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Green Inhibitors : Inhibition Of AA5083 Corrosion In Acidic Medium Using Acacia Auriculiformis And Ixora Coccinea Extracts

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Abstract

The corrosion behavior of AA5083 in Hydrochloric acid and Sulphuric acid in presence of a cathodic material, at 0.4N and 0.5N concentration was studied by gravimetric method. The results showed that the rate of corrosion is influenced by concentration of acid and presence of chloride ions. The corrosion of AA5083 was found to be many folds greater in acid chloride medium compared to that of neutral chloride medium. The ethanolic extract of Acacia auriculiformis leaf exhibited appreciable inhibition against AA5083 in 0.5N HCl. The flower extract of Acacia auriculiformis was found to possess better efficacy than the flower extract of Ixora coccinea. The results revealed that inhibition is dependent on concentration.

Keywords: Green inhibitors, AA5083, Acacia auriculiformis, Ixora coccinea, acid corrosion, Aluminium alloys, FSW.

1. Introduction

Al-Mg alloys are used as structural materials in marine, air craft and cryogenic applications [1]. Al alloys possess moderate strength, high ductility, appreciable corrosion resistance and weldability [2].

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Use of chemicals to prevent metallic corrosion has a long history [3]. However, in addition to degrading environment they are also hazardous to human health. With the growing concern about the environment, the research for eco friendly green inhibitors has attained priority and popularity. The use of plant products as corrosion inhibitors has been well documented [4]. Green inhibitors are preferred for their eco friendliness, ease of availability and cost effectiveness. Various parts of plants contain different amount of tannins. The effectiveness of tannins in retarding metallic corrosion in acid medium is discussed by Semra [5].

Ixora coccinea is a common flowering shrub native to Asia. Its name is derived from an Indian deity and is found to possess various biological activity. Latha and Panikar have reported the chemo protective effect of Ixora coccinea against toxicity induced by cyclophosphamide and cis-platin [6]. However, Ixora has gained importance due to its antimicrobial [7], anti oxidant [8], anti inflammatory and anti mitotic [9] properties.

Acacia auriculiformis also known as northern black wattle, has gained commercial importance due its use as fire wood and timber [10]. Acacia ariculiformis is used as analgesic [11].Saponins isolated from Acacia auriculiformis is reported to be active against certain microbes and helminthes [12].The flowers are a source of bee forage for honey production [13].

The present study aims to evaluate the corrosion behavior of AA5083 in acidic medium and also to study the inhibitory effects of Ixora coccinea and Acacia auriculiformis against the corrosion of AA5083 in acidic medium containing chloride ions

2. Materials and Methods

2.1 Material, Extract and Reagents

2.1.1. Material: Test Coupons Composition (%wt)

Mg - 4.15 , Mn - 0.73 , Fe- 0.31 ,Si- 0.13 , Cu <0.025 , Cr <0.01 , Ti < 0.01 and rest Al

Dimension: Length – 50mm, Breadth – 15mm and thickness- 6mm

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2.1.2. Preparation of Ethanolic extract

The spindle like leaves and flowers from Acacia auriculiformis and the flowers from Ixora coccinea were collected early morning washed with distilled water .The moisture was removed by straining through sieve and air dried. The dry leaves and flowers were cut into small pieces and weighed. About 20 grams each and 100 ml of ethyl alcohol were taken in soxhlet apparatus. Extraction was carried out at around $60^{O}C$ for an hour. The extract was cooled to room temperature and poured into evaporation trays. The solid left behind weighed about 3 grams. This was preserved in amber coloured air tight containers.

2.1.3. Regents

All chemicals used are Analar Grade. NaCl, HCl and H_2SO_4 were diluted with deionised water to obtain the required concentration. The strength of these solutions was established by carrying out conductometric titration [14].

2.2 Experimental Methods

Method 1: Weight loss of BA in presence and in absence of FSW was studied without stirring the electrolyte.

Method 2: Weight loss of BA in presence and in absence of FSW was studied by stirring the electrolyte using a mechanical stirrer (75 rpm) .

Method 3: Seven BA and 7 FSW coupons were immersed in 3.5% NaCl for 360 hours and the extent of corrosion calculated from the loss in weight.

2.2.1. Weight Loss measurement

AA 5083 base alloys (BA) and Friction Stir Weld alloys (FSW) were cut as per the given dimension. 7 coupons each were used for various methods of measurement. Weight loss measurements were carried out according to the procedure stated in ASTM G31 [15].

