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Effects of *Lavandula* and *Ricinus Communis* Oil as Inhibitors of Mild Steel Corrosion in HCL and H_2SO_4 Media

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Abstract

Lavandula and *ricinus communis* oils were used as inhibitors of mild steel corrosion in 0.5 M HCl and in 0.5 M H_2SO_4. The inhibition effects of these oils were studied at ambient temperature of 25°C. Gravimetric and potentiodynamic polarization measurement methods were used for the experiments. A Digi-Ivy potentiostat, interfaced with a computer for data acquisition and analysis was used for the potentiodynamic polarization experiments. The inhibition performance decreased with increasing concentration of the mixed inhibitors in the test media for H_2SO_4 and increased with increasing concentration for the HCl acid medium. For the test in H_2SO_4, the low inhibitor concentrations of 2ml, 4ml, 6ml/250 ml H_2SO_4 were relatively similar and the obtained weight loss were 0.152g, 0.254g, and 0.21g respectively. At 336 h of the experiment, the concentration of 12 ml/250ml H_2SO_4 had the highest recorded weight loss value of 0.821g. For similar concentrations as above, the corrosion rate values of 0.84 mm/yr, 1.40 mm/yr and 1.16 mm/yr were achieved. In 0.5M HCl, the 2 ml, 4 ml, 6 ml, 8 ml / 250 mL HCl concentrations had low but constant weight loss until 144 h. The 2ml/ 250 mL HCl concentrations recorded 0.307gweight loss at 312 hr. The 12 ml/250 mL HCl concentration performed best with 0.088g weight loss at 312 h and the corrosion rate was 0.48mm/yr. Inhibition efficiency for the 12ml/250 ml HCl inhibitor concentration was 88% and in H_2SO_4, it was 96.35% at 336 h. Also obtained was polarization resistance which was 3.90E+02 Ω; corrosion rate- 0.68 mm/yr and current density was 5.84E-05 A cm^{-2} for the 2 ml/ 250 mL H_2SO_4 concentration in H_2SO_4 test medium. Similarly, for the 12 ml/ 250 mL HCl concentration, polarization resistance recorded 3.07E+02 Ω; corrosion rate was 0.86 mm/yr; and current density (Icorr) was7.41E-05 A/cm^2.

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Keywords: Corrosion; Castor oil, Lavender oil

Introduction

Corrosion and protection of metallic materials, particularly the mild steel are apparently a perpetual struggle between man and nature. Mild steel is generally low in cost, very widely available and has the properties that make it to be most versatile in metals' technology applications. However, its mild to severe susceptibility to corrosion in diverse environments –acidic, alkaline, aqueous and atmospheric, is disadvantageous due to its technological and consequent economic adverse effects. Mild steel must therefore be protected. Among the various means of the steel's protection is by inhibitors. Both inorganic and organic compounds had been effectively used for this purpose but they are not without their environmental unfriendliness. In recent time, the use of

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plant extracts and oil for corrosion prevention and control (protection), particularly, as green inhibitor has been gaining some considerable research interest [1-14]. The reason for this is not unconnected with environmental friendliness.

In general corrosion inhibitors are chemical compounds whose reacting species react with the metal to produce a protective film at the metal-environment interface to inhibit the electrode's corrosion reactions. In this instance, the mechanism of inhibition could be either by altering the anodic or cathodic polarization behaviour, increasing the electrical protection of the metal, reducing spreading of ions to the metal surface or a combination of any of the three with another one. The influence of inhibitors is often associated with physical or chemical adsorption. This phenomenon had been related to the presence of hetero atoms (N, O, S, and multiple bonds or aromatic rings in the inhibitor [15].

In this work, two different oil types were used as the corrosion green inhibitor. These are: Lavender oil (Lavandula latifolia) and the Castor oil (Ricinus communis L). lavender oil is a complex mixture of phytochemicals, including linalool and linalyl acetate. Its chemical components include α-pinene, limonene, 1, 8-cineole, cis-ocimene, trans-ocimene, 3-octanone, camphor, linalool, linalyl acetate, caryophyllene, terpinen-4-ol and lavendulyl acetate. The second oil used was the castor oil. The main principal constituents of castor oil are: up to 90% ricinoleic, 4% linoleic, 3% oleic, 1% stearic and less than 1% linoleic fatty acids. The presence of the hydroxyl group in *ricinoleic* acid (RA) and its derivatives, provide a functional group location for performing a variety of chemical reactions that include halogenation, dehydration, and alkoxylation [7].

This work aims at studying the inhibition effect of *ricinus communis* and *lavendul*a oils on mild steel corrosion in acid media.

