Studies on corrosion rate of Aluminum in Methane Sulphonic acid

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Abstract: Methane Sulphonic acid is described as a green acid which is biodegradable within 28 days by the liberation of CO2 and SO4. It is a strong Organic acid with PKa= -1.9. Sulphuric acid is an Inorganic acid. The inhibition of corrosion of aluminium in acidic media was studied by applying weight loss method. Results showed that Methane Sulphonic Acid is less corrosive and toxic than other mineral acids. Researchers are in progress of replacing highly corrosive acids like H2SO4, HF by Methane Sulphonic acid in order to avoid environmental damages.

Key words: Aluminum, methane sulphonic acid, corrosion, corrosion inhibition, weight loss.

I. INTRODUCTION

Corrosion of a metal is said to be due to chemical or electrochemical reactions when it comes in contact with matters present in its environment. However, corrosion can be controlled by suitable modifying the environment which stifles the anodic or cathodic reaction or both, and is achieved by the use of inhibitors. Usually, acid solutions are generally used for the removal of undesirable scale and rust in several industrial process. Acids are widely used in the pickling process of metals. Most of the severe corrosion problems encountered involve the mineral acids or their derivatives. Use of inhibitors is one of the most practical methods for protection against corrosion especially in acid solution to prevent metal dissolution and acid consumption. [1]. When compared to other mineral acids, Methane Sulphonic Acid is usually described as a "green acid" due to its environmental advantages [2, 3]. Methane Sulphonic Acid is a colourless liquid with the chemical formula CH3SO3H. MSA may be considered as intermediate compound between sulphuric acid and methyl sulfonyl methane, effectively replacing an –OH group with a –CH3 group at each step. MSA is a strong organic acid with PKa= - 1.9[4] with low tendency to oxidize organic compounds. MSA is far less corrosive and toxic than usual mineral acids employed industrial processes [5]. MSA is biodegradable within 28 days, only carbon di oxide and sulphates being formed [6]. Highly toxic and corrosive HF can also be replaced by MSA in paraacetomol production [7].The use of organic hetero compounds containing oxygen, sulphur or nitrogen to the medium can reduce corrosion attack on metals appreciably [8].The literatures shows that most of the organic inhibitors get absorbed on the metal surface by displacing water molecules and form compact barrier film [9].Environmental compatibility is a prime requirement for reliable performance of metal. It is therefore essential to measure corrosion susceptibility in the media that are being used in real industrial applications. Aluminium and its alloys possess light weight, low density, superior malleability and high mechanical strength aluminium and its alloys are very attractive materials for engineering applications. The very important property of aluminium is very easy to recycle. Inhibition of metal corrosion is a result of adsorption of organic molecule at the surface of metal forming a protective layer. The extent of adsorption depends on the nature of metal, the metal surface condition, the mode of adsorption, the chemical structure of inhibitors and the type of corrosive media. In the present study, comparative corrosion studies of aluminum in methane sulphonic acid have been examined using weight loss measurements.

II. MATERIALS AND METHODS

2.1. Material preparation.

Aluminium sheet of purity 98.5% of thickness 0.1cm was mechanically press cut into coupons of dimension 5cm X 2.5cm. The specimens were polished successively using 1/0 to 6/0 emery paper and degreased in absolute ethanol, dried in acetone, weighed and stored in moisture free desiccator prior to use. The solvent used in this study were of analytical reagent grade.

2.2: Preparation of different composition of MSA and Sulphuric acid.

The solutions used were made of analar grade sulphuric acid and methane sulphonic acid. Appropriate concentrations of acids were prepared by using triple distilled water. The various concentrations of 0.1N, 0.5N,

1.0N, 1.5N, 2.0N were prepared for both sulphuric acid and MSA.

2.3: Preparation of different composition of inhibitor.