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The test coupons were mechanically polished using emery paper. It was then rinsed with double distilled water and washed with acetone. The dry coupons were preserved in desiccator cabinet.

Both base alloy and friction stir weld samples were weighed using an analytical and digital balance with a precision of 0.0001g. The weighed samples were suspended using inert glass hooks and immersed in the electrolyte.

Fourteen BA coupons and Fourteen FSW coupons were immersed in each electrolyte (0.4N HCl, 0.5N HCl, 0.4N H_2SO_4 and 0.5N H_2SO_4). After 24 hours, seven coupons each (7BA and 7 FSW) were removed and washed with doubled distilled water. It was then rinsed with acetone and air dried. The dry samples were weighed as before.

The remaining samples were removed after 72 hours and treated in the same way.

3. Results and Discussion:

Table 1 shows the corrosion behavior of AA5083 under various environments.

Table 1: Weight Loss of AA 5083 in acidic medium

Acid/Immersion Time in Hours	**Hydrochloric acid**		**Sulphuric Acid**	
	0.4N	0.5N	0.4N	0.5N
24 Without FSW	0.052 ± 0.008	0.25 ± 0.018	0.024 ± 0.002	0.058 ± 0.013
24 With FSW	0.099 ± 0.006	0.455 ± 0.07	0.04 ± 0.002	0.099 ± 0.005
72 Without FSW	0.596 ± 0.039	0.675 ± 0.044	0.174 ± 0.019	0.262 ± 0.063
72 With FSW	1.074 ± 0.035	1.276 ± 0.08	0.297 ± 0.011	0.44 ± 0.07

Usually metals and alloys corrode at a faster rate and to a greater extent in acidic medium than in alkaline or neutral media. It has also been proved that the presence of chloride

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ions is detrimental to metals [16] .The AA5083 test coupons were found to undergo corrosion in HCl medium at much faster rate than in H_2SO_4 as the acidic chloride is more detrimental and the rate of corrosion was found to be dependent on the concentration of the acid.

The corrosion of base alloy AA5083 in both Hydrochloric acid medium and sulphuric acid medium is more prevalent in presence of Friction Stir Welded sample (Fig 1), than in absence of FSW samples. This suggests that the FSW samples behave cathodically on coupling with base metal coupons. Similar tendency has been already reported in salt solutions [17].

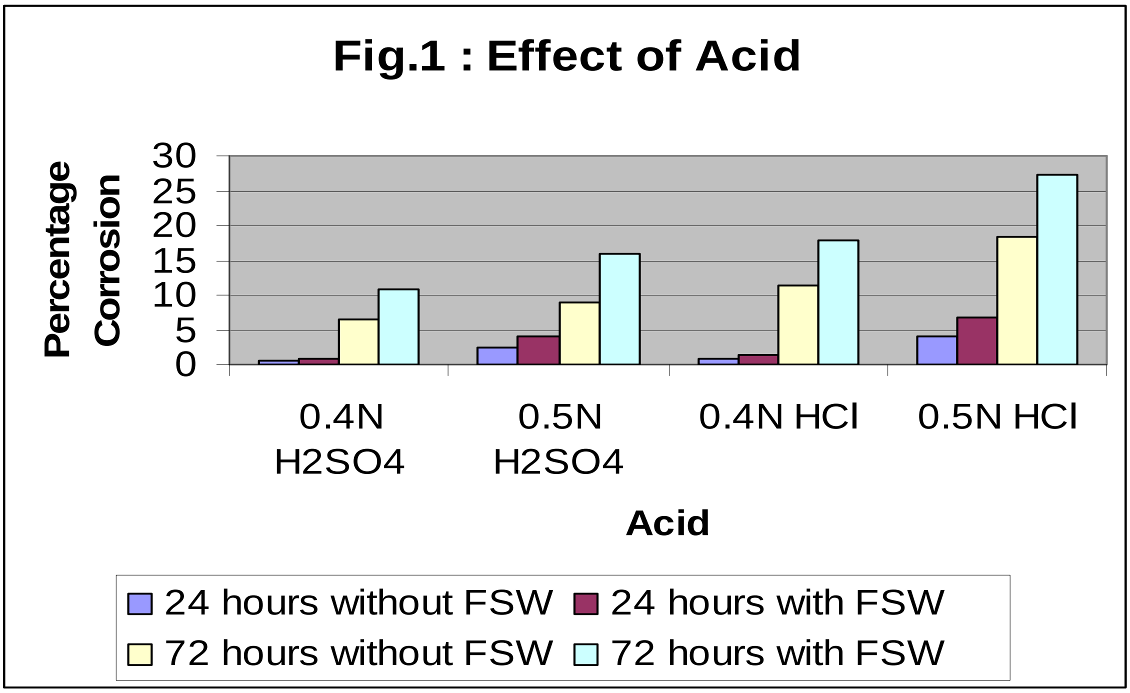


Table 2 shows the effect of stirring the electrolytes (0.5N HCl and 3.5 % NaCl) continuously using a mechanical stirrer, at a rate of 75 rpm, in order to assess the effect of mechanical agitation on the corrosion behavior of the samples under test.

