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A Study of Veronia Amygdalina Leaf Extract on Corrosion Resistance of 96%Al, 3.5%Zn and 0.5%Mg in Nacl Solution

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Abstract: This paper presents a study of corrosion resistance of 96% Al, 3.5% Zn and 0.5% Mg using Veronia Amygdalina leaf extract as the inhibitor. The experiment was conducted in different concentration of Veronia Amygdalina (15, 30, 45, 60ml) at 4M Nacl solution. The experiment was evaluated using the weight or metal loss method. The results obtained were compared against a control experiment without addition of an inhibitor. The highest inhibitive effect was obtained at the corrosion rate of 0.34750mmpy at 240hrs in 30ml of aqueous extract of Veronia Amygdalina in Nacl solution.

Keywords: Veronia Amygdalina, Sodium Chloride (NaCl), Corrosion, Inhibitor

1. Introduction

Aluminium (Al) is the world's most abundant metal and does the third most common element comprise 8% of the earth's crust. The versatility of aluminium makes it the most widely metal after steel.

Pure aluminium is soft, ductile, and corrosion resistant and has a high electrical conductivity. It is widely used for foil and conductor cables, but alloying with other elements is necessary to provide the higher strength needed for other applications. Aluminium is one of the lightest engineering metals, having strength to weight ratio superior to steel [7]. By utilizing various combinations of its advantageous properties such as strength, lightness, corrosion resistance, recyclability and formability, aluminium is being employed in an ever increasing number of applications. This array of product ranges from structural materials through to thin packaging foils [9].

Aluminum has a density around one third that of steel and is used advantageously in applications where high strength and low weight are required. This includes vehicles where low mass results in greater load capacity and reduced fuel consumption.

Corrosion is the chemical or electrochemical reaction between a material (metal) and its environment. In chemical reaction corrosion reaction occur through an exchange of electrons [10]. In electrochemical reactions, the electrons are produced by a chemical reaction in one area, the anode, travel through a metallic path and are consumed through a different chemical reaction in another area, the cathode [2]. When the surface of aluminium metal is exposed to air, a protective oxide coating forms instantaneously. This oxide layer is corrosion resistant and can be further enhanced with surface treatments such as anodizing. Weight or metal loss method can be used accurately and reliably to estimate corrosion rate in all generalized corrosion forms [3].

The first patented corrosion inhibitors were either natural products such as flour, yeast or bye products of food industries for restraining iron corrosion in acid media [8]. Researchers have carried out to find measures in which the rate of metal corrosion can be reduced, below are some of the researches conducted; The application of natural honey as natural inhibitor for copper in aqueous solution was studied. The aqueous extract of hibiscus flower and Angaricus is a good corrosion inhibitor for industrial cooling system [1]. The use of herbs Coriander, Hibiscus, Anis, Black cumin and Garden crème as green inhibitor for acid corrosion of steel [7]. Uniform corrosion normally does not cause metal failures as rapidly as localized corrosion, but it is detrimental to appearance. Knowledgeable selection of materials and protection methods (e.g. painting) are used to control it. Uniform corrosion is the easiest form of corrosion to measure, and unexpected failures can easily be avoided by regular inspection [4]. The ethanoic extract of Ricimuni leaves as corrosion inhibition of mild steel in acid media was studied by [3]. For any specific inhibitor in any given medium there is an optimal concentration [5]. For example, a concentration of 0.5% sodium benzoate, or 0.2% sodium cinnamate, is effective in water that has a pH of 7.5 and contains 17ppm sodium chloride or 0.5% by weight of ethyl octanol. The hard water that is high in calcium and magnesium is less corrosive than soft water because of the tendency of the salts in the hard water to precipitate on the surface of the metal and form a protective film [8]. A model for predicting the formation of a corrosion fouling deposit was studied by [12] and utility dimensionless variables were deduced for the study of fouling heat transfer surfaces which is caused by corrosion due to consequence of their exposure to flowing oxygenated water. By the application of the paint on a triavalent chromate treated zinc plated steel sheet [15] using a highly anti corrosive organic – inorganic hybrid paint was developed for automobile steel parts. Aging of biodiesel results in the formation of degradation products, such as short chain fatty acids (SCFA) and water. These products may cause corrosion of metals in fuel system. When performing corrosion tests, biodiesel continuously degrade during the test, resulting in an uncontrolled test system, a test fuel was developed by [14] using a saturated FAME (methyl myristate), which was doped with RME degradation products at typically seen in field test. The aggressive effect of different concentrations of HNO_3 and the inhibitive action of some organic and inorganic additives on the corrosion metal was studied by [13], the degree of surface coverage of adsorbed organic and inorganic additives was determined from the reaction number (R.N) values. The thermodynamic parameters of organic additives are calculated and illustrated; the values obtained gave a clear strong physisorption tested organic inhibitor on copper metal surface. High efficiency of physical and chemical properties of organic inhibitors were used in the study of protection of steel in concrete against ingress of chlorides, oxygen and carbon dioxide, as species causing the corrosion of rebars [17].

