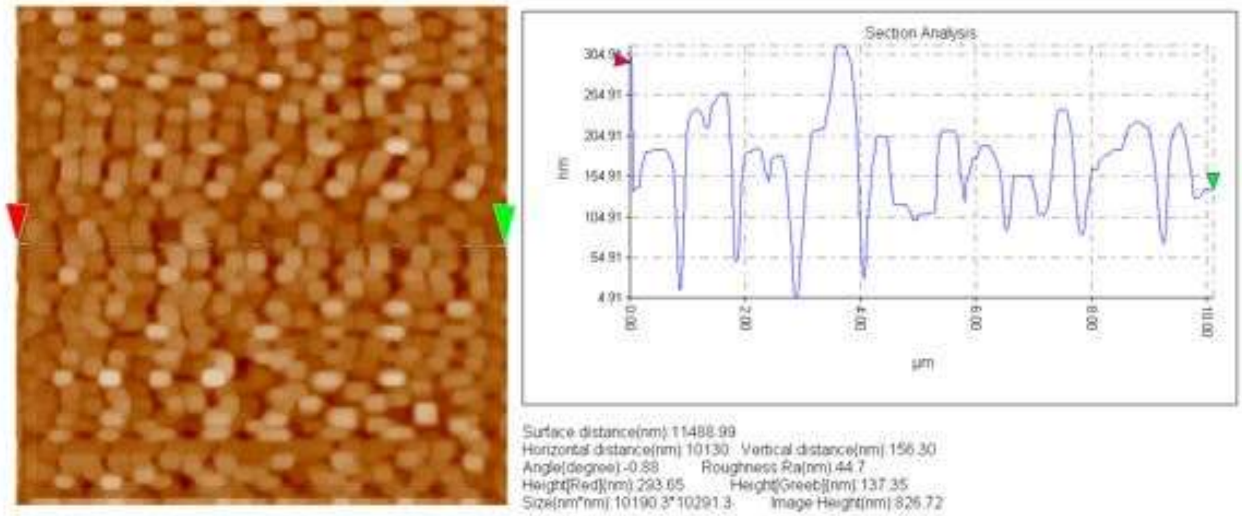

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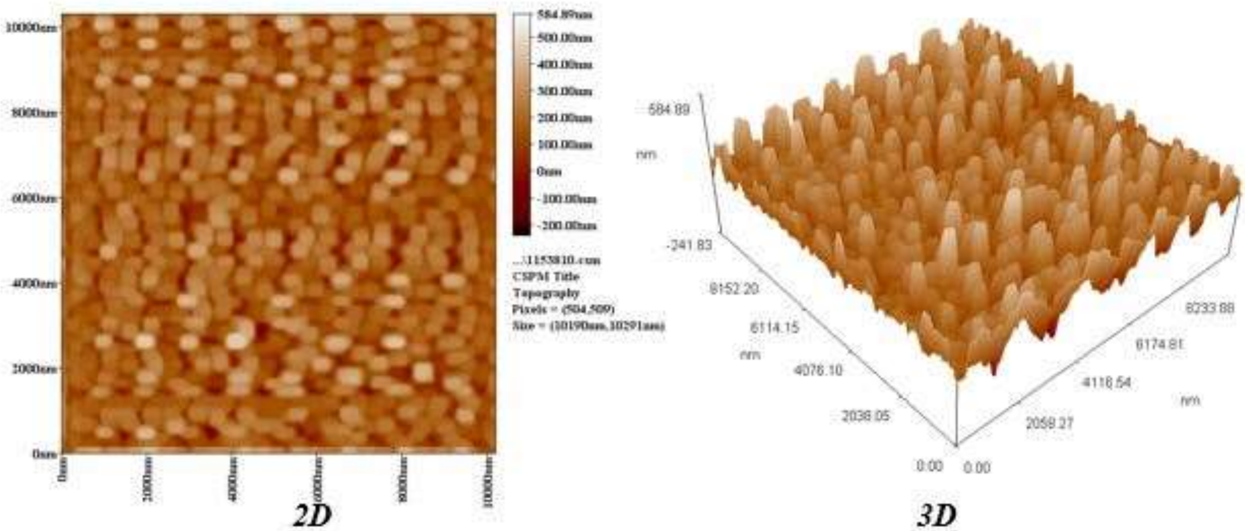

Figure 3: AFM images of the surface of steel immersed in petroleum medium (blank).