2. **Materials and Method**

Materials Preparation

Cylindrical steel sample of 12 mm diameter was each cut into average size of 12 mm x 10 mm coupons for weight loss and also for potentiodynamic polarization test. Samples used for weight loss method were de-scaled with a wire brush, ground with various grades of abrasive papers and further polished to 6 micron meter (μm). The specimens were subsequently rinsed in distilled water to remove any dirt and cleaned with acetone to degrease. The samples were separately fully immersed in each of the acids – 0.5 M H_2SO_4 and 0.5 M HCl. For the corrosion polarization experiments, another set of samples were cleaned in the same manner as those for the weight loss. They were then mounted in resin ensuring that only the tested surface of the sample was exposed to the corrosive medium. Copper wire was spot-welded to each of the samples before mounting. The surface of the samples were thoroughly polished with silicon carbide papers of up to 1000 grade before being cleansed in distilled water and dried with acetone.

The experiments were set up in 6 different environments. There was one control experiment and five other experiments with different concentrations of the castor oil and lavender oil inhibitors in 0.5 M H_2SO_4 and 0.5 M HCl. The concentrations of the oil inhibitors used were, respectively: 0, 2, 3, 4, 6, 8.10 and 12g /200 ml H_2SO_4 and also for HCl. The test media without added inhibitor served as the control experiment.

2. 1. **Weight loss method**

Weighed test species were fully and separately immersed in 200 ml in each of the test environments at predetermined specific concentrations of the inhibitors for 336 hours at the room temperature of 25^{o}C. The weight of the sample were taken and recorded at regular time intervals. Each of the test samples was taken out every 24 hours, washed with distilled water, rinsed with acetone, dried and re-weighed. Plots of weight loss (g), corrosion rate (mm/year) and percentage inhibition efficiency (% IE) versus exposure time in hours were made from the readings previously recorded in the tables.

From the weight loss data, corrosion rates (C_r) were calculated from the formula:

$$\text{Corrosion Rate (in mm/year)} = \frac{87.6 \times \text{Weight Loss(g)} \times 1000\ \text{mg}}{\text{Metal Density } (g/cm^3) \times \text{Surface Area } (cm^2) \times \text{Exposure Time (hours)}}$$

The per cent inhibition efficiency (% IE) is calculated as:

I.E % = [(W1 – W2)/W1] * 100 ……………………. (1)

Or: (1-W2/W1)*100 ……………………… (2)

Where W1 is the weight loss of the control sample; and W2 is the weight loss of the other samples respectively.

2. 2. **Potentiodynamic polarization**

Electrochemical polarization tests were performed on the prepared specimens. Each of the specimens was immersed separately in the two different acids. One set of the tests was with addition of various inhibitor concentrations and the other was without the inhibitor addition. In this experiment the specimen was polarised about 300 mV in both the anodic and cathodic directions from the corrosion potential, Ecor to generate Tafel plots. The resulting current is plotted on a logarithmic scale. D2ata such as current density, corrosion rate, and polarisation resistance were generated.

3. Results and Discussion

Weight loss method

0.5 M Hydrochloric acid medium

The obtained results showed the different weight loss and corrosion rates of steel specimens. Data obtained from the experiment were used to draw table and plot graphs. Results obtained from weight loss experiments for the tests performed in the HCl medium are presented in Figure 1. The weight loss of the control sample test was significantly greater than that of other samples which contained inhibitors of different concentrations, achieving a weight loss of 0.78 g at 336 hours. Weight loss of samples with inhibitor concentrations of 2ml, 4ml, 6ml and 8ml/200 ml HCl remained, generally, in almost steady state of corrosion reactions with very slight increase in weight loss till 144 hours of the experiment. Thereafter, the weight loss increased as inhibitor concentration decreased. The 2ml/200 ml HCl concentration of the LACA inhibitor had a weight loss of 0.307g at 336 hours and the 12 ml/200 ml HCl concentration recorded 0.088g weight loss at 336 hours.

