

Aspilia Africana extracts as organic corrosion inhibitor of mild steel in corrosive acidic media.

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Abstract: Extracts of *Aspilia Africana* as organic corrosion inhibitor of mild steel in corrosive media of sulphuric acid (H_2SO_4) and hydrochloric acid (HCl) has been investigated at room temperature of 25.6 °C using gravimetric (weight loss) technique. Mild steel coupons of 30 mm² and 0.45 mm thickness were exposed for varying durations in steps of 24 hours, in 0.5M of H_2SO_4 and 0.5M HCl mixed with varying concentrations of *Aspilia Africana* extract (100mg/L-700mg/L). The results show that corrosion rates dropped from maximum value of 8.3×10^{-3} mpy (mills per year) for the uninhibited medium to maximum value of 1.5×10^{-3} mpy for the inhibited medium of 0.5M H_2SO_4 with extract concentration of 100 mg/L. Corresponding values for 0.5M HCl are 10.0×10^{-3} to 2.5×10^{-3} mpy. Further increases in the extract concentrations result in less drastic decrease in the corrosion rate as reported in this paper. Values of corrosion inhibition efficiencies of 58.5-98.8% for H_2SO_4 and 70-90.9% for HCl media occurred for various extract concentrations with the highest values occurring at 600mg/L. Thus, *Aspilia Africana* extracts whose plants are bountiful in the tropical forests of West, East and Central Africa, provide good corrosion inhibition for mild steel.

Keywords: *Aspilia Africana* extract, corrosion inhibition, gravimetric technique, inhibition efficiencies.

I. Introduction

Corrosion of metals involves anodic and or cathodic reactions [1] with reverse economic, environmental and safety consequences. The use of inhibitors is one of the most practical ways of protecting metals from corrosion, especially in acidic media [2]. The wide use of acid solutions in industries for acid pickling of steel, chemical cleaning and processing, ore production and oil well acidizing among others, are corrosion prone processes. Synthesized commercial corrosion inhibitors in use, such as chromates, silicates and organic amines, are expensive, toxic and non environmental friendly. This has led to continued search for low cost and effective inhibitors with low or zero environmental impact.

Plant extracts which are low-cost and biodegradable have therefore been the focus of intense research on corrosion inhibitors for some decades due to their economic and environmental benefits. As early as 1930, plant extracts (dried stems, leaves and seeds) of *Chelidonium majus* were used as corrosion inhibitors for steel in H_2SO_4 pickling baths [1]. By 1972 studies of the extract of *Hibiscus subdariffa* (Karkode) as the corrosion inhibitor for Al and Zn in HCl and NaOH solutions had been carried out. In 1980s [3,4] reported the inhibition effect of some plant leaves (*Opuntia*, *Aleo eru*) and fruit peels (orange, mango) on the corrosion of steel, aluminum, zinc and copper in acids and aluminum in NaOH solution. Also, [5,6] reported *Azadirachta* and *Vernonia amygdalina* (bitter leaf) leaves extracts as good corrosion inhibitors for steel in HCl and H_2SO_4 solutions.

By 21st century, a large volume of literature was available about plant leaves extracts as effective corrosion inhibitors of iron or steel in acidic media. Some of the studied plants include *henna* [7-10] *Nype fruticans* Wurumb [11,12] *Azadirachta Indica* [13] *Acalypha Indica* [14] *Zenthoxylum alatum* [15,16] among others. Through these studies, it was established that the inhibition performance of plant extracts is normally ascribed to the presence in their composition of complex organic species such as tannins, alkaloids and nitrogen bases, amino acids and proteins as well as hydrolysis products. These organic compounds contain polar functions with N, S, O atoms as well as conjugated double bonds or atomic rings in their molecular structures which are the major adsorption centers. However, given the vast varieties of plants, the data regarding the use of plant leave extracts as corrosion inhibitors are still limited. In this work, *Aspilia Africana* (African Merrygold) leaf extract has been investigated as corrosion inhibitor with a focus on the corrosion characteristics of low-carbon mild steel in HCL and H_2SO_4 media with and without the inhibitor.