In this study, Vernovia Amygdalina leaf extract was added in solution of Nacl and effect of corrosion rate on 96%Al, 3.5%Zn and 0.5%Mg was carefully observed.

2. Materials and Methods

2.1. Materials

The Al-Zn-Mg was cut into nine pieces of same length (15mm by 10mm). Mass of 250g of Sodium chloride (NaCl) was dissolved in 1000ml of water were specimen would be immersed.

2.2. Experiment Procedure

The method used in this work for estimation of corrosion rate was weight loss method. The coupons were weighed and separately immersed into nine beakers for a period of 240hours. Each coupon was removed and washed with distilled water, dried and reweighed. Loss in weight was obtained by finding the difference between the initial and final weight of the sample using the relation below [5];

$$W_L = W_{In} - W_{Fn} \tag{1}$$

Corrosion rate and exposure time can be estimated with each parameter been defined as shown in the expression below [6];

$$\text{Corrosion rate (C.R)} = \frac{87*W}{D*A*T} \tag{2}$$

Where; C.R = Corrosion rate
W = Weight loss in milligrams
D = Density of specimen in gcm^{-3}
A = Total exposed area in cm^2
T = Exposure time in hrs
Area of the cylindrical specimen is given as [3];

$$A = 2\pi r(r + 1) \tag{3}$$

Where; r = radius of specimen
l = length of specimen

$$\text{Weight loss ratio (W.L.R)} = \frac{\text{Weight loss of specimen immersed in inhibited solution}}{\text{Weight loss of specimen immersed in uninhibited solution}} \tag{4}$$

3. Results and Discussion

Table 1 presents weight loss of Al-Zn-Mg immersed in 4M of Nacl solution. It can be seen from table 1 that at zero initial time there was no reduction in weight, likewise in corrosion rate and weight loss ratio. It can also be seen from the table that after an interval of 48hrs the weight loss was recorded and corrosion rate was computed for each experiment. From the table the column for weight loss ratio was not computed because the Al-Zn-Mg was not immersed in an inhibitor for this experimentation.

Tables 2 – 5 present the weight loss of Al-Zn-Mg in Sodium Chloride (Nacl) solution at different molar concentration with aqueous extract of Vernonia Amygdalina. The results of the experimentation with Al-Zn-Mg in 4M Nacl and aqueous extract of Vernonia Amygdalina at 15ml, 30ml, 45ml and 60ml at an interval of 48hours for each experiment as presented in different tables as shown below.

It can also be seen from the tables that at zero initial time no weight loss was recorded in the mass 11.1826g, 11.6412g, 24.1734g, 23.1376g respectively, but at interval time of 48 hours reduction in weight loss was recorded, the corrosion rate and weight loss ratio was also computed as shown in the tables below.

