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Manuscript Information of : Re16470529
Publish in Journal : Research & Reviews in ElectroChemistry
Manuscript Title : CORROSION INHIBITIVE EFFECT OF VERNONIA AMYGDALINA EXTRACT ON ALUMINIUM IN ACIDIC MEDIA
Submission Date : 5/5/2010
Corresponding Author : Kolawole Oluseyi Ajanaku
MS Type : Full Paper

Full Paper

Corrosion inhibitive effect of *Vernonia amygdalina* extract on aluminium in acidic media

Kolawole O.Ajanaku*[1], Oladele O.James[1], Tolutope O.Siyanbola[1], Ayorinde Falomo[1], Oluwakemi A.Adetoro[1], Oluwatosin M.John[2]
[1]Department of Chemistry, College of Science & Technology, Covenant University, Canaanland, Ota, (NIGERIA)
[2]Department of Chemistry, University of Lagos, Lagos, (NIGERIA)
E-mail : ajanakukolawole@gmail.com
Received: 5th May, 2010 ; Accepted: 15th May, 2010

ABSTRACT

The corrosion inhibition of aluminium in 0.5 M HCl by extract of *Vernonia amygdalina* was studied using the gravimetric (weight loss) method at 40°C temperature. The result revealed that the extract of *V. amygdalina* inhibited the corrosion process of aluminium in the HCl solution. The percentage inhibition efficiency (% I.E.) study of the process increased with inhibitors concentration implying that adsorption of the species in the extract is responsible for the inhibition behavoiur of aluminium in the *V. amygdalina* extract at 40°C. The surface coverage study obeyed Langmuir's adsorption isotherm, which suggest that there is no interaction between the molecules adsorbed at the metal surface.

KEYWORDS

Hydrochloric acid;
Aluminium;
Corrosion inhibitor;
Vernonia amygdalina;
Inhibition efficiency.

INTRODUCTION

Corrosion is one of the major problems today; hence there is need for use of inhibitors to reduce the corrosion rate of metals and alloys that is in contact with these aggressive environments. Corrosion protection by using inhibitors has been employed to many systems namely, cooling systems, refinery units, oil and gas produuction units, boiler etc.[1-3]. The use of inhibitors has now become one of the most practical methods of protecting metals against corrosion and it is becoming popular. Majority of these protecting materials are synthetic chemicals[4-6] which invariably becomes expensive and hazardous to the environment[7], hence the search for natural means of preventing corrosion becomes inevitable. It has been reported that natural products of plant origin has organic compound such as amino acids, tannins and alkaloid which have inhibitive effect as well[8-11]. The principle of inhibition is by adsorption of the phytochemical molecules in the plant on the surface of the metal resulting in the replacement of water molecule at the corroding surface[12,13].

Due to economic importance of aluminium and its alloys, its protection against corrosion has attracted much attention[14,15]. Recent work reported succesful uses of extrudate gum extract from natural plants as corrosion inhibitors of aluminium in alkaline media[16], hence it become evident that more are

yet to be done since there are lot of natural plants that possess organic compounds having inhibitive effect. *Vernonia amygdalina* which is popularly known as bitter leaf is a shrub of 2 – 5 m with petiolate leaf of about 6 mm diameter and elliptic shape. The leaves are green with a characteristic odour and bitter taste which can be abated by boiling or by soaking in several changes of clean water[17]. The bitter taste is due to anti-nutritional factors such as alkaloids, saponins, tannins and glycoside and the active ingredients of the plant have been shown to be mainly sesquiterpene lactones like vernodalin and vernoamygdalin and steroid glycosides[18]. There are reports about the inhibitive properties of *V. amygdalina* extract, which is able to inhibit and even reverse carbon tetrachloride-induced hepatotoxicity in rats[19]. The aim of this study therefore was primarily to examine and report on the inhibitive effect of *V. amygdalina* on the corrosion behaviour of aluminium in 0.5 M HCl solution.

EXPERIMENTAL

Material preparation

Pure aluminium metal of type AA 1100, 1xxx was obtained from Systems Metals Industries Cross River State, Nigeria. Each sheet of 1.8 mm in thickness was pressed cut into 3 cm by 1.5 cm coupons. The coupons were prepared by degreasing in absolute ethanol, dried in acetone and stored in a moisture-free desiccator before use in gravimetric (weight loss) corrosion studies.

