



INHIBITING PROPERTIES OF SOME SODIUM SALTS ON CORROSION BEHAVIOR OF ALUMINIUM ALLOYS (1060) IN THE PRESENCE OF ORGANIC ACIDS

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ABSTRACT

Inhibition of corrosion of aluminium alloy (1060) in aqueous solution of acetic acid, monochloroacetic acid, dichloroacetic acid and trichloroacetic acid in the presence of sodium arsenite and sodium nitrite in relation to the concentration of inhibitor and concentration of corrosive media by applying loss in weight method was observed and for above support, electrostatic measurements were made to study the corrosion behavior.

Key words: Aluminium alloy (1060), Loss in weight, Sodium arsenite, Sodium nitrite, Acetic acid, Chloroacetic acids.

INTRODUCTION

The carboxylic acid and its chloro-derivatives are used in various applications and it has been observed that in the production of these acids or in the other chemical synthesis where chloro-substituted carboxylic acids are used, no metal withstands corrosion. Some sodium salts are found to have cathodic and anodic inhibitive properties. Sodium nitrite has anodic inhibitor while sodium arsenite has cathodic inhibitive properties. Sodium arsenite and sodium nitrite inhibitions have already been reported to be effective in sulphuric acid¹, oxalic acid² and acetic acid^{3,4}.

In this paper, the results of study on the inhibition properties of some sodium salts on aluminium alloys in the various concentrations of carboxylic acid and chloro-substituted carboxylic acids are reported. For the present investigation, the aluminium alloy 1060 has been taken for observation as it has maximum tendency to protect itself from corrosion than other alloys.

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The experiments were carried out at 35⁰C temperature and for 24 hours immersion period. The inhibitor concentrations were taken 0.01 %, 0.05 %, 0.1 %, 0.3 % and 0.5 % for each acid to calculate weight losses. For the purpose of corroding media, acetic acid, monochloro-, dichloro- and trichloroacetic acids were used and potentiostatic measurements, in view of the polarization curves (current / potential), have also been made and discussed in detail.

EXPERIMENTAL

For the investigation of weight loss⁵, the sizes of specimens were 75 × 50 × 0.5 mm. The surface of the specimens were polished with wax coated emery papers of the grades 1/0 to 5/0 (John Okey). The specimens were washed with benzene and running tap water and rinsed with acetone. Before using the specimen in experiments, they were dried and kept in vacuum desiccators.

Potentiostatic anodic and cathodic polarization experiments⁶ were carried out using a Wenking Potentiostate (Laboratory mode). The experiments were carried out in a 200 mL Pyrex glass cell containing 100 mL test solution. 0.1 N acetic acid or chlorosubstituted acetic acids, without and with concentration of inhibitors at which maximum efficiency was observed. Platinized platinum foil was used as auxiliary electrode. Standard calomel electrode with Lugging capillary was used for the measurement of electrode potentials.

RESULTS AND DISCUSSION

The results were given in Tables 1 and 2 and Fig. 1 to 8. Table 1 shows the inhibition efficiencies of different inhibitors and Table 2 shows Tafel parameters and the values of inhibitor efficiencies, calculated from the extrapolation of anodic Tafel line to the open circuit potential and from the intersection of cathodic and anodic Tafel lines.

It was observed that 0.1 N solution of acetic, monochloroacetic and dichloroacetic acids were less corrosive while those of trichloroacetic acid were highly corrosive. The order of corrosivity of the acids is.

Trichloroacetic >> Dichloroacetic > Monochloroacetic > Acetic acid

In acetic acid, sodium arsenite affects 88 % protection to aluminium. However, by substituting chlorine atom at the place of hydrogen atom, the extent of inhibition was decreased to 39 % in monochloro and 29 % in dichloroacetic acids. But the extent of inhibition was again increased (99 % protection) in case of trichloroacetic acid. This

suggests that the mechanism of corrosion was different in the case of trichloro acetic acid.

