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Green corrosion inhibition performance of orange leaves extract on mild steel sheet buried in an acidified soil

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Abstract

The green corrosion inhibition of buried low-carbon steel (LCS) in 1M HCl using orange leaves extract (OLE) as inhibitor has successfully been carried out. Weight loss measurement, was used to determine the corrosion behaviour of the mild steel in the composed medium. The weight loss tests were carried out at room temperature and inhibitor concentration of 0.5 to 2.5g/L over a time interval of 25 to 125 h. Results show that OLE is a good corrosion inhibitor of LCS steel in acidic medium. Over the time interval of study, the inhibition efficiency of the OLE increased with increase in inhibitor concentration. The highest inhibition efficiency obtained was 86.57% at 2.5g/L extract concentration.

Keywords: Corrosion, orange leaves, inhibitor, low carbon steel, immersion time, corrosion

Introduction

Corrosion is the irreversible deterioration of metals by chemical attack. It occurs when metal interact with its environment causing it or its alloys to return to their unrefined natural forms as minerals and ores. Metals generally tend to corrode as they always prefer to return to the stable oxide form as a result of corrosion. Low carbon steel is one of the most important metals in existence and has a wild variety of industrial applications. However, it corrodes due to pH, oxidation-reduction potential, chloride, and sulfate contents in the acidified moisture in the environment. The Studies on LCS surface reactions in acidified moisture have been the subject of investigation due to areas of applications of LCS for durability in performance and in service. Typical situations abound where Synthetic inhibitors have been widely applied to protect metal surfaces against corrosion in the chemical industries, textile wet processing plants, marine, oil and gas industries.

Various studies have been carried out on the usage of plant extracts as an alternative inhibitor of corrosion. Plants extracts such as Rheum Ribes flower, Rubia tinctorum root, Hemigraphis colorata leaves, Passiflora edulis Sims peels, Rheum ribes leaf, Camellia chrysantha flower, Chromolaena Odorata leaf, garlic, Dysphania ambrosioïdes leaf, rice straw, Etlingera Elatior inflorescence, Pulicaria undulate, Vicia Sativa weed aerial, Malpighia glabra leaf, Cnicus Benedictus weed, Eruca sativa seed, Irvingia gabonensis and wombolu [1-18] have been explored and established as potential inhibitors for mitigation corrosion. In this present research, the inhibition performance of orange leaves extract on low carbon steel buried in an acidified soil was investigated.

Experimental procedure

1. Preparation of steel sheet coupons

Low-carbon steel was sourced from new site mechanical workshop in Nsukka, Enugu State, Nigeria. The low- carbon steel sheet samples 3.0 x 2.0 x 4 mm were cut from large sheet as coupons. Holes of about 0.1cm dimension were drilled at one end to enable tying up the coupons with nylon thread. The coupons were mechanically polished with series of emery papers of variable grades starting with coarse and proceeding to the finest (320) grade. These polished coupons were washed with distilled water and dried in acetone and weighed. The weighed coupons were then used for analyses.

2. Preparation of the inhibitor extract

The fresh orange leaves were obtained from local garden in Amokwe in Nsukka Local Government Area, Enugu State, Nigeria. Fresh orange leaves were washed with distilled water, dried at room temperature (27^{0}C) for 14days and ground to powder. The OLE powder was taken to Divine Chemical and Analytical laboratory Nsukka for extraction. 1000g of the sample was placed in the thimble, which is placed inside the soxhlet extractor and 250ml of analytical ethanol was poured into the round bottom flask, which was attached to a soxhlet extractor and condenser on an isomantle. The side arm is lagged with glass wool. The solvent was heated at 60^{0}C for 3hrs. As the ethanol vapour reached the condenser through the side arm of the soxhlet extractor, it condensed and dropped back into sample in the thimble; the ethanol soluble substance dissolved and was siphoned back into the flask. The extraction continued for 4 hours. The flask with the extract was disconnected and heated at 40^{0}C for 4 hours until almost all the ethanol evaporated to form a gel, cooled in desiccators and weighed. Total 0f 33g of gel was obtained.