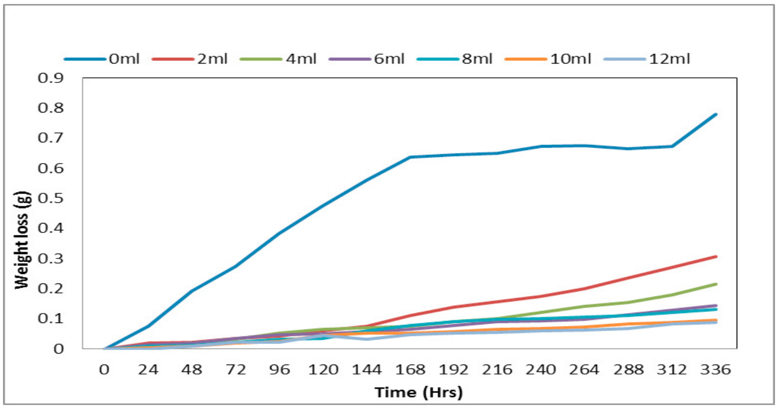

Figure 1: Weight-1oss curves versus time for the various concentrations of mixed lavender and castor oils (LACA) inhibitor for the test in HCl

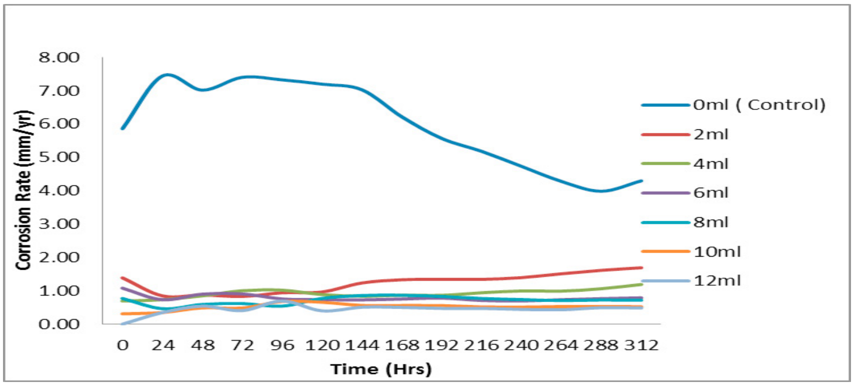

Figure 2: Curves of corrosion rate versus time for various concentrations of mixed lavender and castor oils (LACA) inhibitor.

Results of corrosion rate with the exposure time are presented in Figure 2. Corrosion rate of the control electrode was much greater than the other samples when varied concentrations of the mixed inhibitor were added. It recorded 4.3 mm/yr corrosion rate at 336 hours. Corrosion rate of the other tests with inhibitor addition decreased with the inhibitor concentration after 144 hours. The test with 2 ml/HCl concentration inhibitor addition achieved corrosion rate of 1.69 mm/yr at 336 hours. The test with the 12 ml/ 200 ml HCL concentration (the highest concentration used) achieved the lowest corrosion rate of 0.48 mm/yr at 336 hours. This confirms the more inhibitive action of the inhibitor with the increase in inhibitor concentrations.

Presented in Figure 3, are results of calculated inhibition efficiency for corrosion rates at 336 hours of the experiment. Inhibition efficiency of the sample with lowest concentration of the inhibitor was very much less than that of other samples; it was calculated to be 60.64% at 336 hours. The per cent inhibition efficiency value of the test sample with the highest inhibitor concentration of 12 mil/200ml

HCl remained constant generally from the onset of the experiment to the end at 336 hour achieving a per cent inhibition efficiency value of 8.72. The inhibition efficiency values of 72.31%, 81.67%, 83.33%, 87, and 82% were respectively obtained for the inhibitor concentrations of 4, 6, 8, and 10 ml/200 ml HCl. It could thus be inferred that inhibition efficiency for the test electrode in the HCl medium increased as the inhibitor concentration increased.

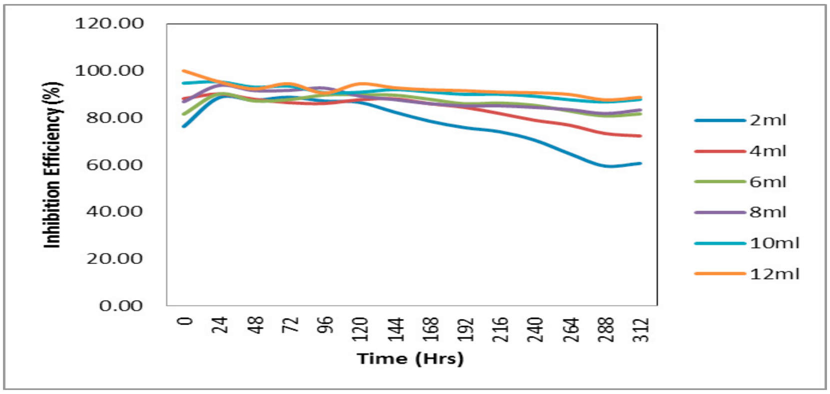

Figure 3: Plot of inhibition efficiency against time for concentrations of lavender/castor oil mix (LACA) inhibitors in HCl.