The two inhibitors thio urea and 2-2' dipyridyl were chosen for inhibition studies. 2-2' dipyridyl is a metalloprotease inhibitor which has very good adsoption property. Both the indicators were prepared for different concentration from 100 ppm to 500 ppm by using triple distilled water.

2.4: Gravimetric method.

Aluminium specimen of size 5 X 2.5 X 0.1 cm was employed for the determination of the corrosion rate by weight loss method. The specimens were hanged into the experimental solution with the help of glass hooks. After the surface treatment the initial weight of the specimen was noted and was completely immersed into the experimental solution maintained at room temperature. The weight loss was determined by retrieving coupons from test solution at 24 hours intervals for 3 days. The aluminium coupons after retrieving from test solution were scrubbed with bristle wire brush under running water dried an acetone and weighed. From the initial and final weight, the loss in weights was calculated. The experimental solutions used were sulphuric acid and MSA of various concentrations. Weight loss measurements with and without the presence of inhibitors for both media were performed. From the weight loss measurements, the corrosion rate, Inhibitors Inhibition efficiency and surface coverage (θ) of aluminium were calculated by using the following formulae.

$$CR = \frac{\text{Weight loss X 1000}}{\text{S.Area } (dm^2) \text{ X Time (days)}} \quad (1)$$

$$\% \text{ of I.E} = \frac{(W_1 - W_2) \text{ X } 100}{W_1} \quad (2)$$

Where W1 and W2 are weight losses in acids without and with the inhibitor respectively.

$$S.Coverage\ (\theta) = 1 - \frac{(CR_{\text{with inhibitor}})}{(CR_{\text{without inhibitor}})} \quad (3)$$

III. RESULTS AND DISCUSSION

3.1. Gravimetric results.

The weight losses for aluminium in various concentration of sulphuric and MSA were determined for 3 days at 24 hours intervals. The results obtained are presented in table 1. It shows that the corrosion rate increases as the concentration of both the acids and the immersion period is increased. From the figure 1, it is clear that MSA is less corrosive than sulphuric acid on the aluminium metal at all concentrations

TABLE 1: Corrosion rate of Al in H2SO4 & MSA

Normality	24 hours		48 hours		72 hours	
	H_2SO_4	MSA	H_2SO_4	MSA	H_2SO_4	MSA
0.1 N	89	28	101	81	171	109
0.5 N	93	32	227	122	297	150
1.0 N	101	73	260	130	382	171
1.5 N	138	77	333	140	487	252
2.0 N	142	85	340	158	492	305

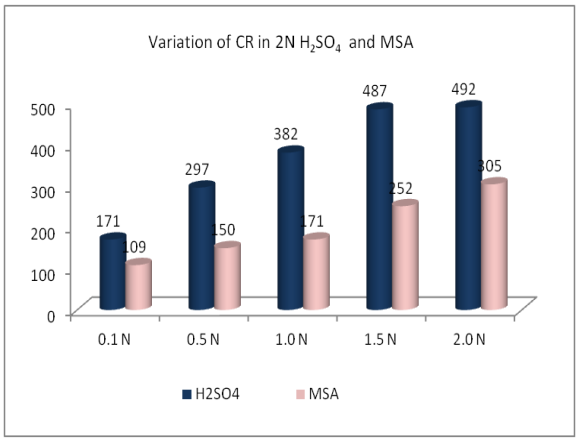

Fig.1. Variation of corrosion rate of Aluminium in 2N H2SO4 and MSA at 303K.

3.2. Inhibition efficiency and Surface coverage.

The percentage of inhibition efficiency of thiourea and 2-2'dipyridyl of various concentrations were calculated and represented in table.2 at 303K. The results indicates that the percentage of inhibition efficiency increases as the concentration of thiourea and 2-2'dipyridyl increases. This suggests that inhibitor molecule absorbed at aluminium sample mechanically screen the coated part of aluminium surface from the action of corrosive medium [10].