Preparation of inhibitor extract

Fresh leaves of *V. amygdalina* were obtained from CRIN, Oyo State, Nigeria. The leaves were airdried and milled and the acidic extract of the leaves were prepared by weighing 0.5 g of the milled *V. amygdalina* in 250 ml round bottomed flask and was refluxed with 100 ml of 0.5M HCl solution for 2 hours. The resulting solution was left overnight before filtering and standard solutions of 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0 g/l concentrations were prepared and used for the study. The concentration of HCl used for the extraction was analytical grade concentrated HCl (BDH).

Weight loss determination

The weight loss measurements were carried out as described elsewhere[20] using a clean weighed aluminium coupon of 3 x 1.5 cm and maintained at 40°C thermostated water bath. The coupons were retrieved from their corrodent at intervals of 30 minutes progressively for 150 minutes, scrubbed with bristle brush in distilled water and then immersed in ethanol (specific gravity: 0.79) for 2 mins to remove the corrosion product, dried in acetone and weighed.

The percentage inhibition efficiency (% I.E.) and the parameter (θ) that represents the weight of the metal surface covered by inhibitor molecules were calculated using the following equations.

$$\% \text{ I.E.} = \frac{W_1 - W_2}{W_1} \times 100 \quad (1)$$

$$\theta = \frac{W_1 - W_2}{W_1} \quad (2)$$

where W_1 and W_2 are weight losses of aluminium in unhibited and inhibited solutions respectively.

RESULTS AND DISCUSSIONS

The variation of weight loss with time for inhibition of corrosion of aluminium in 0.5M HCl solution by *V. amygdalina* is shown in Figure 1. This revealed that aluminium corrodes in 0.5M HCl solution but the presence of inhibitor decreased the extent of the metal degradation. However, little weight loss was observed in the presence of inhibitor compared with that obtained

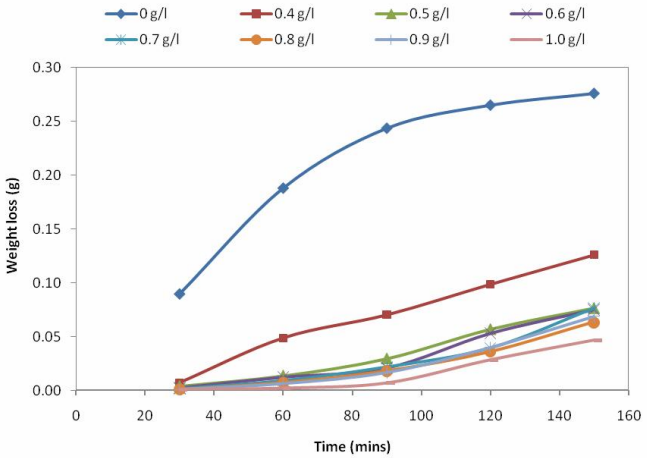

Figure 1 : Variation of weight loss with time by *Vernonia amygdalina* inhibition of aluminium in 0.5M HCl solution.

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with the corrodent without the inhibitor. This clearly revealed that the extract of *V. amygdalina* inhibit the corrosion of aluminium and can therefore serve as corrosion inhibitors for aluminium. The weight loss is generally observed to decrease with increasing additives concentration and this was obviously connected to the orientation kinetics of adsorbed molecules. The major reasons for this particular behavior of aluminium are that the surface may no longer adsorb after a particular concentration, and also that the inhibitor may have maximum performance concentration.

The variation of the weight loss with percentage inhibition efficiency (% I.E) at varying concentrations of the *V. amygdalina* extract is shown in Figure 2. The inhibition efficiency was observed to increase with increasing concentration of the acid extract of *V. amygdalina* which can be attributed to adsorption of the inhibitor on the aluminium surface. This observation followed the same pattern reported[22] for steel and aluminium in acidic media. The inhibitive action can be attributed to binding unto the cathodic sites on the metal surface and its corrosion inhibitive action increases with concentration. However, tannin containing plants extracts are reported to exhibit varying inhibition efficiency and inhibition mechanism[23]. The inhibition tendency of tannins extracts is a function of the molecular properties of its constituents. This also determines the molecular reactivity which as well is related to its adsorbability. This may in part account for the differences in the inhibition efficiencies and mechanisms reported for different tannins sources. For example, it has been observed that natural tannins extract from pine exhibit better corrosion inhibition and better adherence to metallic substrates than the tannins extracted from acacia[24].