3. Collection of soil

Soil sample was collected from Ngwo in Udi local government area in Enugu State using composite sample method, the soil was taken from the depth of about 1 meter below ground level. The soil collected was crushed to uniform size, sieved, and mixed with 1 M HCl solution. The initial pH value of the soil before mixing was 7.2. Soil pH value after acid treatment in 1M HCl is 5.9

4. Weight loss method

Coupons of dimensions 3.0 x 2.0 x 4 mm with composition P-0.35wt%, Si-0.27 wt%, C-0.20 wt%, Cu-0.30 wt%, S-0.35 wt%, and Mn-0.65 wt% were used for this experimental study. The iron constituent makes up the composition to 100%. The weight loss measurements were obtained by recording the weight losses of LCS coupons submerged in 1M HCl in the presence and absence of inhibitor. The inhibitor concentrations were varied from (0.5-2.5g/L) and immersion times were 25, 50, 75, 100 and 125 h. For each experiment, the coupon was weighed before it was buried in the acidified soil. The buried sample was removed, washed, dried and reweighed (M_2). The difference in weigh was determined using an electronic weighing balance (M411L). The corrosion rate and inhibition efficiency were calculated using equations 1 and 2.

$$Cr = \frac{8.76 \times 10^4 (W_1 - W_{11})}{ypt} \quad (1)$$

Where Cr is the corrosion rate (in mm/yr), W_i-W_{ii} is the change in weight of the sample before and after immersion (in gram), y is the surface area of the specimen (in mm^2), t is the immersion time (in h), and ρ is the density of the sample (in g/mm^3).

$$\varepsilon\ (\%) = \frac{Cr_o - Cr_i}{Cr_o}\ x\ 100 \quad (2)$$

Where ε is the inhibition efficiency, Cr_o is the corrosion rate without extract addition, Cr_i is the corrosion rate with extract addition.

Results and discussion

The soil resistivity is a soil characteristic that is dependent on the moisture content, concentration of dissolved organic matter, degree of compactness temperature etc. From the soil resistivity test, performed under standard conditions, the resistivity value of the soil sample was 15, 000 Ω.cm. From the experiment, the resistivity of the soil sample shows that it is mildly corrosive (MiC) due to the appreciable moisture content and organic matter present in the soil (see Table 1). The resistivity of the soil value is vital in the soil analysis and has been proven over the years by scientists to be in inverse variation with the corrosive nature of the soil.

The effect of inhibitor concentrations on corrosion rate and inhibition efficiency are shown in Figures 1 and 2. It could be ascertained that at various concentrations of orange leaves extract, the corrosion rate decreased while the inhibition efficiency increases with immersion time. This could be attributed to increase in adsorption of the surface active groups of the inhibitor on the LCS. In 25 h of exposure, the inhibition efficiency of the OLE was only 23.71%, 40.18%, and 50.00% for inhibition concentration of 0.5g/L, 1.0g/L and 2.5g/L in 1M HCl while at a time of 125 h, the inhibition efficiency increased to 62.07%, 75.36% and 86.54% for the same inhibitor concentrations. In Figure 1, it is observed that in the absence of inhibitor, the corrosion rate increased without but decreased with increased inhibitor concentrations, indicating the effective inhibition performance of OLE.