Table 2: Weight Loss of AA 5083

Condition	3.5 % NaCl (360 hrs immersion)		0.5N HCl (24 hrs immersion)	
	Without FSW	With FSW	Without FSW	With FSW
With stirring	0.008 ± 0.0025	0.011 ± 0.0028	0.24 ± 0.018	0.459 ± 0.05
Without stirring	0.009 ± 0.003	0.01 ± 0.003	0.25 ± 0.018	0.455 ± 0.07

The results indicated that, stirring does not have any profound effect on the corrosion behavior of both base alloy and Friction Stir Welded Samples (FSW).
The results also indicated that the rate of corrosion in neutral medium is very less compared to that of acidic medium.

As this investigation was designed to study the acute corrosion behavior, acidic medium corrosion had been chosen and it was decided to conduct further investigation without stirring the electrolyte as agitation did not have profound effect on the corrosion behaviour.

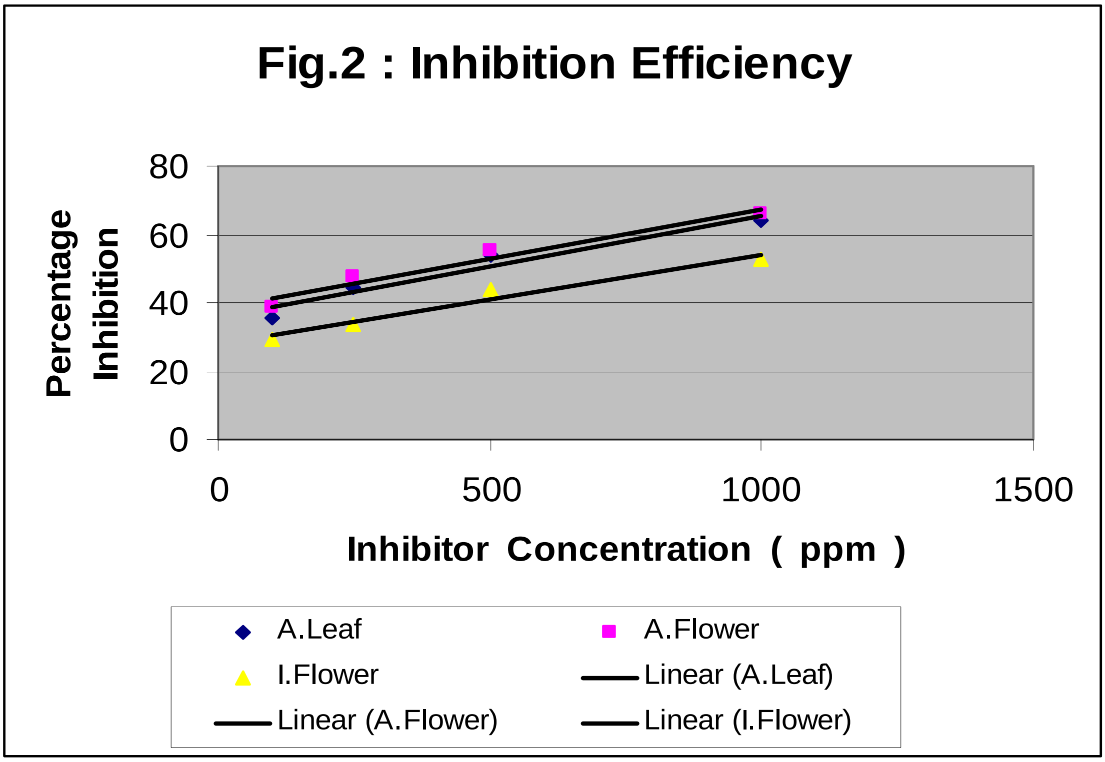
Qualitative analysis of the electrolyte after removing the samples, carried out as per the procedure given in Vogel [14] showed the presence of Aluminium and Magnesium indicating that both Al and Mg are leached out from the base metal alloy during corrosion

The inhibitory effect of the ethanolic extract of Acacia auriculiformis and Ixora coccinea against the corrosion of AA 5083 in 0.5N HCl is shown in Table 3.

