Aromatic aldehydes as corrosion inhibitors for Aluminium 56S in Hydrochloric acid

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THE work in this laboratory is concerned with the development of new corrosion inhibitors for non-ferrous metals in acidic media. The present article reports the results obtained in an investigation on aromatic aldehydes as corrosion inhibitors for A1-56 S in hydrochloric acid solutions.

Composition of the metal

A1-56s : Mn : 0.3%
Mg : 5.0%
Al : Remainder.

Corrosion test : The preparation of specimens and corrosion tests were carried out as described in our previous publication[1]. The Tafel parameters and inhibitor efficiencies calculated from polarization data are given in Table 1.

Observations : The corrosion of A1-56 S in hydrochloric acid concentration increases with time as well as with hydrochloric acid concentration. Polarization measurements indicate that the corrosion process is predominantly cathodically controlled.

Benzaldehyde : Even at as small as concentration as 2.17 ml/1 benzaldehyde affords > 99% protection to A1-56S in 2.0 to 4,0 N hydrochloric acid. In 0.5 N and 1.0 N hydrochloric acid there is a considerable decrease in the efficiency of benzaldehyde with the passage of time but in 2.0, 3.0 and 4.0 N hydrochloric acid, there is an improvement in the efficiency of benzaldehyde with the passage of time. In 1.0 N HCl and 2.0 N HCl benzaldehyde is predominantly a cathodic inhibitor and the extent of cathode polarisation increases

TABLE 1

Tafel parameters and efficiency of inhibitors in 1.0 N hydrochloric acid

Inhibitor and Inhibitor concentration	Tafel slope b		Energy transfer coefficient cathode	Corrosion current amp/cm2		Inhibitor efficiency		
	Anodic volts	Cathodic volts		From Extrapolation of cathodic Tafel line	From intersection of cathodic and Anodic lines at open circuit potential	From (5)	From (6)	From loss in weight method
1	2	3	4	5	6	7	8	9
Nil	0.016	0.12	0.50	1.945×10^{-3}	1.945×10^{-3}	—	—	—
Benzaldehyde (4.35 ml/l)	0.03	0.27	0.22	6.03×10^{-4}	7.586×10^{-4}	69	61	68-94%
Salicylaldehyde (4.35 ml/l)	0.06	0.40	0.15	7.244×10^{-4}	6.31×10^{-4}	63	65	–24-89%
m-Hydroxybenzaldehyde (0.2%)	0.015	0.22	0.28	1.24×10^{-4}	3.57×10^{-4}	94	81	40-82%
p-Hydroxybenzaldehyde (0.001%)	0.01	0.12	0.50	7.244×10^{-4}	1.0×10^{-3}	63	49	48-75%
β-Resorcylaldehyde (0.01%)	0.024	0.12	0.50	8.32×10^{-4}	1.905×10^{-4}	57	90	45-72%
Anisaldehyde (4.35 ml/l)	0.045	0.22	0.28	3.55×10^{-5}	6.03×10^{-5}	98	97	92-96%
Vannillin (0.2%)	0.015	0.30	0.20	7.224×10^{-4}	8.32×10^{-4}	63	57	65-85%
Cinnamicaldehyde (0.43 ml/l)	0.013	0.20	0.30	1.26×10^{-4}	2.0×10^{-4}	94	90	82–90%

with an increase in inhibitor concentration. The open circuit potential shifts in negative direction, with an increasing the concentration of benzaldehyde, indicating the increased action on cathodic areas.

Salicylaldehyde : Salicylaldehyde does not seem to be an effective inhibitor for the corrsoion of Al-56S at longer durations. In 0.5 N hydrochloric acid at 24 hours duration and in 1.0 N hydrochloric acid at 2 hours duration, it actually accelerates the corrosion of Al-56S. In 2.0 to 4.0 N hydrochloric acid solution, its protective action it seen and even at 0.43 ml/l concentration it gives 87 to 92% protection. Polarization data shows the cathodic action of salicylaldehyde.

m-Hydroxybenzaldehyde : The efficiency of m-hydroxybenzaldehyde improves with an increase in inhibitor concentration. In 0.5 N and 1.0 N hydrochloric acid the efficiency of m-hydroxybenzaldehyde decreases considerably with time, but in 2.0 to 4.0 N hydrochloric acid concentrations, in general, its efficiency improves with time. m-Hydroxybenzaldehyde acts as an inhibitor by predominant influence on cathodic reaction and the extent of cathode polarization increases with an increase in concentration from 0.001% to 0.2%.

p-Hydroxybenzaldehyde : Compared to m-Hydroxybenzaldehyde, p-Hydroxybenzaldehyde is a better inhibitor. Its efficiency increases with an increase in inhibitor concentration. In 0.5 N hydrochloric acid the efficiency of p-hydroxybenzaldehyde decreases with time but in 3.0 and 4.0 N hydrochloric acid it improves with time.

In 1.0 N and 2.0 N hydrochloric acid p-Hydroxybenzaldehyde acts as an inhibitor by influencing the cathodic action.

β-Resorcylaldehyde : The protective action of β-Resorcylaldehyde increases with an increase in inhibitor concentration in 2.0 to 4.0 N HCl, but in 0.5 and 1.0 N hydrochloric acid solutions, its efficiency decreases with an increase in inhibitor concentration. In 0.5 and 1.0 N hydrochloric acid concentrations the protective action of β-Resorcylaldehyde decreases with time but in 3.0 and 4.0 N hydrochloric acid solutions it improves with time. It is a cathodic inhibitor.