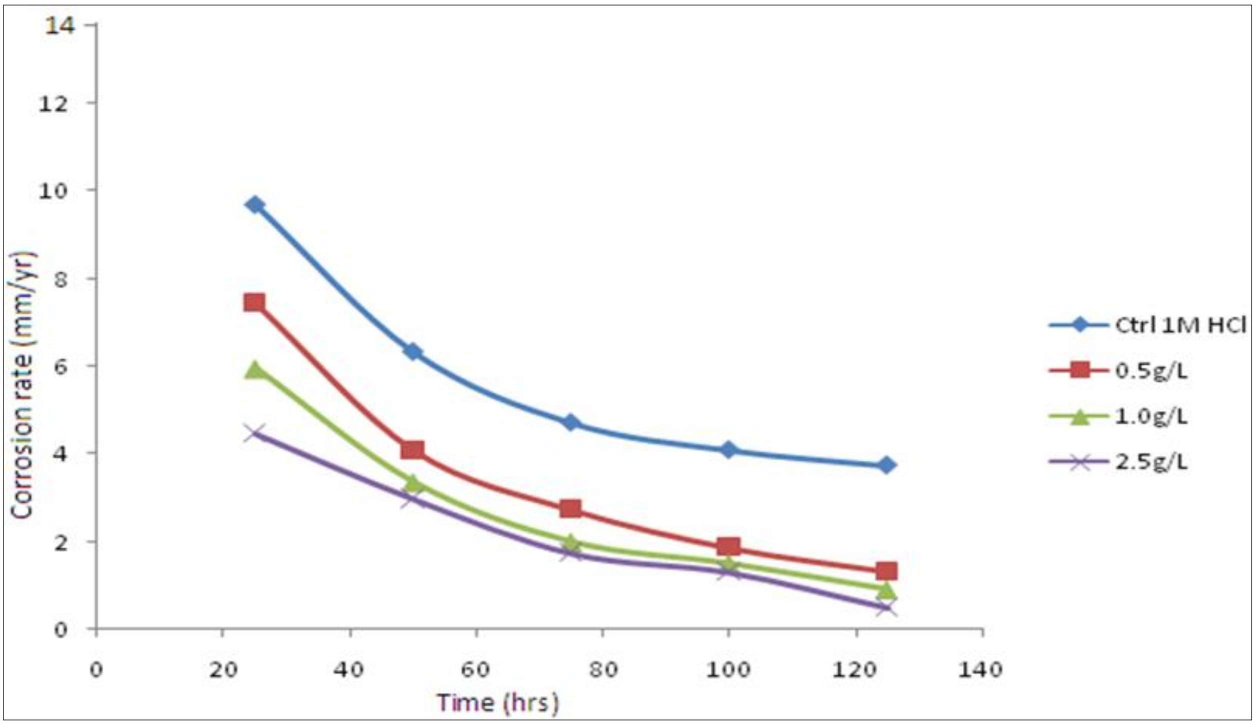

Fig 1: Effect of inhibitor concentration on corrosion rate of LCS in 1M HCl

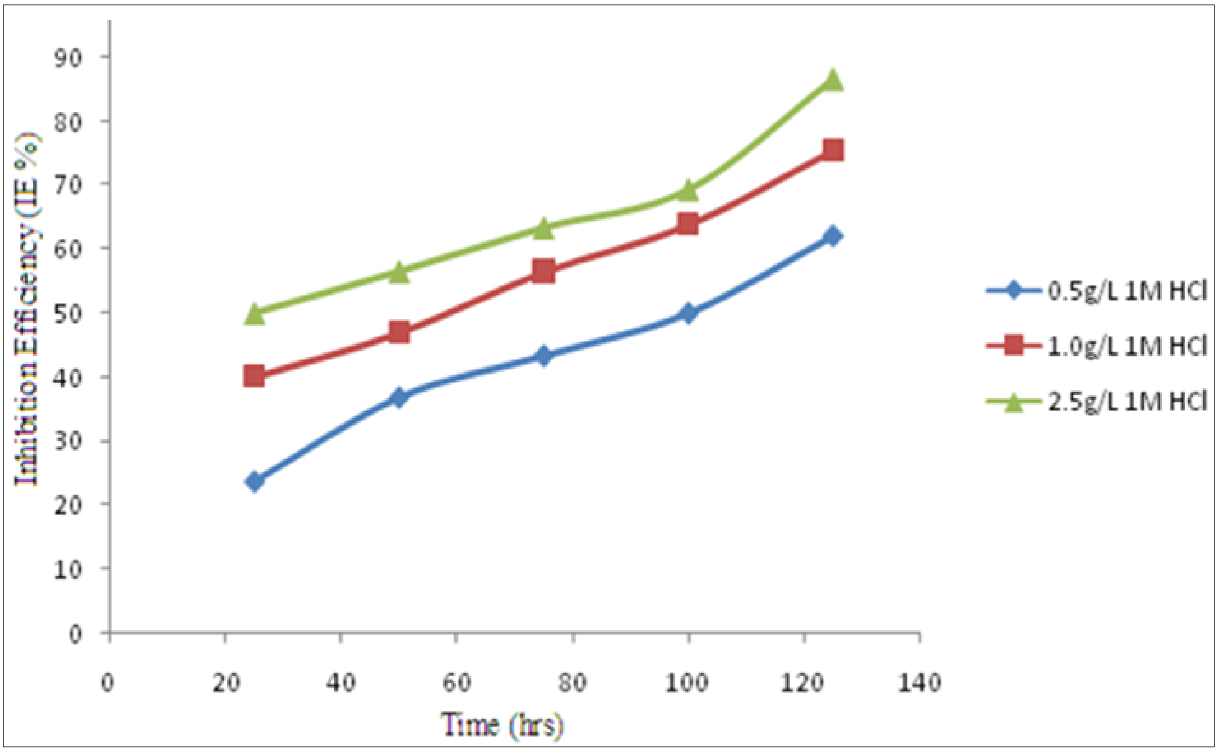

Fig 2: Effect of inhibitor concentration on inhibition efficiency (I.E%) of OLE in 1M HCl

Conclusion

From the results of this study, the following conclusion could be drawn.

1. Soil collected from Ngwo has moisture content of 37.05%, pH 7.2, soil resistivity of 15000 Ω.cm, ORP of 250mV, sulfate content of 170ppm and chloride content of 80ppm which generally would be "mildly corrosive" to the buried LCS used for underground structures like petroleum tanks.
2. The inhibition efficiency increased while corrosion rate decreased with increase in extract concentrations for buried LCS used for underground structures like petroleum tanks. OLE is good corrosion inhibitors for buried LCS in acidic soil.
3. It was observed that even at a very low concentration of OLE, it can be effectively used as inhibitor for LCS corrosion in HCl.

Conflict of interests

The authors declared no conflict of interests

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