II. Experimental Details

2.1 Materials

The materials used in this study of corrosion inhibition of mild steel include sulphuric acid (H_2SO_4), hydrochloric acid (HCl), ethanol, concentrated Nitric acid, distilled water, beakers, measuring cylinder, electronic weighing balance, venier caliper, micrometer screw gauge, wooden stick, reflux apparatus, heating mantle, water bath, grinding stone, abrasive papers, thread, masking tape and emery papers

Aspilia Africana extracts as corrosion inhibitor of varying concentrations ranging from 100mg/L to 700mg/L were also used, while the corrosive media consist of 0.5M H₂SO₄ and 0.5M HCl. Sheet of mild steel was obtained from Universal Steel Company Limited, Lagos, Nigeria.

2.2 Preparation of mild steel coupons

The sheet of mild steel was cut into coupons of 30mm × 30mm with thickness of 0.45mm. A hole of uniform diameter of 3mm was drilled in each coupon to facilitate its suspension in the test solution. The coupons were mechanically cleaned followed by polishing with emery paper to expose shining polished surface. To remove any oil and organic impurities the coupons were degreased with ethanol and finally washed with distilled water, dried in air and then stored in a desiccator. Accurate weight of each coupon was taken using electronic balance and recorded as initial weight W_i. The coupons were labeled in a manner to avoid any mix up.

2.3 Determination of corrosion rate

Weight loss technique was employed in the experiment as follows. Each coupon was weighed using digital weighing balance and recorded as weight W_i. Then 200ml of a corrosive medium was introduced into reaction beakers. The pre-weighed coupons were fully immersed into each of the test media using twine tied to a small stick for support. The experimental set-up was kept in a cool place in the laboratory away from direct sunlight, while the time of exposure for each coupon was carefully noted. Each coupon was retrieved from the test medium in intervals of 24 hours and visual observation was carried out on each coupon retrieved from the solution.

The corroded coupons were washed under running water dipped in ethanol and acetone and then air-dried. The coupons were reweighed and the final weights, W_f recorded. Weight losses, ΔW = W_i - W_f were calculated. The above process was carried out for *Aspilia Africana* concentrations of 100mg/L, 200mg/L, 300mg/L, 400mg/L, 500mg/L, 600mg/L and 700mg/L in the two media of 0.5M H₂SO₄ and 0.5M HCl. The corrosion rate may be expressed as an increase in corrosion depth per unit time and the corrosion rate equation 1, in mpy is given by :

$$CR = K\Delta W/\rho At \quad (1)$$

where K = constant for unit conversion

ΔW = weight loss of coupon

P = density of coupon

A = area of coupon

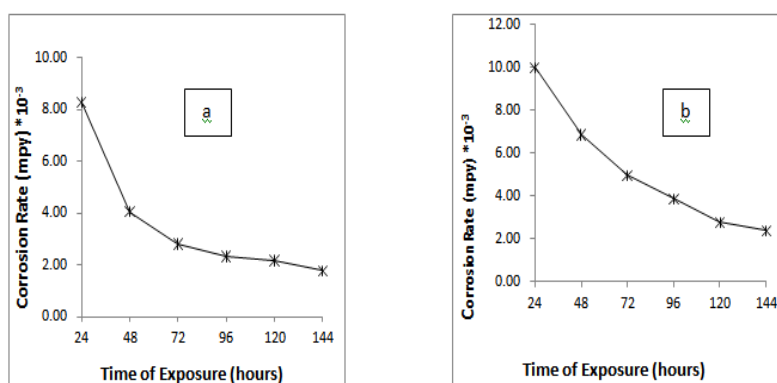


Fig. 1: Corrosion rate values of mild steel in (a) 0.5M H₂SO₄ and (b) 0.5M HCl for uninhibited corroded coupons

III. Results and Discussions

Figure 1(a) shows that the corrosion rate of mild steel in uninhibited 0.5M H₂SO₄ decreased significantly till the 72nd hour of exposure and the decrease then tends to be exponential up to 144 hours of exposure and beyond. Figure 1 (b) also shows great decline in the 0.5M HCl corrosion rate for uninhibited coupon of mild steel all through the entire hours of exposure. The rate of deterioration was consistent with the hour of exposure. For both acid media, the corrosion rate reduced significantly as the hour of exposure increased and this could be that the metal developed passivity in addition to the effects of layers of corroded metal.