Anisaldehyde : Even at 0.43 ml/l concentration, anisaldehyde gives 96% protection to Al-56S. In 2.0 to 4.0 N hydrochloric acid and with further increase in the concentration of anisaldehyde upto 4.35 ml/l, it gives nearly complete protection to Al-56S.

In 0.5 N hydrochloric acid the efficiency of anisaldehyde falls with time, but at other concentrations of hydrochloric acid, it is nearly constant for the duration of study. Anisaldehyde is a cathodic inhibitor and the extent of cathode polarisation increases with an increase in inhibitor concentration.

Vanillin : The protective action of vanillin becomes evident at 0.1% concentration. In 0.5 N and 1.0 N hydrochloric acid its efficiency decreases with time but in 3.0 and 4.0 N solutions of hydrochloric acid the efficiency of vanillin improves with time.

In 1.0 N and 2.0 N HCl vanillin is a predominantly cathodic inhibitor and the extent of cathode polarization increases with an increase in its concentration.

Cinnamicaldehyde : The solubility of cinnamicaldehyde is very low (0.43 ml/l) but even at this concentration it gives considerable protection to Al-56S. In 0.5 N hydrochloric acid its efficiency decreases with time whereas in 4.0 N hydrochloric acid it improves with time.

Cinnamicaldehyde is a very good inhibitor, which functions by increasing cathodic polarization in 1.0 N and 2.0 N hydrochloric acid. All the aldehydes show an increase in protective action with an increase in HCl concentration. Data given in Table 1 show that there is a good correlation in the efficiencies calculated from loss in weight data and polarisation data.

Influence of temperature : In uninhibited 1.0 N HCl, activation energy is 25.2 k cal/mole. The activation energies are less in the presence of inhibitor than that in uninhibited hydrochloric acid in case of benzaldehyde (14.7), p-Hydroxybenzaldehyde (20.2), β-Resorcylaldehyde (20.2), anisaldehyde (18.4) and cinnamicaldehyde (18.4) whereas the activation energies are more in the presence of inhibitor than that of uninhibited hydrochloric acid in case of salicylaldehyde (29.4) m-Hydroxybenzaldehyde (30.3) and vanillin (27.6).

All the inhibitors obey Freundlich adsorption isotherm.

Cathodic protection (Table 2) : The following aldehydes have been investigated as corrosion inhibitors for Al-56S in 2.0 N hydrochloric acid and the results of combined cathodic protection of Al-56S in 2.0 N hydrochloric acid in the presence of these aldehydes are reported here. Benzaldehyde, salicylaldehyde, m-Hydroxybenzaldehyde, p-Hydroxybenzaldehyde, β-Resorcylaldehyde, anisaldehyde, vanillin and cinnamicaldehyde.

Addition of 4.35 ml/l benzaldehyde reduces the protective current to 0.0974 amp/dm^2. Compared to benzaldehyde, hydroxy substituted aldehydes namely salicylaldehyde, m-Hydroxybenzaldehyde, p-Hydroxybenzaldehyde and β-Resorcylaldehyde are less effective inhibitors. In monohydroxybenzaldehydes the order of efficiency in reducing the protective current is ortho > para > meta. The values of protective current are 0.130, 0.438 and 0.487 amp/dm^2 respectively. Results obtained with β-Resorcylaldehyde indicate that the protectvie current in the presence of 0.2% β-Resorcylaldehyde

TABLE 2

Weight loss in the absence of protection Current, Electrode potentials and efficiencies

Inhibitor and Inhibitor concentration ml/l or %	Without external cathodic current		Open circuit potential in (mV) with ref. to S.C.E.	With external cathodic current			
	Weight loss mg/dm2	Inhibitor Efficiency (%)		Current for complete protection	Protective potential in mV with ref. to S.C.E.	Theoretical current need for complete protection amp/dm2	Ratio of theoretical current to observed current
Nil	1159	—	—700	2.48	—770	1.12	0.45
Benzaldehyde (4.35 ml/l)	16.2	99	—850	0.0974	—1010	0.0154	0.16
Salicylaldehyde (4.35 ml/l)	39.0	97	—735	0.130	—960	0.0372	0.29
m-Hydroxybenzaldehyde (0.2)	76.1	93	—820	0.487	—970	0.0727	0.15
p-Hydroxybenzaldehyde (0.05)	92.3	92	—820	0.568	—995	0.0881	0.16
-Resorcylaldehyde (0.05)	298	74	—820	1.169	—1050	0.286	0.24
Anisaldehyde 4.35 ml/l)	16.2	99	—840	0.0812	—1040	0.0154	0.19
Vanillin (0.2)	58.3	95	—800	0.487	—985	0.0554	0.11
Cinnamicaldehyde (0.43 ml/l)	37.2	97	—770	0.195	—960	0.0354	0.18

All the aldehydes decreased considerably the current required for cathodic protection of Al-56S in 2.0 N hydrochloric acid. With an increase in inhibitor concentration there is further reduction in protective current. Anisaldehyde is the most effective inhibitor in this respect. Addition of 2.17 to 4.35 ml/l anisaldehyde to 2.0 N hydrochloric acid reduces the protective current to 0.0812 amp/dm^2 as compared with 2.48 amp/dm^2 in its absence.

Benzaldehyde is also a good inhibitor for the corrosion of Al-56S in 2.0 N hydrochloric acid. is 0.731 amp/dm^2. Thus introduction of a second hydroxyl group in benzene nucleus does not seem to be very favourable to inhibitor action.

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REFERENCE

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