Dextrin as an Inhibitor for the Corrosion of Pure Aluminium in Hydrochloric Acid Solutions

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ABSTRACT

Dextrin has been found to be a fairly satisfactory inhibitor for the corrosion of pure aluminium in hydrochloric acid solutions. Polarization studies with this inhibitor show that the anode polarization is low, whereas the cathode polarization is considerable. The Tafel plot holds good in this case. The dissolution of the metal is electrochemical in character. The corrosion process with dextrin appears to be essentially under cathodic control.

INTRODUCTION

Aluminium is a versatile metal with many desirable properties: light weight, low cost, and fairly good corrosion resistance. In India there are abundant resources of aluminium. In view of the fact that there is a shortage of the common non-ferrous metals and also in view of the steel position not being quite satisfactory, it is very necessary that in this country aluminium should be used wherever possible. In many cases encountered in practice, indoor as well as outdoor, the metal is subject to corrosion due to the breakdown of the oxide film which normally affords protection. Further, the corrosion is altered by the alloying elements that are introduced in order to obtain certain desirable properties. Methods of preventing the corrosion of aluminium under different conditions are therefore important. The addition of inhibitors to the corrosive medium is one of the important techniques of anticorrosion. Polarization studies are of significance in corrosion work in order to indicate the possibility of cathodic or anodic protection, and also throw light on the mechanism of corrosion inhibition.

Inhibitor efficiency and polarization studies have been made in this laboratory with dextrin in the following systems: 98.8 per cent aluminium in hydrochloric acid[1]; pure aluminium[2], 92 per cent aluminium-iron-manganese alloy[3], and aircraft aluminium-zinc alloy[4] in sodium hydroxide solutions. The corrosion of pure aluminium in hydrochloric acid solutions has also been investigated with thiourea inhibitor[5]. This paper presents the results of studies with dextrin inhibitor for pure aluminium in acid medium.

EXPERIMENTAL AND RESULTS

The aluminium sheet (S. W. G. 22) was of the composition corresponding to the specification SIB HH-aluminium 99.5 (minimum), copper 0.05, manganese 0.05, silicon 0.3 and iron 0.4 per cent (maximum). The inhibitor efficiencies were determined by the weight loss method. Polarization studies were made with aluminium as cathode or anode, the other electrode being one of platinum of the same dimensions. Weight loss as well as electrode potentials were determined with and without inhibitor. The experimental details have been described in previous communications. Table I presents some typical results on inhibitor efficiencies, and Table II shows the effect of current density on cathode polarization and anode weight loss at the optimum inhibitor concentration. The current density is calculated on the basis of apparent surface area.

DISCUSSION

Dextrin is a fairly satisfactory inhibitor for the corrosion of pure aluminium in acid medium, the efficiency being 58 to 92 per cent. The effect of acid concentration (1 to 2N) on efficiency is appreciable, the values ranging from 20 to 96 per cent under all conditions. The efficiency increases with inhibitor concentration up to 5 g/l, the optimum, beyond which it is practically constant. The table also shows that the efficiency decreases up to two hours, and thereafter the immersion period has little effect. The latter is the case in 1N acid, whereas the efficiency decreases with

TABLE I

Inhibitor Efficiencies

Temp. 32°C, apparent surface area 6·3 sq. cm , 1·25N hydrochloric acid.

Immersion period, hrs	*Inhibitor efficiency %, for inhibitor conc. g/l*			
	1	2	5	10
1	64	75	90	92
2	58	65	76	78
4	59	65	75	76
6	58	64	75	76

TABLE II

Anode Weight Loss and Cathode Polarization

Apparent surface area 3·14 sq. cm., immersion period 2 hrs, temperature 32°C, inhibitor concentration 5 g/l, *open circuit potential (–ve sign) in volts on hydrogen scale.

c. d. amp/dm²	Anode weight loss, mgms		Cathode polarization, mv	
	Without inhibitor	*With inhibitor*	*Without inhibitor*	*With inhibitor*
0·0	28	7	*0·566	*0·588
0·32	57	21	5	95
0·64	72	31	28	143
0·95	81	42	53	175
1·27	92	52	72	195
1·59	102	63	85	216
1·91	112	74	95	230
2·55	132	94	110	253
3·19	151	112	127	270

time in 2N solutions. The efficiency of this inhibitor for 98·8 per cent aluminium in acid is 30 to 90 per cent, and the values in alkali are: pure aluminium 7 to 44, 92 per cent alloy 32 to 83, and zinc alloy 72 to 74 per cent[6]. This indicates that dextrin is not a very good inhibitor for various aluminium compositions in acid or alkaline solutions

The steady state corrosion potential is shifted to a more negative value by dextrin. Increase in the anode current density increases the corrosion rate and decreases the inhibitor efficiency. Without the inhibitor the cathode polarization is high and is increased considerably by the inhibitor. On the other hand, the polarization on the anode side is negligible, the values being 20 and 37mv

respectively without and with inhibitor at a current density of 1·91 amp/dm² under similar conditions. It is not possible to obtain anodic protection by impressing high current densities. Cathode polarization and weight loss measurements show that complete protection of this alloy is possible by impressing low cathodic currents. The corrosion of the metal is electrochemical in character as shown by the existence of the negative difference effect during anodic polarization. In this case the weight loss due to local cell action with impressed current is greater than the normal weight loss without current. Straumanis and Wang[7] have also observed the negative difference effect and attributed the same to the presence of a protective film on the metal surface, and self corrosion by external current. The results are similar for 98·8 per cent aluminium in acid medium with this inhibitor.

The Tafel equation is obeyed for the plot of cathode polarization against the logarithm of the current density. The Tafel plot gave the following values for the slope b, exchange current density i_o, and energy transfer coefficient α, without and with inhibitor: 0.13, 0.18; 3.8×10^{-4}, 1.1×10^{-4} amp/cm²; 0.45, 0.33. They are in fair agreement with the literature values for the cathodic hydrogen evolution reaction, and indicate that the rate determining step is the discharge of the hydrogen ion[7]. A rough calculation of the inhibitor efficiency from the exchange current gives a value of the order of 71 per cent, which is quite close to the observed efficiency.

Cathode and anode polarization values indicate that the effect of the inhibitor is essentially on the cathodic reaction. The decrease in the exchange current density by dextrin shows that the inhibitor functions by adsorption on cathodic regions[9,10]. The effect of the inhibitor on the corrosion potential also suggests the polarization of local cathodes due to its adsorption on the metal surface. It can be concluded that the corrosion process is essentially under cathodic control. The mechanism is similar in acid medium for inhibition by dextrin for 98.8 per cent aluminium[1]; thiourea for pure and 92 per cent aluminium[6]; thiourea[11], quinine hydrochloride[12] and strychnine[13] for zinc alloy; quinine hydrochloride for aircraft copper alloy[14]. On the other hand, the anode polarization for pure aluminium and the alloys in alkali is high and is considerably increased by dextrin. The polarization on the cathode side is negligible in these cases. The results indicate that the corrosion of aluminium and its alloys in sodium hydroxide solutions is under mixed control, with predominance of inhibitor action on the anodic areas. All these considerations show that the mechanism of corrosion inhibition is rather complicated, the same inhibitor functioning in a different manner for a given metal in two different media.

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