Figures 2 (a) and (b) show the corrosion rates in 0.5M H₂SO₄ and 0.5M HCl for various concentrations of *Aspilia Africana*. With extract concentration of only 100mg/L the corrosion rate in 0.5M H₂SO₄ decreased to 1.5 × 10⁻³ mpy in the first 24 hours from 8.3 × 10⁻³ mpy for the uninhibited case. Also, minimum value of about 0.2 × 10⁻³ mpy occurred for extract concentration of 600mg/L in the first 24 hours. The corresponding values for 0.5M HCl as shown in fig.2 (b) are 2.5 × 10⁻³ mpy for the first 24 hours of 100 mg/L of extract concentration and a minimum value of about 0.8 × 10⁻³ mpy occurring for concentration of 600 mg/L after 72 hours.

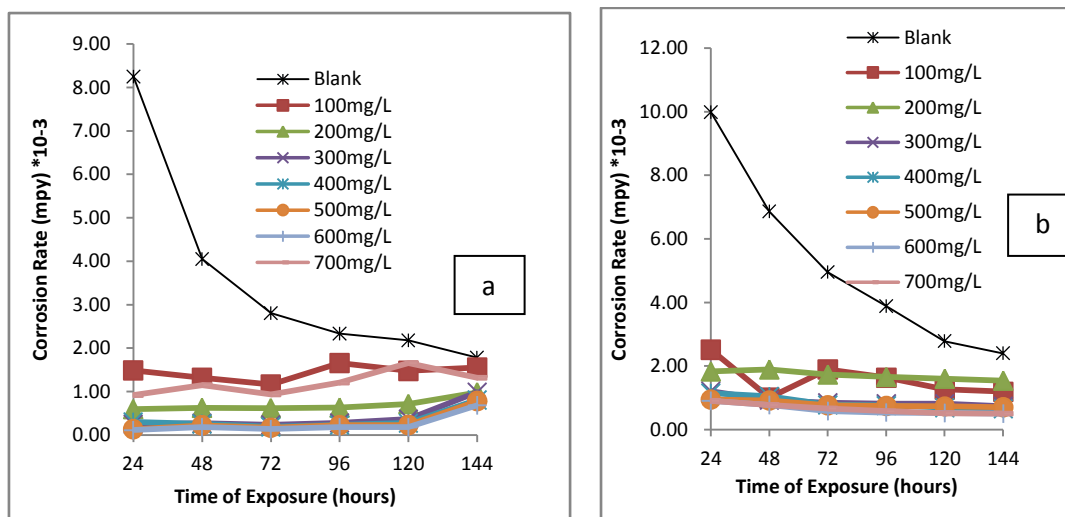
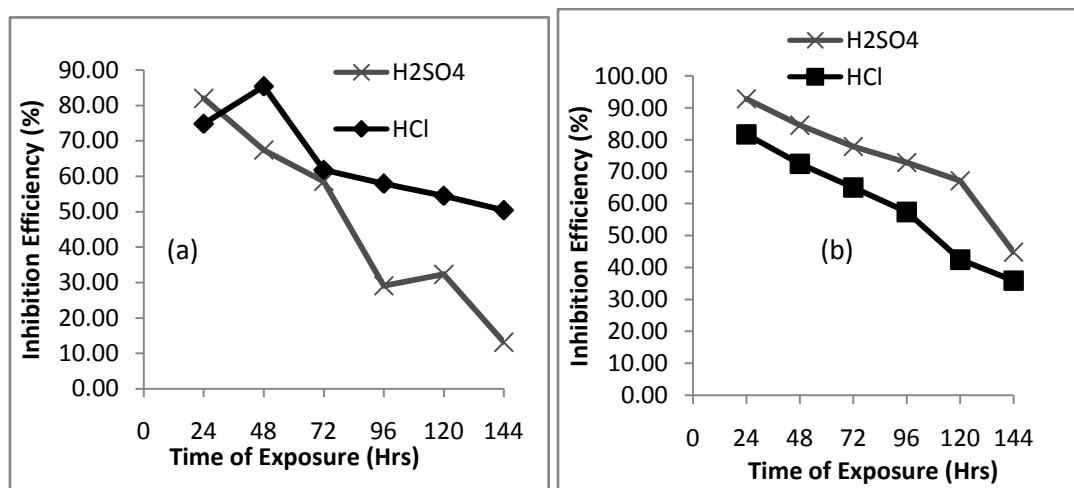