Table 1. Inhibition of corrosion of aluminum alloy 1060 in 0.1 N acetic acid and chloro substituted acetic acids

Acid	Inhibitor conc. n (%)	Sodium arsenite		Sodium nitrite	
		Corrosion loss (mg.dm ⁻²)	% Inhibition	Corrosion loss (mg.dm ⁻²)	% Inhibition
Acetic acid blank loss = 9.5 mg.dm ²	0.01	7.20	24.20	1.31	86.20
	0.05	5.22	45.10	1.51	84.10
	0.10	3.68	61.30	1.52	84.00
	0.30	1.36	85.70	1.51	84.10
	0.50	1.14	88.00	1.55	83.70
Monochloroacetic acid blank loss = 18.2 mg.dm ²	0.01	16.20	11.00	8.30	54.40
	0.05	14.30	21.40	7.20	60.40
	0.10	13.70	24.70	5.60	69.20
	0.30	12.10	33.50	4.90	73.10
	0.50	11.00	39.60	4.60	74.70
Dichloroacetic acid blank loss = 470 mg.dm ²	0.01	20.10	6.90	19.10	11.60
	0.05	19.20	11.10	16.50	23.60
	0.10	18.70	13.40	16.80	22.20
	0.30	16.20	25.00	15.10	30.10
	0.50	15.30	29.20	13.20	38.90
Acetic acid blank loss = 9.5 mg. dm ²	0.01	23.80	94.90	186.40	60.30
	0.05	16.00	96.60	72.50	84.60
	0.10	15.10	96.80	49.90	89.40
	0.30	9.40	98.00	44.30	90.60
	0.50	6.30	98.70	29.10	93.80

Table 2: Tafel parameter and efficiency of inhibitor of aluminium alloy 1060 in acetic and chloro substituted acetic acids

Inhibitors and their concentrations	Tafel's slope 'b' (Volt)		Corrosion current (Amp/cm ²)		Inhibitor efficiency		Inhibitor efficiency from mass loss method
	Anodic	Cathodic	Extrapolation of anodic Tafel line to the open circuit potential [A]	Intersection of cathodic and anodic Tafel lines to the open circuit potential [B]	From [A]	From [B]	
0.1N Acetic acid							
Nil	0.31	0.12	1.83×10^{-5}	1.1×10^{-5}	-	-	-
Sodium arsenite	0.08	0.22	1.36×10^{-5}	0.51×10^{-5}	-	50	85.6
Sodium nitrite	0.5	0.2	1.2×10^{-5}	0.84×10^{-5}	33	19	83.3
0.1N Monochloroacetic acid							
Nil	0.15	0.11	3.47×10^{-6}	4.76×10^{-6}	-	-	-
Sodium arsenite	0.1	0.34	-	2.32×10^{-6}	-	49.1	35
Sodium nitrite	0.7	0.18	1.83×10^{-6}	1.51×10^{-6}	44.6	65.6	71.1
0.1N Dichloroacetic acid							
Nil	0.28	0.12	2.40×10^{-6}	2.65×10^{-6}	-	-	-
Sodium arsenite	0.12	0.26	1.513×10^{-6}	2.16×10^{-6}	-	13	35
Sodium nitrite	0.5	0.16	1.02×10^{-6}	1.18×10^{-5}	-	-	-
0.1N Trichloroacetic acid							
Nil	0.5	0.14	3.47×10^{-5}	3.25×10^{-5}	-	-	-
Sodium arsenite	0.14	0.29	2.63×10^{-5}	1.89×10^{-5}	-	26.6	95.6
Sodium nitrite	0.64	0.15	8.12×10^{-6}	6.41×10^{-6}	76.2	79.6	93.3