Table 3: Loss in weight in presence of inhibitor(0.5N HCl , after 72 hours)

Concentration (ppm)	**Acacia auriculiformis**		**Ixora coccinea**
	Leaf extract	Flower extract	Flower extract
0	1.276 ± 0.08		
100	0.82 ± 0.054	0.78 ± 0.072	0.906 ± 0.022
250	0.71 ± 0.051	0.67 ± 0.046	0.846 ± 0.047
500	0.59 ± 0.012	0.57 ± 0.026	0.72 ± 0.024
1000	0.46 ± 0.03	0.43 ± 0.1	0.606 ± 0.04

The inhibition efficacy of the leaf and flower extract of Acacia and the flower extract of Ixora can be understood from Fig .2.



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Both Leaf and flower extract of Acacia offered more protection against corrosion induced by 0.5N HCl on AA5083 , than the Ixora flower extract The inhibition of ethanolic extract of Acacia may be due to the high tannins content in various parts of the plant [18] The result clearly shows that the inhibition efficiency of flower extract is greater than that of the leaf extract of Acacia. It was also found to increase with increase in concentration. The flavanoid concentration may be greater in flower than in leaf thus making the flower extract offer more protection.

Of the two flower extracts under test, Acacia auriculiformis extract offered 12.3 % more inhibition than that of Ixora coccinea. The mechanism of inhibition can be understood only after carrying out further studies.

The experimental findings were found to be in accordance to Langmuir adsorption isotherm as the plot of log C /θ Vs log C (Fig.3) gave a straight line whose slope is given in Table 4.

The slope for the line obtained for all the plant products were near unity suggesting that the inhibitory action may be due to consistent adsorption of the flavanoids at the surface of the alloy. It can also be concluded that there is no lateral interaction between the adsorbed molecules [19].

Fig.3 : Langmuir Adsorption Isotherm

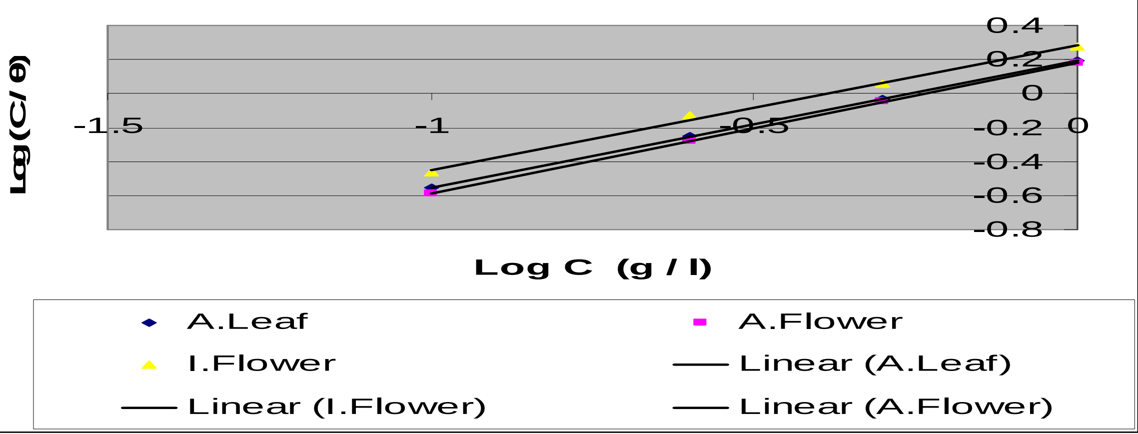

Table 4: Adsorption Characteristics

log c (g/l)	log (C / θ)		
	A. Leaf	A.Flower	I.Flower
-1	-0.553	-0.589	-0.461
-0.6	-0.249	-0.279	-0.128
-0.3	-0.032	-0.044	0.059
0	0.194	0.178	0.279
Slope obtained	0.7452	0.7689	0.7322

Conclusion

AA 5083 Friction stir welded alloy behaves cathodically with respect to base alloy in acidic medium.

Ethanolic extract of Acacia auriculiformis leaves, flowers and Ixora coccinea flowers exhibited appreciable inhibition against corrosion of AA5083 in 0.5NHCl.

The inhibition efficacy increased with increase in concentration.

The inhibition is due to the physisorption and follows Langmuir adsorption isotherm.

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