

COLLOIDS AS CORROSION INHIBITORS FOR ALUMINIUM COPPER ALLOY IN HYDROCHLORIC ACID

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The corrosion of B₂₆₈ aluminium (3.9% Cu) and its inhibition in solutions of hydrochloric acid has been studied. From the results, it can be generalised that the efficiency, at a concentration of 1.0% of the inhibitor increased in the orders; dextrin (40%) < gelatin (56%) < agar agar (64.3%) < acacia (77.5%) and glue (81%). It was found that the percentage of inhibition decreased with increase in the concentration of the acid. The inhibition efficiency of inhibitors decreased with increase in period of immersion except glue. All the five inhibitors appear to be effective mixed inhibitors.

Keywords : Colloids; Corrosion Inhibitors; Aluminium-Copper Alloy; Hydrochloric Acid

INTRODUCTION

CORROSION of aluminium in acid solutions has been studied by a number of workers but the comparative information about aluminium-copper alloy in hydrochloric acid is not much available. The present investigation was, therefore, taken up to study the corrosion of alluminium-copper alloy in hydrochloric acid and the effect of some hydrophilic colloids on such corrosion.

EXPERIMENTAL

Each specimen was first washed with distilled water and dried. It was then polished by alien buffing wheel using first the tripoli composition and then jeweller's rouge (Fontana, 1970), the direction of final polishing being perpendicular to that of the first one. The method gave a mirror like finish. The specimen was slowly decreased in quantity by immersion in A.R. Carbon tetrachloride (sulphur free). The specimens were then exposed to the solution for inhibition studies.

For inhibition studies, a decinormal solution of hydrochloric acid containing controlled addition of various hydrophilic colloids in the range 0.0–1.5% was generally employed. Only one specimen was suspended in each beaker containing 230 ml. of the test solution and the solution was left open to air. Further experiments were performed in each case and the mean value of the weight loss has been recorded. The specimens were cleaned after the test with a chromo-phosphoric acid mixture (Stevens *et al.*, 1923), of composition of phosphoric acid—5%—and chromic acid—2%.

For the collection of polarization data, the desi-normal solution of hydrochloric acid containing 1.5% (W/W_i) of inhibitor has been employed. The external current was applied from a regulated power supply, the other electrode being that of platinum. The change in potential was measured by a D. C. microvoltmeter.

For the collection of polarization data, the decinormal solution of hydrochloric acid containing the concentration of the inhibitor which gave maximum inhibition in the absence of applied current. The external current was supplied from a regulated power supply, the other electrode being that of platinum. The change in potential was measured by a D. C. microvoltmeter.

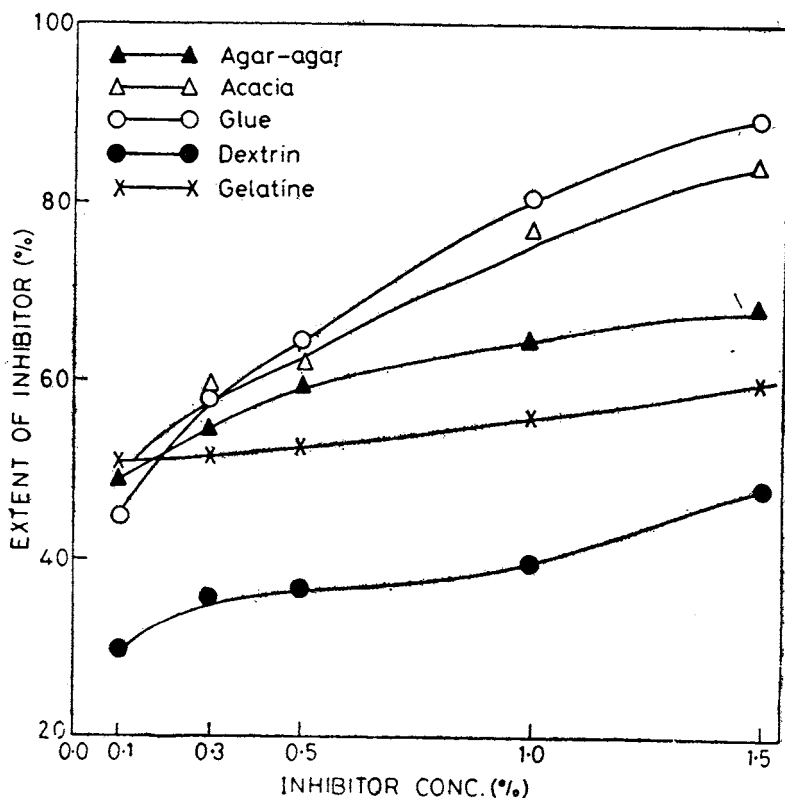


FIG. 1.