0.5 M Sulphuric acid medium

Figure 4 shows the results of weight loss in sulphuric acid. It could be observed from Figure 4 that weight loss of 4.162g at 336 hours for the control sample was much greater than those of the other test electrodes with various concentrations of inhibitor addition. Weight loss of other test electrodes with relatively low inhibitor concentrations addition of 2ml, 4ml, and 6ml/ 200 ml HCl were relatively similar and had weight loss of 0.152g, 0.254g, 0.21g respectively. The 12 ml/200 ml H_2SO_4 concentration (the highest concentration used) had the highest weight loss of 0.821 g. In this experiment, the lowest concentration of the mixed inhibitors was the most effective.

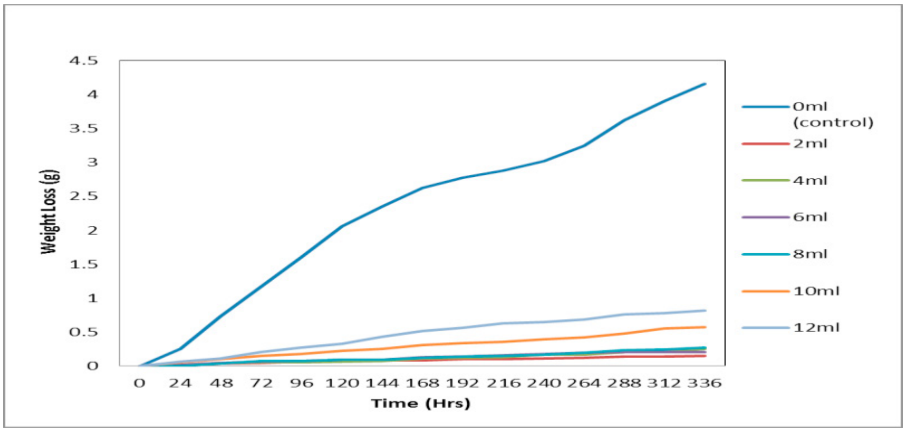

Figure 4: Plot of weight loss with time for specimen immersed in 0.5 M H_2SO_4 with different concentrations of added mixed lavender/castor oils (LACA) as inhibitors

Figure 5 shows corrosion rate results. Corrosion rate of test sample without inhibitor concentration is very much greater than obtained with added inhibitor concentrations. It recorded corrosion rate of 22.92 mm/yr. Corrosion rates for the test samples with added inhibitor concentrations of 2 ml, 4 ml, and 6 ml/200 ml H_2SO_4 were 0.84, 1.40 and 1.16 mm/yr respectively. It is apparent here that the test electrode with the lowest concentration of LACA inhibitor addition gave the most effective corrosion inhibition. Also, the highest inhibitor concentration had the least inhibitive effect.

The inhibition efficiency results of the weight loss experiment performed in sulphuric acid for 336 hours are presented in Figure 6. In the curve, it could be observed that the sample with highest concentration is significantly lower than those of the other samples. It recorded 80.27% at 336 hrs.

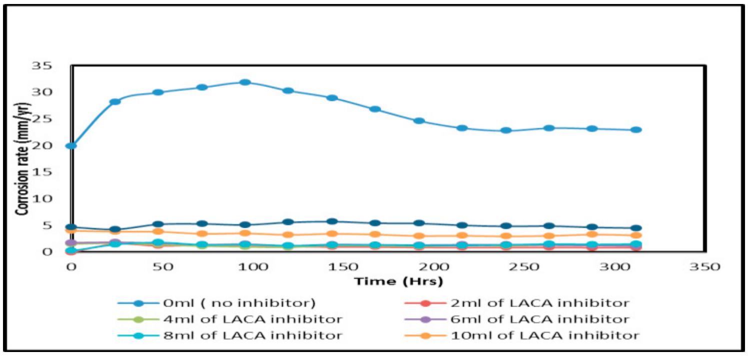

Figure 5: Curves of corrosion rate with time for steel specimen immersed in 0.5M H_2SO_4 + different concentrations of mixed lavender/castor oils (LACA) inhibitor addition

The inhibition efficiency values of samples with inhibitor concentrations of 2ml, 4ml, and 6ml/200 ml H_2SO_4 remained generally constant from the onset and had inhibition efficiency of 96.35%,93.90% and 94.95% respectively. The sample with the lowest concentration of LACA inhibitor addition gave the most effective corrosion inhibition; the test electrode with the highest concentration of LACA inhibitor was the least effective.