There was a critical concentration that was observed from the extract of *V. amygdalina* in the inhibition of aluminium. This concentration was observed using 0.8 g/l in between 120-150 minutes (Figure 2). This phenomenon has been observed in other studies[21], in which it was reported that the inhibitive action of some plant extracts on the corrosion of metal in acidic media was found to increase with increasing concentration of the plant extract up to a critical concentration.

The effect of immersion time on the inhibition efficiency of *V. amygdalina* leaves is shown in Figure 3. The adsorption of the adsorbate on the surface of the electrode is regarded as substitution adsorption process between adsorbate in the aqueous phase and the water molecules adsorbed[25]. Several efforts were made in order to fit θ values to the Freundlich, Langmuir, Bockris-Swinkels and Temkin isotherms. The best fit was obtained using the Langmuir isotherm (Equations 3 and 4).

$$\frac{\theta}{\theta-1} = KC \qquad (3)$$

Rearrangment gives

$$\frac{C}{\theta} = \frac{1}{K} + C \qquad (4)$$

The plot of C/θ against C gives a straight line as it was observed in Figure 3. This means the adsorption of *V. amygdalina* on the aluminium sheet in 0.5 M HCl so-

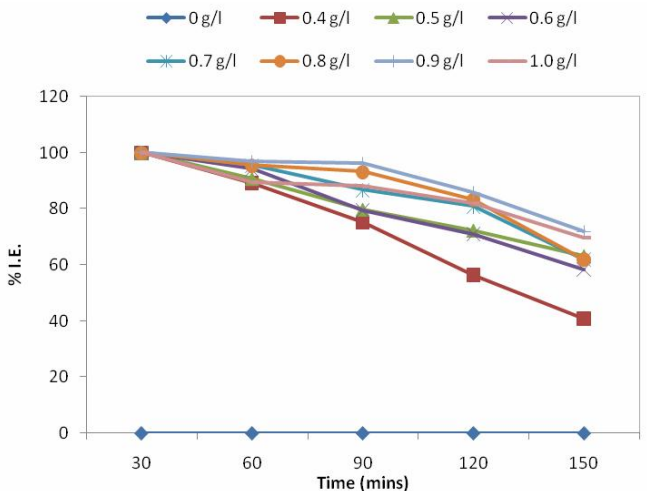

Figure 2 : Variation of inhibition efficiency (% I.E) by *Vernonia amygdalina* of aluminium at different exposure time in 0.5M HCl.

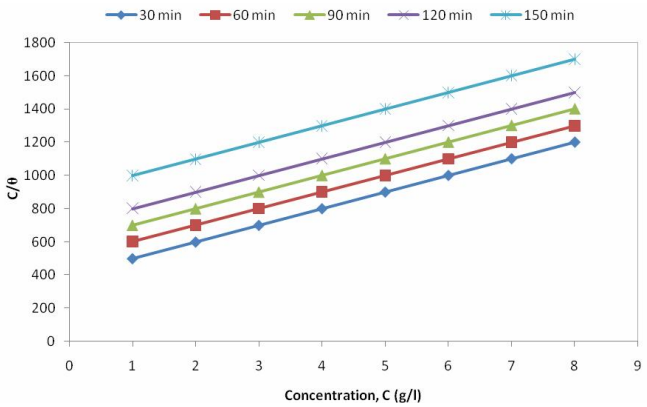

Figure 3 : Langmuir adsorption isotherm relationship between C and C/θ for using *Vernonia amygdalina* as inhibitor for aluminium at different exposure time in 0.5M HCl.

lution obeys Langmuir's adsorption isotherm principle which means there is no interaction between the molecules adsorbent at the surface of aluminium metal.

This also implies that the adsorbate was physically adsorbed on the aluminium coupons in order for the inhibition to be effective therefore a physical adsorption mechanism can be proposed and a multi-layer protective coverage is expected on the entire aluminium surface for the inhibition to be totally effective.

CONCLUSION

- The corrosion rate of the aluminium in the extract of *V. amygdalina* decreases with increase concentration of inhibitor.
- The percentage inhibition efficiency increased with extract concentration.
- The extract offers an excellent anti-corrosive effect for aluminium in 0.5M HCl environment.
- The adsorption of the extract on the aluminium surface follows Langmuir adsorption isotherm.

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