TABLE II. Effect of inhibitor on % I.E and Surface coverage (θ) for Al in 2N MSA.

Concentration mg/l	Thio urea Inhibitor		2-2'dipyridyl	
	% I.E	(θ)	% I.E	(θ)
100	38.11	0.38	53.61	0.54
200	43.64	0.44	59.12	0.59
300	48.76	0.49	64.12	0.64
400	53.81	0.54	68.21	0.68
500	58.62	0.59	71.71	0.72

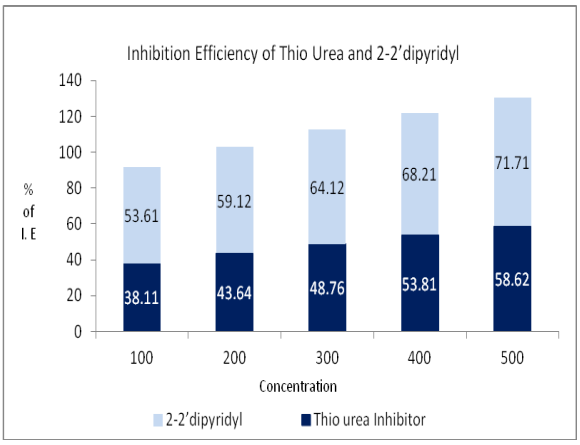

Fig. 2. Comparative parameters for inhibition efficiency of thio urea and 2-2'dipyridyl in 2N MSA at 303K

Figure 2 shows plot of inhibition efficiency versus concentration of various inhibitor at 303K. The results indicates the inhibition efficiency of 2-2'dipyridyl is greater than inhibition efficiency of thio urea

3.3. Adsorption consideration:

The adsorption isotherm for the inhibition property of inhibitor can be determined by assuming that inhibition effect is mainly due to the adsorption at metal/solution interface. In order to obtain the isotherm, the fractional surface coverage value (θ) as shown in table 2. The values of surface coverage (θ) for different concentration of different inhibitor in 2N MSA solution were evaluated from weight loss measurements data were tested graphically by fitting to various isotherm including Langmuir, Frumkin and Temkin. A Straight line relationship was obtained when (θ) is plotted against log C as shown in figure 3. This shows that it followed Temkins adsorption isotherm [11].

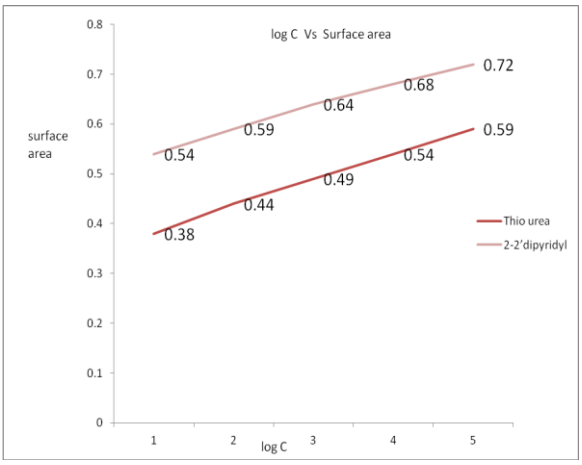

Fig. 3. Temkins adsorption isotherm for Aluminium in 2N MSA with and without inhibitor at 303K

From this we conclude that the adsorption of both inhibitors at the metal solution interface is the first step in the action mechanism of inhibitor in aggressive methane sulphonic medium.

IV. CONCLUSIONS

The following conclusions can be drawn from the investigation.

1. From the weight loss measurements the corrosion rate of aluminium in Methane Sulphonic Acid is lesser than Sulphuric acid.

2. Inhibition efficiency increases with increasing inhibitor concentration whereas 2-2'dipyridyl inhibition property is higher than thiourea in 2N MSA.

3. Thio urea and 2-2' dipyridyl shows Temkins adsorption isotherm on Aluminum metal.

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