Adsorption and Inhibitive Properties of Ethanol Extracts of *Muntingia Calabura* as a Green Corrosion Inhibitor for Mild Steel in Acidic Media

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Abstract: The inhibitive effect of the ethanol extract of the mixture of leaves, fruits and twigs of *Muntingia calabura* (EEMC) on mild steel corrosion in 1M HCl and 1M H₂SO₄ solutions was studied by using weight loss method at room temperature. The results demonstrate that EEMC suppressed the corrosion reaction in both acid media and inhibition efficiency increased with EEMC concentration with slightly higher values obtained in 1 N H₂SO₄. The adsorption of this EEMC in both acids on the mild steel surface obeyed the Langmuir adsorption isotherm. Frumkin isotherm is best applicable in inhibitor with H₂SO₄. The addition of halide ions to the EEMC enhanced the inhibition efficiency due to synergistic effect.

Key words: *Muntingia calabura*, mild steel, Adsorption, corrosion inhibition, Synergism.

INTRODUCTION

The use of inhibitors is one of the best options for protecting metals against corrosion. Several inhibitors in use are either synthesized from cheap raw material or chosen from compounds having hetero-atoms in their aromatic or long chain carbon system. However, most of these inhibitors are toxic to the environment. This has prompted the search for green corrosion inhibitors.

Green corrosion inhibitors are biodegradable and do not contain heavy metals or other toxic compounds. The successful use of naturally occurring substances to inhibit the corrosion of metals in acidic and alkaline environment have been reported by some research groups[1-7]. The present study seeks to investigate the inhibitive properties of the EEMC on mild steel corrosion using weight loss technique.

2. Experimental:

2.1. Extraction of Plant: Samples of the EEMC was dried, grounded and soaked in a solution of ethanol for 48 h. After 48 h, the samples were cooled and filtered. The filtrates were further subjected to evaporation at 50°C in order to leave the sample free of ethanol. This was the stock solution of the extract.

2.2. Material Preparation: Materials used for the study were mild steel sheet of composition (wt percent) C (0.084), Mn (0.369), Se (0.129), P (0.025), Ni (0.013) and the rest Fe. The sheet was mechanically pressed cut to form different plates, each of dimension 2.5 x 5cm². Each plate was degreased by washing with ethanol, dried in acetone and preserved in desiccators. All reagents used for the study were of analar grade and double distilled water was used for their preparation.

2.3. Corrosion Weight Loss Tests: Weight loss measurements were performed on rectangular iron specimens of size 2.5 x 5cm². After polishing successively by different grades of emery paper (400-1200), the samples were immersed for 2 hours in 60ml of 1M H₂SO₄ and HCl solution with and without addition of the plant extract at room temperature in the air without bubbling. Afterwards, the samples were removed from the test solution and washed with distilled water to remove the corrosion products. The corrosion rate, inhibition efficiency (percentage), and degree of surface coverage (θ), were calculated using equations 1, 2 and 3 respectively.

\[
\text{Corrosion rate (mpy)} = \frac{(87.6 \times W)}{D \times A \times T} \quad (1)
\]

\[
\text{Inhibition efficiency (\%)} = \left(\frac{W_0 - W_e}{W_0}\right) \times 100 \quad (2)
\]

\[
\text{Degree of surface coverage (θ)} = \left(\frac{W_0 - W_e}{W_0}\right) \quad (3)
\]

Where W is the weight loss in mg, D is the density in g/ml, A is the area of exposure in cm², T is the time in hours, W₀ and Wₑ were the weight loss without and with inhibitors.

RESULTS AND DISCUSSION

3.1. Effect of Concentration: Figure 1 shows the values of corrosion rate on mild steel, increases with increase in acids concentration and decrease with increase in concentration of EEMC. This is because
inhibitor molecules adsorbed on the surface in the form of neutral molecules through a chemisorptions mechanism were involved in the displacement of water molecules from the metal surface. So, EEMC functions as a good corrosion inhibitor.

3.2. Effect of Time: Figure 2 shows the variation of the corrosion rate in the corrosion coupon exposed to acids and the differently inhibited acid media with time. The corrosion rate in the exposed coupons increased with time in uninhibited acids and decreased with time in inhibited acids, the increase in corrosion rate could be adduced to the loss of electrons from the coupon. Observation during the experiment showed that the uninhibited acid solution showed progressive colour change from transparent solution to brownish solution due to the release of various forms of corrosion products suspected to be Fe₂O₃, Fe₂O₄ and Fe(OH)₃ that were formed on the surface of the corroded surface.

3.3. Synergistic Effect: Figure 3 shows that the additions of halides of potassium increase the corrosion inhibition efficiency. The increase in inhibition efficiency indicates that a higher surface coverage was obtained in a solution with the optimum concentration of inhibitor due to the adsorption of the inhibitor and halides of potassium salts on the metal surface. This suggests a synergic effect between corrosion inhibitor and halides of potassium salts in the order Cl<Br<I.

3.4. Adsorption Isotherm: Langmuir and Frumkin equation were employed to study the adsorption isotherms. Langmuir isotherm is an ideal isotherm for physical or chemical adsorption where there is no interaction between the adsorbate and the adsorbent. Assumptions of Langumir relate the concentration of the adsorbate in the bulk of the electrolyte(C) to the degree of the surface coverage (θ) according to equation

\[ \log \left( \frac{C}{\theta} \right) = \log C - \log K \]

The Langumir plots of adsorption are shown in Fig.4 for the extract adsorption from 1M HCl (R² = 0.9987) and 1M H₂SO₄ (0.0645). Applicability of Langumir adsorption isotherm (slope values are unity) to the adsorption of EEMC on mild steel confirms the formation of multimolecular layer of adsorption where there is no interaction between the adsorbate and the adsorbent.

Frumkin isotherm equation is obeyed when a plot of \( \log \left( \frac{\theta}{1-\theta} \right) \) versus \( \theta \) produces a straight line with slope equal to 2α / 2.303.

\[ \log \left( \frac{\theta}{1-\theta} \right) [C] = \log K + \frac{2\alpha}{2.303} \theta \]

Where α is lateral interaction term describing the molecular interaction in the adsorbed layer, K is the desorption –adsorption equilibrium constant and C is the concentration of the inhibitor. Fig.5a and Fig.5b shows Frumkin plots for the used inhibitor in HCl and H₂SO₄. Values of α calculated from the slope of line on the plot are-1.9124(HCl) and 3.9977(H₂SO₄) respectively, indicating that Frumkin isotherm is best applicable in inhibitor with H₂SO₄.

Conclusions: From the present study, it is found that the ethanol extract of the mixture of leafs, fruits and twigs of Muntingia calabura (EEMC) can be used as an inhibitor of mild steel corrosion. The inhibitor acts by being adsorbed on mild steel surface according to classical adsorption models of Langmuir and Frumkin adsorption isotherms. It is found that the inhibitive
Fig. 2: Variation of corrosion rate with exposure time

Fig. 3: Synergetic effect between inhibitor and potassium halides.

Fig. 4: Langmuir isotherm for adsorption of EEMC on the surface of mild steel.
Fig. 5a: Frumkin isotherm for adsorption of EEMC on the surface of mild steel.

Fig. 5b: Frumkin isotherm for adsorption of EEMC on the surface of mild steel.
action of the ethanol extract of the mixture of leaves, fruits and twigs of *Muntingia calabura* (EEMC) is basically controlled by concentration of acid and inhibitor. The plant extract have synergic effect with potassium halides.

**REFERENCES**