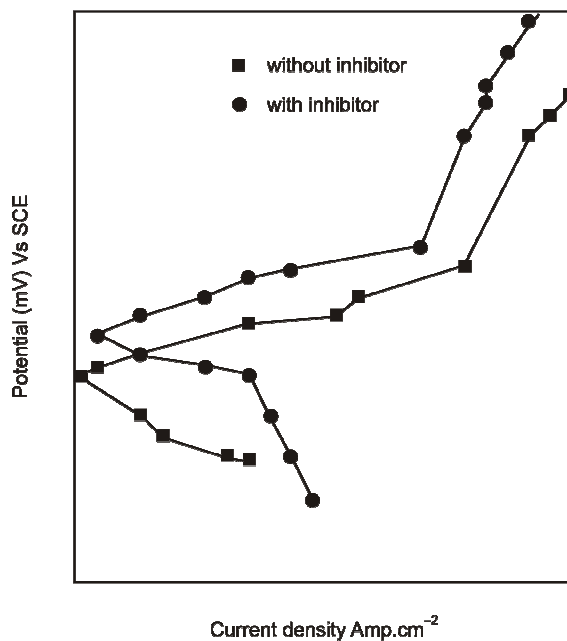


Fig. 1: 0.1 N Acetic acid

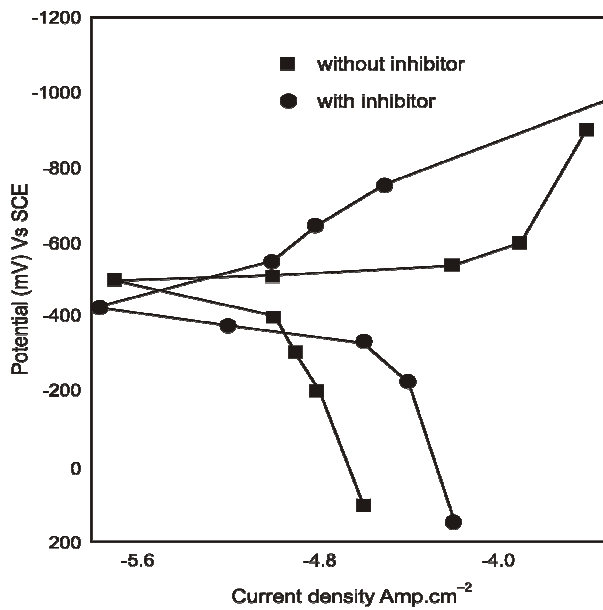


Fig. 2 : 0.1 N Monochloroacetic acid

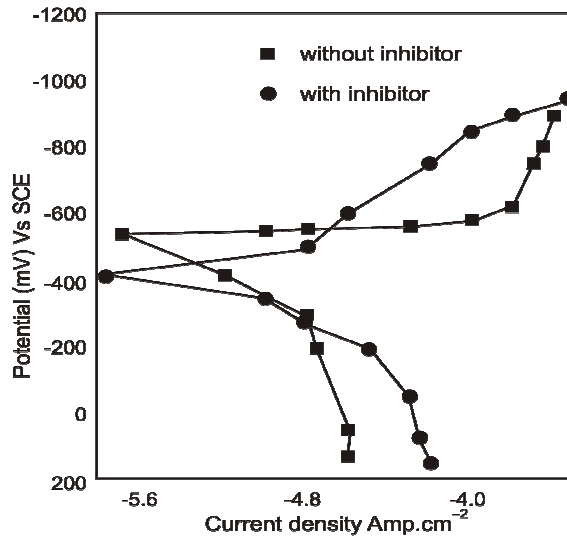


Fig. 3 : 0.1 N Dichloroacetic acid

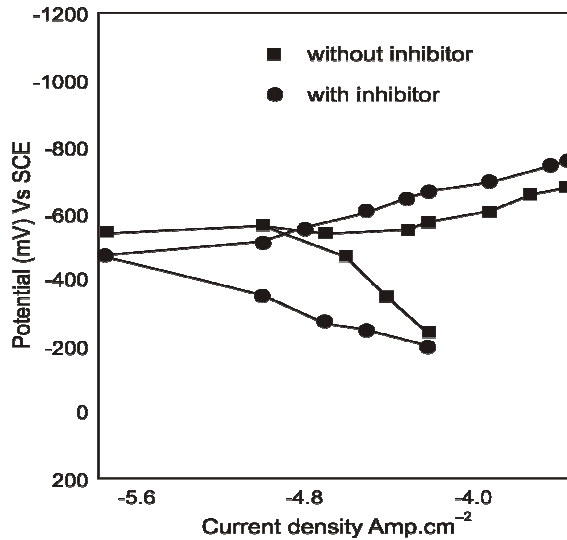


Fig. 4 : 0.1 N Trichloroacetic acid

Fig. 1-4: Influence of current density on the cathode and anode potential of aluminium 1060 in 0.3 % sodium arsenite.