RESULTS AND DISCUSSION

The results are reported in Fig. 1 and Table I. The percentage inhibition, P. I., is as defined as

TABLE I

Effect of acid concentration on inhibitor efficiency in hydrochloric acid

Surface area—40 sq. cm. Duration—one day. Inhibitor Conc. 1.5%. Temp. $30^{\circ} \pm 0.5^{\circ} \text{C}$

Inhibitor	Percentage inhibition in acid concentration of		
	0.1N	0.2N	0.3N
Nil (loss in mg.)	12	109	220
Dextrin	89	72	54
Gelatin	98	95	74
Agar-agar	93	86	80
Acacia	100	95	88
Glue	100	97	86

$$\text{P. I.} = \frac{W_u - W_i}{W_u} \times 100$$

where W_u = weight loss of metal in uninhibited solution and W_i = weight loss of metal in inhibited solution.

Effect of Inhibitor Concentration

The specimens immersed in acid solutions containing very little or no inhibitor, suffered pitting type of attack all over the surface, specially more so at the edges. In those cases wherein the extent of corrosion was less, the specimens appeared dull metallic.

From the results presented in Fig. 1, it can be generalised that the inhibitor efficiency increases with concentration of inhibitor in almost all the cases. Even this increase in the efficiency is not proportional to the increase in the concentration of inhibitor.

In the case of acid solutions containing 0.1% inhibitor, the efficiency increased in the order :

$$\begin{aligned} &< \text{dextrin (30\%)} < \text{glue (44.5 \%)} < \text{acacia (49.2\%)} \\ &< \text{agar-agar (50\%)} < \text{gelatin (51.2\%)} \end{aligned}$$

At 1.5% concentration the efficiency increased in the order :

$$\text{Dextrin} < \text{gelatin} < \text{agar-agar} < \text{glue.}$$

The lowest inhibitive efficiency of 48% was obtained with dextrin, whereas with glue 89% inhibition was achieved.

Effect of Concentration of Acid

When the extent of corrosion was examined in different concentrations (*viz.*, 0.1N, 0.2N, 0.3N) of the acid containing the same quantity (1.5%) of inhibitor, it was observed that the percentage inhibition decreased with increase in the concentration of the acid (Table I). Thus in 0.3N acid, all the colloidal substances studied gave good inhibition ranging from 54% (dextrin) to 88% (acacia).

Effect of Immersion Period of Inhibition Efficiency

Table II shows the efficiency decrease with increase in the period of immersion. The decrease in efficiency may be attributed to the chloride ions in solution or may be due to the redeposited copper acting as an efficient cathode (Kreutzfeldt, 1928) or may be attributed to the formation of aluminium chloride which is also corrosive to aluminium.

TABLE II

Effect of immersion period of inhibitor efficiency in 1.0N hydrochloric acid

(Surface area 40 sq. cm, Inhibitor Conc. 1.5%, Temp. 30° ± 0.5 °C)

Inhibitor	P.I. for immersion period of		
	1 day	2 days	3 days
Nil (loss in mg)	12.0	19.5	40.0
Dextrin	89	70	48
Gelatin	98	85	60
Agar-agar	93	80	69
Acacia	100	90	85
Glue	100	91	90

Polarization Behaviour

The influence of current density on the cathodic and anodic polarization of B₂₆₈ aluminium in 0.1N hydrochloric acid containing 1.5% of inhibitor has been studied (Fig. 2). The values of corrosion current density in the presence and absence of inhibitor were obtained while the percentage efficiency was calculated using the relation.

$$\frac{I_{\text{cor}}(\mu) - I_{\text{cor}}(i)}{I_{\text{cor}}(\mu)} \times 100$$

where *i* represents inhibited and μ uninhibited.

The value of Tafel parameters and the efficiency of the inhibitors obtained by extrapolating cathodic Tafel line to the open circuit potential, are given in Table III. B₂₆₈ aluminium, when immersed in 0.1N hydrochloric acid, developed a steady state potential of 740-mv vs. S.C.E. When 1.5% of the inhibitor was added, there was a slight increase or decrease in this value depending upon whether the inhibitor