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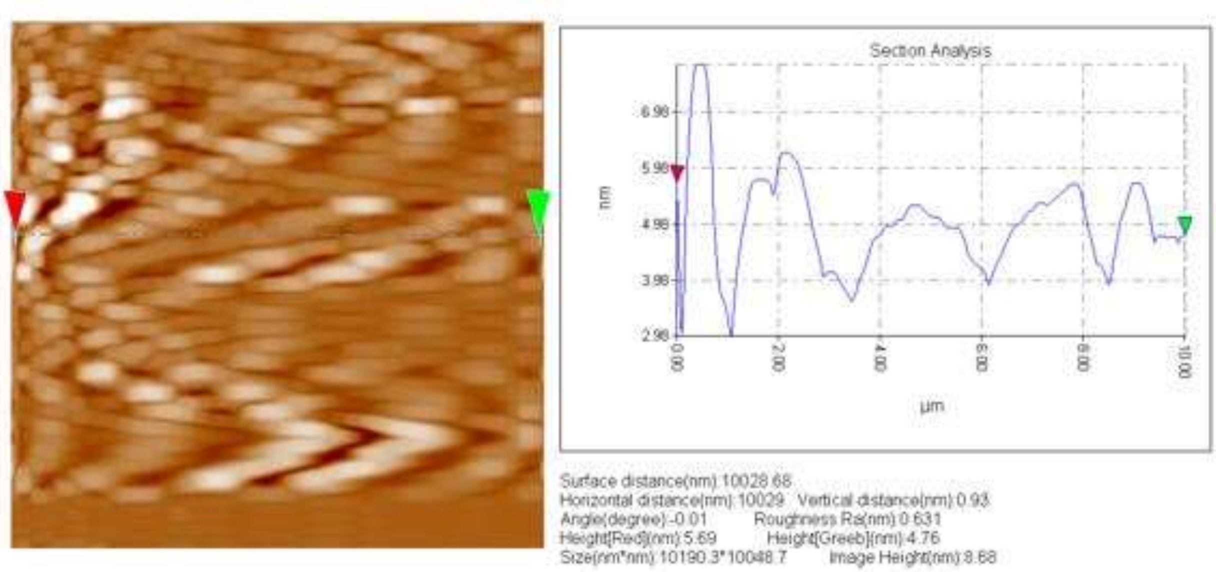

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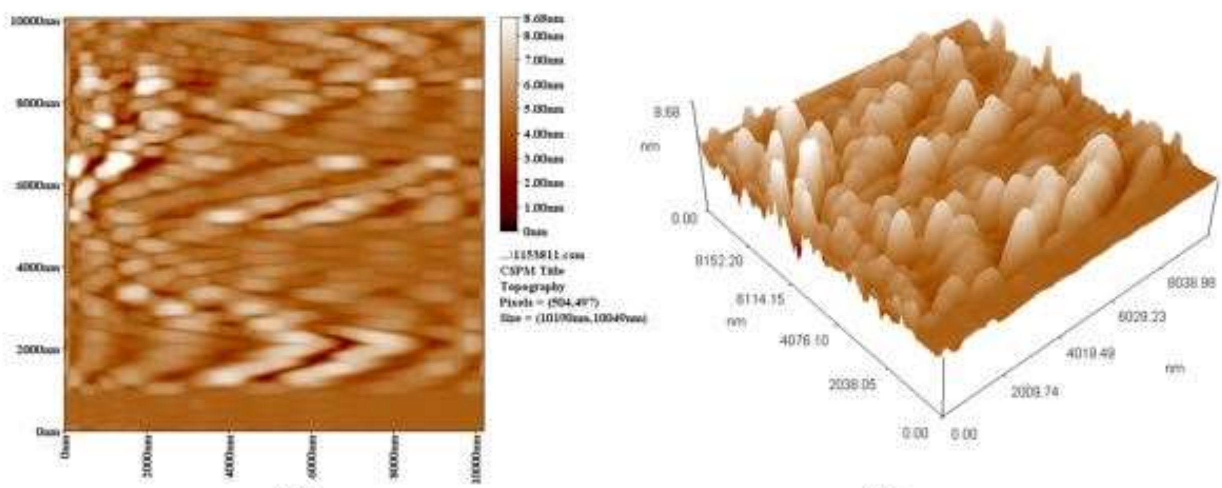

2D **3D**

Figure 4: AFM images of the surface of steel immersed in petroleum medium containing 3mL/L Cinnamon extract.