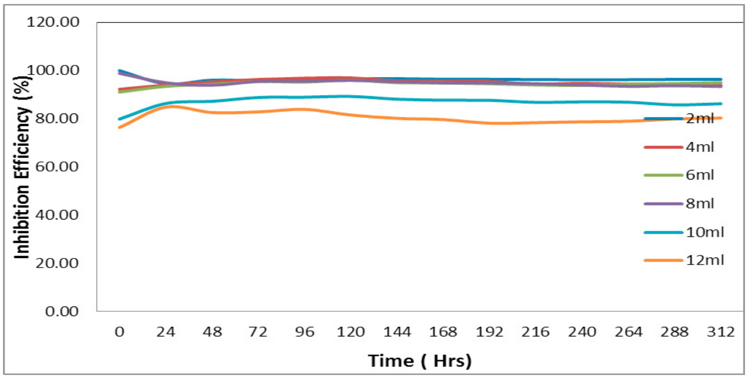

Figure 6: Curves of inhibition efficiency with time for specimen immersed in 0.5M H_2SO_4 + different concentrations of mixed lavender/castor oils

Potentiodynamic polarisation

Figure 10 shows the polarization in 0.5M H_2SO_4. The obtained corrosion rate was 4.57mm/y in the test without added inhibitor. In addition, the inhibitor with the lowest concentration recorded 0.83mm/y. These results correspond with the inhibition efficiency which is above 90% for all the inhibitor concentrations.

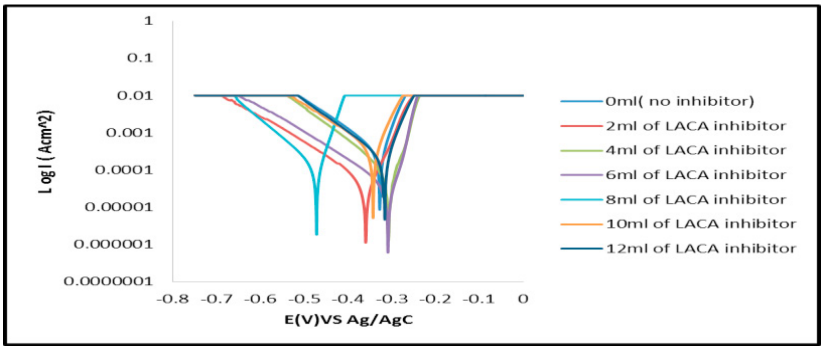

Figure 7: Corrosion polarization of mild steel in H_2SO_4 with and without added inhibitor concentrationsIt could be

observed that the corrosion current of the sample without inhibitor was 2.63E-3A but this reduced significantly with the lowest inhibition concentration which gave a value of 4.80E-4 and decreased slowly until the sample F (10 ml /200 ml H_2SO_4) where it increased to a value of 5.00E-4 before it started to decrease. Results with the HCl was in reverse with the H_2SO_4.

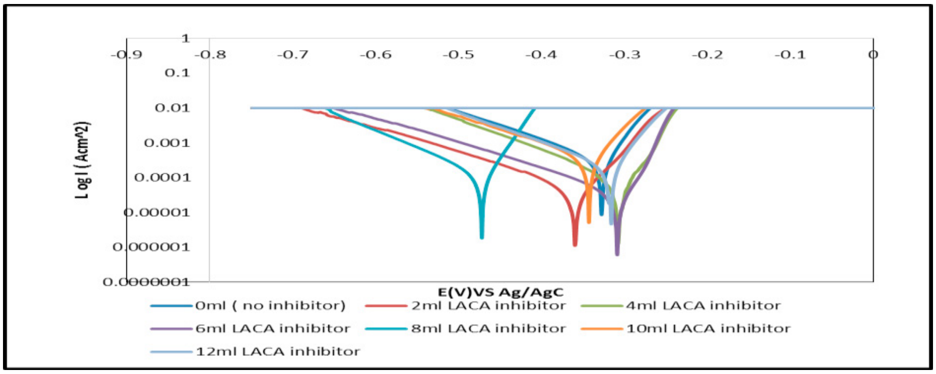

Figure 8: Polarization curves for specimen immersed in HCl with and without added inhibitor concentrations

Conclusions

Mixed *Lavandula and* Ricinus communis oils acted as good inhibitor in the acidic media (H_2SO_4 and HCl). At a concentration of 2ml/ 200 ml H_2SO_4 at 336 hours, it gave 96.35% inhibition efficiency (IE). It also gave 88% inhibition efficiency with a concentration of 12ml/200ml HCl at the same period. With the H_2SO_4, a concentration of 2ml/ 200 ml H_2SO_4 of the inhibitor performed better than the 12ml's after 336 hours. However, with the HCL, a concentration of 12ml/200ml HCl of the inhibitor performed better than 2ml/200ml HCl at 336 hours.

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