Fig 2: Variation with time of the corrosion rate of mild steel in (a) 0.5M H₂SO₄ (b) 0.5M HCl for various concentrations of *Aspilia africana* extract

Figures 3: (a),(b), (c) and (d) and fig. 4: (a), (b) and (c) show the inhibition efficiencies for various concentrations of *Aspilia Africana* extract in the two acid media at different exposure time for mild steel. Here, the efficiencies are given by the percentage ratio of the inhibited over the uninhibited corrosion rates for each extract concentration in the two acid media. [5] reported that a mixture of nitrogen and sulphur containing compounds are better inhibitors than either type alone. The extracts of *Aspilia Africana* investigated contain both nitrogen and sulphur atoms, hence, exhibit good performance on the corrosion of mild steel in both H₂SO₄ and HCl media.

The highest inhibition efficiencies of 98.8% for H₂SO₄ was obtained at extract concentration of 600 mg/L after 24 hours of exposure while that of HCl was 90.9% at the same concentration of 600 mg/L after 24 hours of exposure.



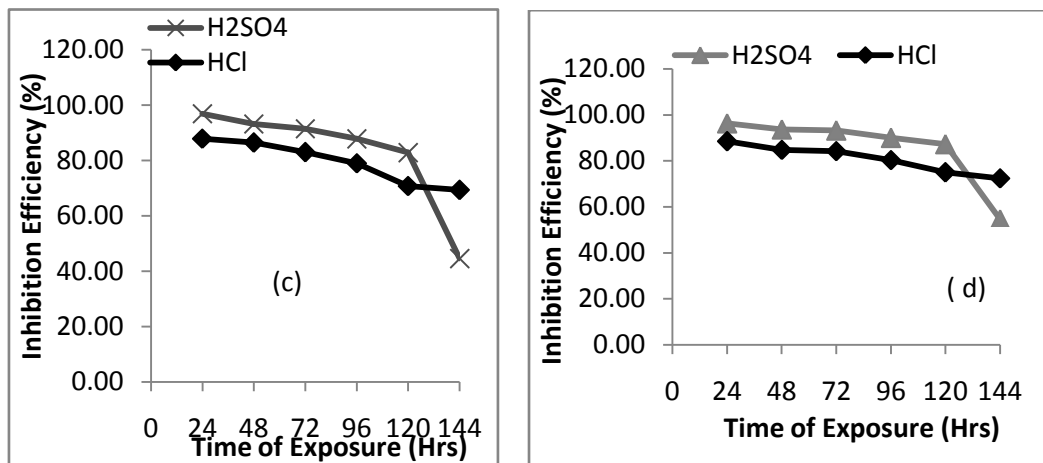


Fig. 3: Variation with time of inhibition efficiency in 0.5M H₂SO₄ and 0.5M HCl media for *Aspilia Africana* extract of different concentrations (a) 100 mg/L (b) 200mg/L (c) 300 mg/L and (d) 400 mg/L.