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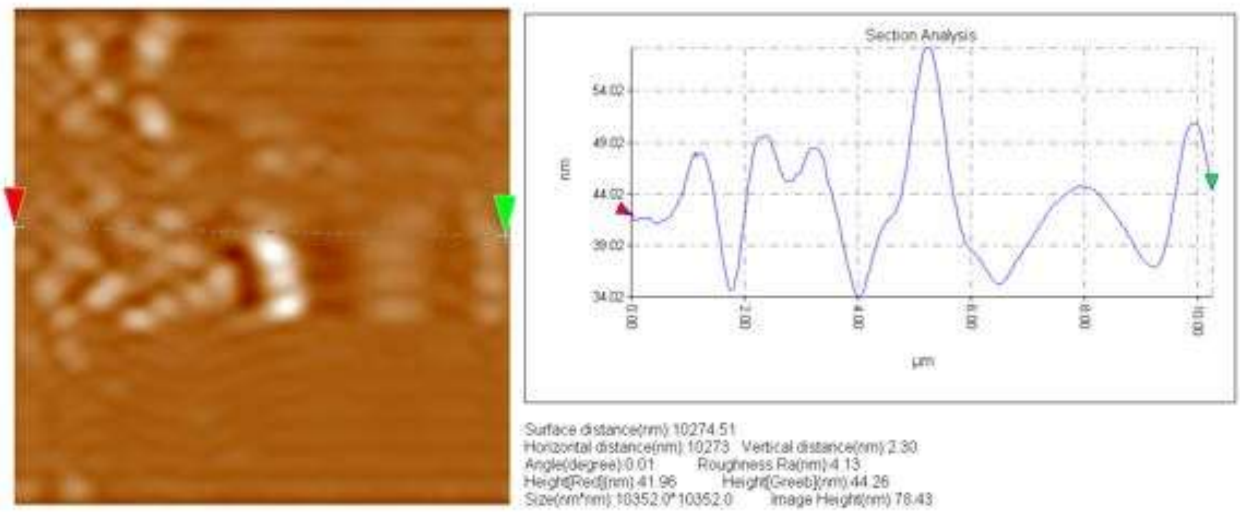

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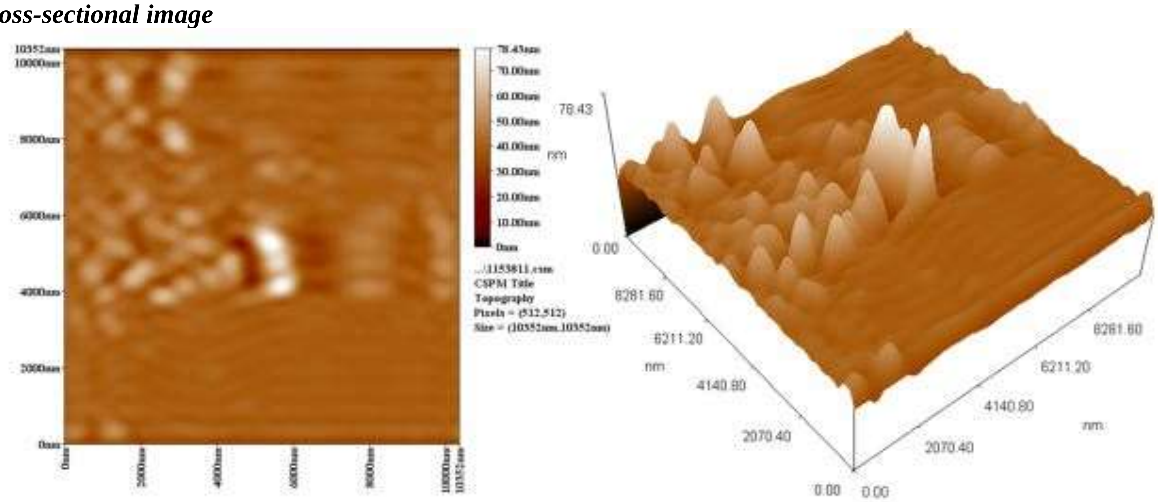

2D ***3D***

Figure 5: AFM images of the surface of steel immersed in petroleum medium containing 3mL/L Ficus carica extract.