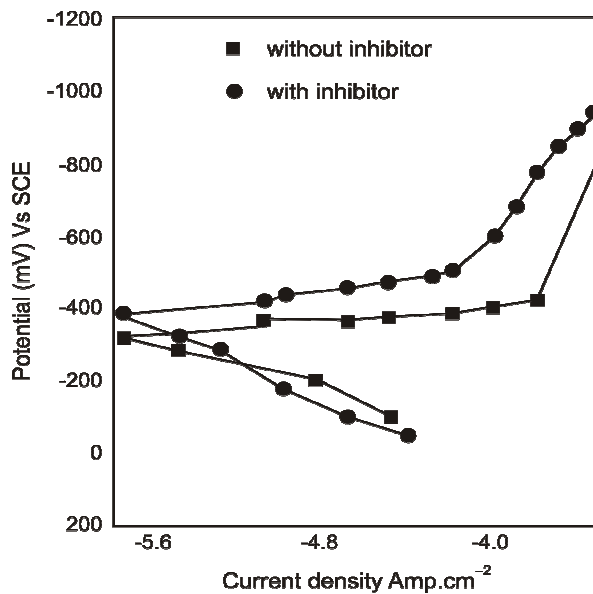


Fig. 5 : 0.1 N Acetic acid

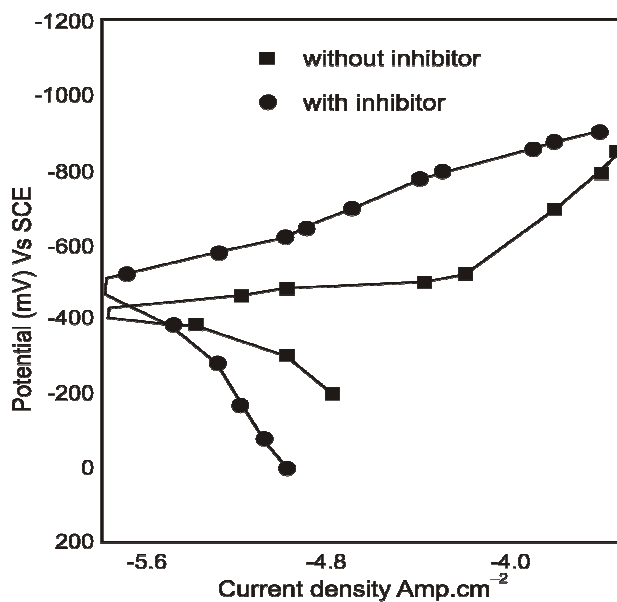


Fig. 6 : 0.1 N Monochloroacetic acid

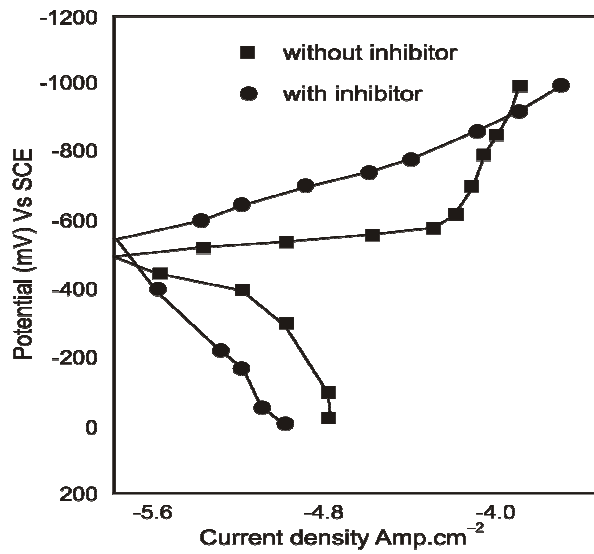


Fig. 7 : 0.1 N Dichloroacetic acid

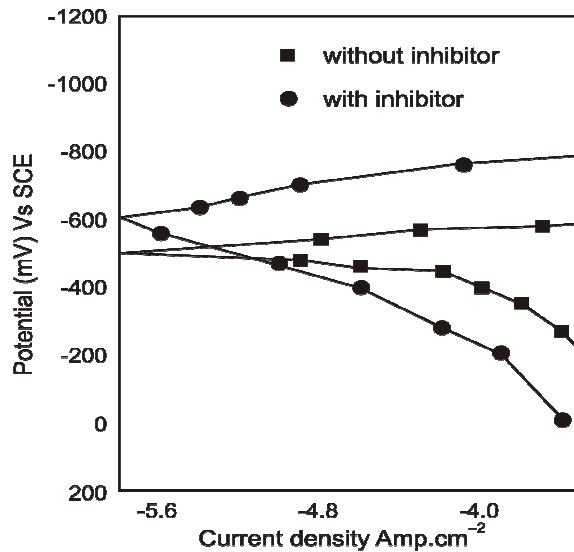


Fig. 8 : 0.1 N Trichloroacetic acid

Fig. 5-8: Influence of current density on the cathode and anode potential of aluminium 1060 in 0.3 % sodium nitrite

The high rate of corrosion in the trichloroacetic acid was due to the setting up of an autocatalytic cycle by the reduction of the trichloroacetic acid into hydrochloric acid⁷.