Table 1. *Weight loss of Al-Zn-Mg immersed in 4M of NaCl solution uninhibited.*

Time (hrs)	Initial weight (g)	Final weight (g)	Weight loss (mg)	C.R. (mmpy)	W.L.R
0	11.1826	-	-	-	-
48	11.1826	11.1798	2.78	0.0486	-
96	11.1826	11.1750	7.60	0.0711	-
144	11.1826	11.1712	11.435	0.0667	-
192	11.1826	11.1698	12.80	0.056	-
240	11.1826	11.1669	15.70	0.0541	-

Table 2. *Weight loss of Al-Zn-Mg in NaCl solution with Veronia Amygdalina molar concentration 15ml.*

Time (hrs)	Initial weight (g)	Final weight (g)	Weight loss (mg)	C.R. (mmpy)	W.L.R
0	12.5671	-	-	-	-
48	12.5671	12.5653	1.80	0.0471	0.6475
96	12.5671	12.5581	9.00	0.1287	1.1842
144	12.5671	12.5564	10.07	0.0673	0.8806
192	12.5671	12.5559	11.20	0.0527	0.8750
240	12.5671	12.5542	12.90	0.0482	0.8217

Table 3. *Weight loss of Al-Zn-Mg in 4M of NaCl solution with Veronia Amygdalina concentration 30ml.*

Time (hrs)	Initial weight (g)	Final weight (g)	Weight loss (mg)	C.R. (mmpy)	W.L.R
0	11.8206	-	-	-	-
48	11.8206	11.8156	5.00	0.00871	1.7986
96	11.8206	11.8146	6.00	0.05275	0.7895
144	11.8206	11.8137	6.90	0.0422	0.6034
192	11.8206	11.8108	9.80	0.04305	0.7656
240	11.8206	11.8107	9.90	0.3475	0.6306

Table 4. *Weight loss of Al-Zn-Mg in 4M of NaCl solution with Veronia Amygdalina concentration 45ml.*

Time (hrs)	Initial weight (g)	Final weight (g)	Weight loss (mg)	C.R. (mmpy)	W.L.R
0	12.0867	-	-	-	-
48	12.0867	12.086	7.00	0.01255	2.5198
96	12.0867	12.0858	9.00	0.00795	1.1842
144	12.0867	12.0835	3.20	0.0187	0.2798
192	12.0867	12.0836	3.10	0.0138	0.2422
240	12.0867	12.0814	5.30	0.0189	0.3376

Table 5. *Weight loss of 96%Al, 3.5% Zn & 0.5%Mg in 4M of NaCl solution with Veronia Amygdalina molar concentration 60ml.*

Time (hrs)	Initial weight (g)	Final weight (g)	Weight loss (mg)	C.R. (mmpy)	W.L.R
0	11.5688	-	-	-	-
48	11.5688	11.5605	8.30	0.1462	2.9856
96	11.5688	11.5560	12.80	0.0772	1.6842
144	11.5688	11.5597	9.10	0.0530	0.7958
192	11.5688	11.5580	10.80	0.0476	0.8437
240	11.5688	11.5567	12.10	0.0423	0.4704

4. Conclusion

From the study, it was observed that the effect of corrosion rate on Al-Zn-Mg at room temperature was 0.0593mmpy Nacl solution only. This implies that an average of 0.0593mmpy was corroded away from the surface of the metal every year in contact with Nacl solution. The corrosion rate on Al-Zn-Mg when an inhibitor (Veronia Amygdalina) was added to the Nacl solution was found to have highest corrosion rate at 0.1287mmpy at 96hrs, 0.3475mmpy at 240hrs, 0.0189mmpy at 240hrs and 0.1462mmpy at 48hrs across the four different concentration i.e. (15ml, 30ml, 45ml and 60ml) and the weight loss are shown respectively in the tables above.

It can be concluded that Veronia Amygdalina has proved to be very good corrosion inhibitor on Al-Zn-Mg.

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