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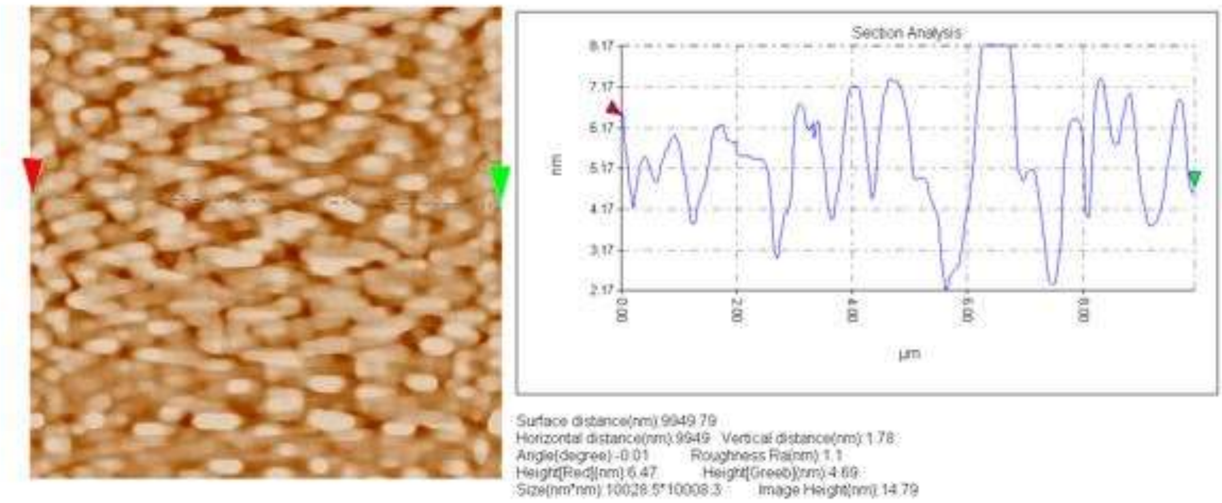

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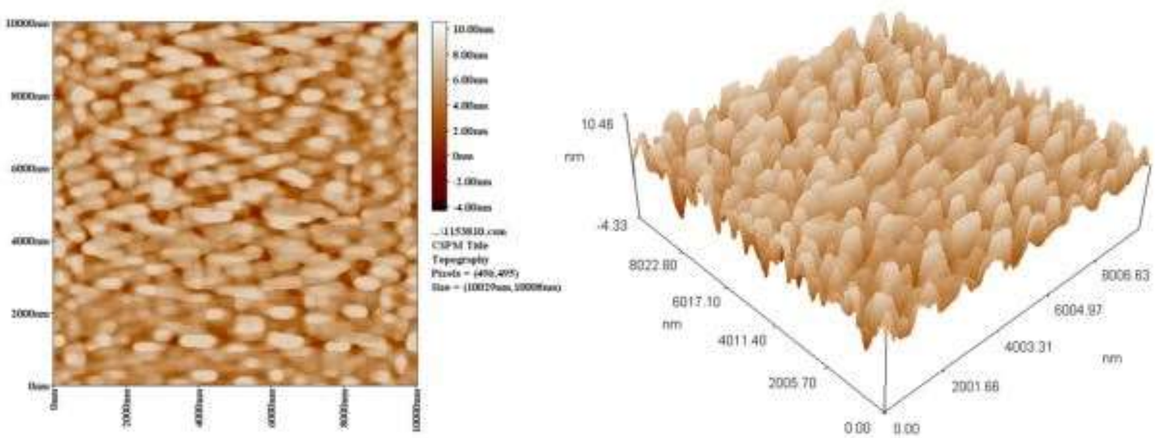

2D *2D*

Figure 6: AFM images of the surface of steel immersed in petroleum medium containing 3mL/L Sweet clover extract.