The addition of 0.5 % sodium arsenite to 0.1 N acetic acid shifts the corrosion potential of aluminium in the negative direction (-325 mV to -410 mV). During anode polarization, the shifts in the anode potential was less than those in the absence of the inhibitors. This indicates the depolarization of the anode. Similarly, 0.3 % of the arsenite shifts the corrosion potential of aluminium, (in 0.1 N monochloroacetic acid) in the negative direction (-435 mV to -520 mV). The inhibitor, however, anodic reaction was depolarized, considerably influences the local cathodes.

On the other hand, in 0.1 N dichloroacetic acid, the addition of 0.3 % sodium arsenite shifts the corrosion potential in the positive direction (-515 mV to -410 mV). In the absence of the inhibitors, the shift in anode potential during polarization were actually less. A significant increase in the cathode polarization by inhibitor is observed.

However, the cathode was considerably polarized, the open circuit potential shifts in the more positive direction in the presence of sodium arsenite, which may be explained by assuming the shift of the open circuit potential of anode sites in the positive direction.

The addition of 0.3 % sodium arsenite in 0.1 N trichloroacetic acid shifts corrosion potential in the positive direction, (-505 mV to -465 mV). It also causes significant increase in both; the cathode and the anode polarization.

The polarization effect and the change in the ratio of anodic and cathodic areas result in the initial shift of the potential, i.e., an oxide layer formed on the metal surface was considered as a cathodic area as compared to the bare metal surface, but the oxide layer itself might be formed on what was to start with, an active anodic point. It may thus result in an increase in the cathodic surface, which may shift the potential in the nobler direction. Thus, the prominent shift of the potential as compatible with the steady potential shifting in the positive direction on addition of the inhibitor.

The change in the anode potential during anode polarization was actually less than the corresponding shifts in the absence of the inhibitor.

For sodium nitrite, it is observed that acetic acid offers maximum protection (84 %) at 0.01 % concentration and the extent of inhibition remains steady or decreases very slightly with further increase in the concentration of the inhibitor.

In the other acids, the inhibitor efficiency increases with increase in the concentration of the inhibitors. The inhibitor appears to be more effective in trichloroacetic acid, where it may prevent the autocatalytic cycle to consume the nascent hydrogen.

Addition of 0.3 % sodium nitrite to 0.1 N acetic acid also shifts the corrosion potential (-325 mV to -350 mV). Addition of inhibitors increased the cathode polarization, whereas, its effect in the increasing the anodic polarization was observed away from a current density of 3.24×10^{-6} Amp.cm⁻². Its effect on the anode side is greater than that of the cathode. Similarly, in the case of monochloroacetic acid also, addition of sodium nitrite shifts the corrosion potential in the negative direction (-435 mV to -505 mV). Here the inhibitor brings about a considerable increase in the cathode and polarizations, it being greater extent for the anode.

Tafel parameters and efficiency of inhibitors

The inhibitive efficiencies of sodium arsenite and sodium nitrite in 0.1N acetic acid, calculated from the extrapolation of the cathodic and anodic Tafel lines at the corrosion potential, do not compare satisfactorily with those calculated from the loss in weight data. The difficulty lies in obtaining more points on the anode polarization curves, as the readings are highly fluctuating and unsteady beyond the current densities as shown in Fig.1 to 8.

The efficiency of the inhibitor in 0.1N monochloroacetic acid, calculated from the intersection of the cathodic and anodic polarization curves to the open circuit potential, shows conformity with those calculated from the loss in weight data, including the mixed action of these inhibitors on the local cathodes and anodes. The efficiencies of sodium arsenite and sodium nitrite in 0.1 N dichloro acetic acid, calculated from loss in weight data and those obtained by extrapolation of Tafel lines to the open circuit potential were not well in agreement.

Efficiencies calculated from polarization data were in general lower than those obtained from weight loss data; thus, indicating that these inhibitors are not so effective right from the beginning. The polarization data gives only instantaneous corrosion rate.

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