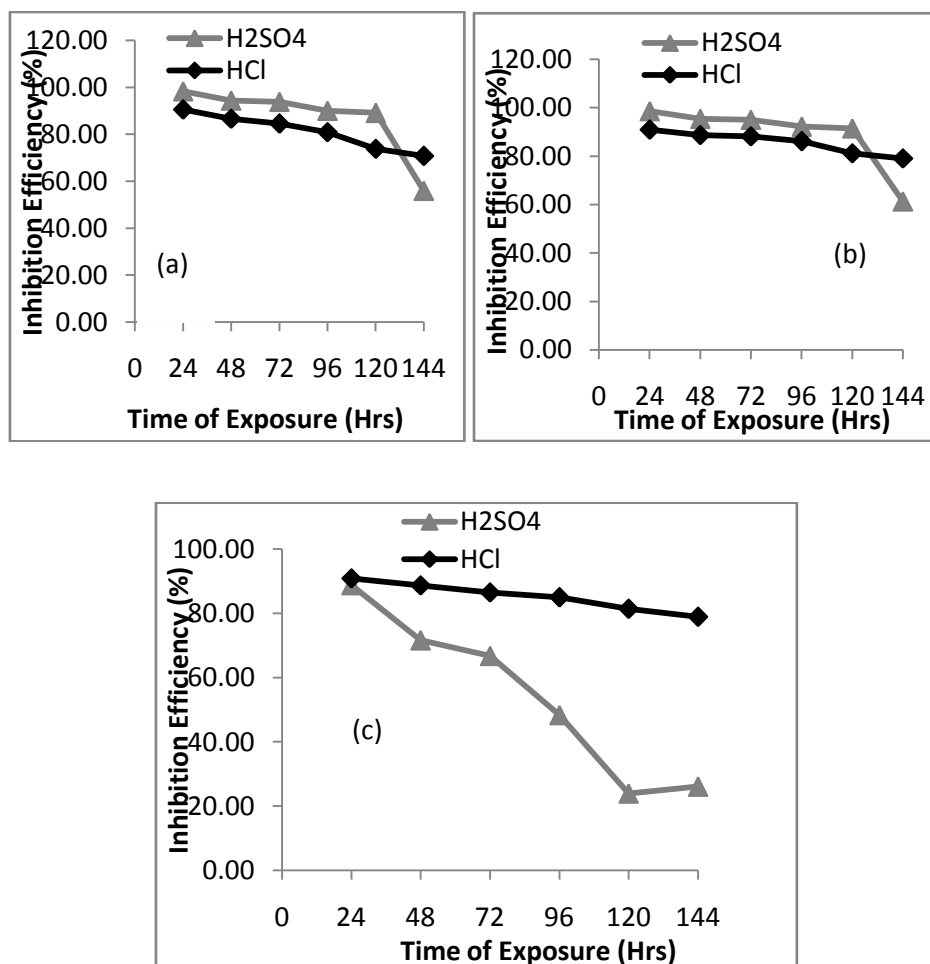


Fig. 4: Variation with time of inhibition efficiency in 0.5M H₂SO₄ and 0.5M HCl media for *Aspilia Africana* extract of different concentrations (a) 500 mg/L (b) 600mg/L (c) 700 mg/L and (c) 700 mg/L.

IV. CONCLUSION

The inhibitive effect of *Aspilia Africana* extract on the corrosion rate of mild steel at room temperature has been determined through gravimetric technique. It was found that extract of *Aspilia Africana* with as low concentration as 100 mg/L produced remarkable decrease in the corrosion rate of mild steel in both 0.5M H₂SO₄ and 0.5M HCl. Higher concentrations of *Aspilia Africana* yielded further inhibition of corrosion of mild steel in

acidic media. Corrosion efficiencies of 58.5-98.8% for H₂SO₄ and 70-90.9% for HCl were obtained. The results show that the greater the number of bonds in the extracts the higher the efficiency in the acidic media which occurs by means of hindering both cathodic and anodic processes.

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