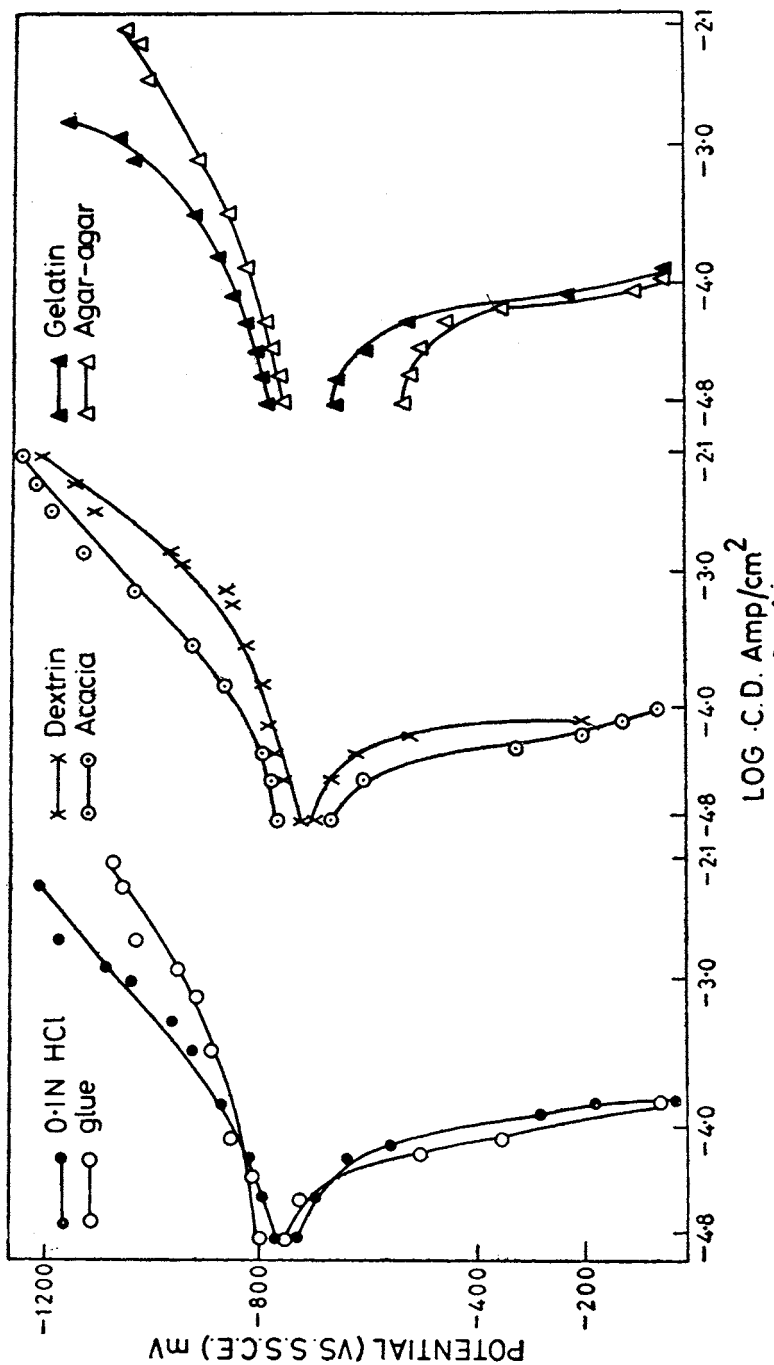


FIG. 2.

polarized the local anodes or the cathodes. Thus in absence of any impressed current the value of the open circuit potential were found to be :

Dextrin—720 mv, gelatin—780 mv, agar-agar—740 mv, acacia—740 mv and glue—780 mv.

TABLE III

Tafel parameters and inhibitor efficiency for B₂₆₈ aluminium 0.1N hydrochloric acid

(Surface area 6.51sq.cm; Temp. 30°C; Inhibitor Conc. 1.5%)

Inhibitor	Corrosion Current Amp/cm ²			P. I. Calculated from			
	(a)	(b)	(c)	(a)	(b)	(c)	(d)
Nil	7.492×10^{-6}	1.0×10^{-5}	1.6×10^{-5}	—	—	—	—
Dextrin	7.120×10^{-6}	5.12×10^{-6}	8.1×10^{-6}	49.8	48.8	49.4	48.2
Gelatin	7.07×10^{-6}	4.21×10^{-6}	6.7×10^{-6}	56.7	57.9	58.8	59.7
Agar-agar	6.969×10^{-6}	3.12×10^{-6}	5.4×10^{-6}	68.5	68.8	69.9	68.6
Acacia	6.870×10^{-6}	1.9×10^{-6}	2.7×10^{-6}	85.8	81.0	83.1	85.2
Glue	6.834×10^{-6}	1.2×10^{-6}	2.1×10^{-6}	89.8	88.0	87.9	89.7

(a) from extrapolation of anodic Tafel line; (b) from intersection of cathodic and anodic Tafel lines (c) from extropolation of cathodic Tafel line (d) from weight loss data.

This shows that neither the local anodes nor the cathodes are predominantly polarized by the inhibitor and, therefore, it can be safely concluded that the colloidal particle was uniformly absorbed on the metal surface.

The mechanism of inhibition of corrosion is generally believed to be due to the formation and maintenance of a protective film on the metal surface. The colloidal inhibitors being substances of high molecular weight have been reported (Machu *et al.*, 1947; Glasstone, 1968; and Evans, 1963) to form a film on the metal surface generally and thus interfere with the attack partly by hindering the replenishment of the corrosive agent and partly in other ways. According to Machu, the inhibitors are believed to be generally molecularly adsorbed on the active centres of the metal surface. These and absorbed layer characterized by high electrical resistance are formed on the metal surface which may be responsible for the reduction in the rate of diffusion of ions necessary for the dissolution process. In the present case, the plot of log (inhibitor concentration) vs. log (percentage inhibition) shows an absorption type of phenomenon occurring on the metal surface.

Hydrophilic colloidal substances have characteristic isoelectric points (*pH* at which the particles have no change). A departure from this *pH* value is likely to cause a sharp increase in viscosity since the particles then carry a charge. Gelatin for example has an isoelectric point *pH* 4.7 and is positively charged below 4.4. The charged particle would then migrate towards the cathode where it will be discharged and coagulated. The inhibitor molecule being very large would thus cover cathodic as well as anodic and act as mixed inhibitor.

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