TRI - n - BUTYLAMINE AS AN INHIBITOR FOR THE CORROSION OF ALUMINIUM - MAGNESIUM ALLOY IN HYDROCHLORIC ACID SOLUTIONS

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INTRODUCTION

Detailed investigations have been made in this laboratory on the inhibition of the corrosion of pure aluminium [1–3] and aluminium-manganese alloy [4–6] in hydrochloric acid solutions by n-, di-n-, and tri-n-butylamines. Similar work covering aluminium-magnesium alloy and n- butylamine has been reported elsewhere[7]. This paper presents the results of studies with tri-n-butylamine for the corrosion of aluminium-magnesium alloy.

EXPERIMENTAL AND RESULTS

The aluminium alloy sheet (S.W.G. 18) was of the composition corresponding to the specification M57S- iron 0.7, silicon 0.6, manganese 0.5, copper 0.10, titanium 0.2, magnesium 1.8-2.7, chromium 0.5, zinc 0.1 per cent and balance aluminium. The metal coupon was punched in one piece with a steel die. It was of a circular design to minimise the edge effects (diameter 2 cm. with a tab), the total weight being approximately 1.8 g. The corrosion rates were determined under the following conditions: (*a*) concentration of hydrochloric acid 0.5, 1.0, 1.25, 1.5 and 2N, (*b*) temperature 32 $\pm$ 0.1°C and (*c*) immersion period 1,2,3,4, 5 and 6 hours. Inhibitor efficiencies were determined by the weight loss method, the concentration of amine ranging from 0.1-1.0 g/l of nitrogen (1 g. of inhibitor contains 0.0755 g. of nitrogen). Polarization studies were made with aluminium electrodes. The experimental details have been described in previous papers. Table I presents some typical results on inhibitor efficiencies, and Table II shows the effect of acid concentration on cathode polarization without and with inhibitor. The current density is calculated on the basis of apparent surface area.

SUMMARY OF RESULTS & DISCUSSION

The efficiency of the inhibitor increases with time, the effect being quite significant up to about three hours. It increases with increase in the inhibitor concentration up to 0.5 g/l of nitrogen beyond which it is constant. The effect of acid concentration is not very significant. Unlike in the other systems the effect of the variables on the efficiency is not marked,

TABLE I

Inhibitor efficiencies

Temp. 32°C, apparent surface area 6.3 sq. cm., time 4 hours.

Acid conc. N	Inhibitor efficiency %, for inhibitor conc. g/l of N_2		Inhibitor efficiency % for inhibitor conc. g/l of N_2	
	0.1	0.25	0.5	1.0
0.5	85	91	91	91
1.0	95	97	98	98
1.25	93	96	98	98
1.5	90	96	97	98
2	78	92	96	98

TABLE II

Cathode polarization

Apparent surface area 3.14 sq. cm., temp. 32°C, inhibitor conc. 0.5 g/l of N_3. * Open circuit potential (- ve sign) in volts on hydrogen scale. Polarization in millivolts.

	0.5N acid		1N acid		1.25N acid	
c.d. amp/dm²	Without inhibitor	With inhibitor	Without inhibitor	With inhibitor	Without inhibitor	With inhibitor
0.00	* 0.503	* 0.586	* 0.519	* 0.579	* 0.540	* 0.581
0.32	12	161	3	107	1	88
0.64	35	286	6	187	2	175
0.96	48	387	10	259	3	206
1.28	61	402	14	310	4	259
1.60	75	411	20	336	6	280
1.92	81	425	26	345	8	310
2.56	92	445	42	371	14	344
3.20	102	470	60	388	23	365

the values being in the range 90-98 per cent under most conditions. The efficiency of the inhibitor is greater than that for pure aluminium or aluminium-manganese alloy, and is more than that of n-, and di-n-butylamines for this alloy [7,8]. Tri-n-butylamine is also a good inhibitor for mild steel in hydrochloric acid, the efficiency being about 98 per cent[8]. It has been reported to give an efficiency of the same order for steel in sulphuric acid[9].

The steady state corrosion potential, 0.50-0.56 v, is shifted to a more negative value by the addition of inhibitor. Straumanis and Wang[10] have reported a value of 0.58 v for the potential. Without the inhibitor the cathode polarization is appreciable and is considerably increased by the amine for all acid concentrations. The anode polarization is quite low, less than 20 mv, and is slightly altered by the addition of inhibitor, the values being 58-77, 25-53, 17-33, 2-21 mv respectively in the current density range 0.32-3.20 amp/dm² for 0.5, 1, 1.25, 1.5N acid with 0.5 g/l of nitrogen concentration. Cathode polarization and weight loss measurements show that cathodic protection of aluminium is possible. 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 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 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 slope b, exchange current density i_o, and energy transfer coefficient α, without and with inhibitor — 0.5 g/l of N_3, in 1N HCl: 0.14, 0.25; 11.75×10^{-7}, 1.00×10^{-3} amp/cm² ; 0.43, 0.24. The values of these parameters 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[11]. A rough calculation of the inhibitor efficiency from the exchange current gives a value of the order of 91 per cent, which is quite close to the observed efficiency.

Cathode and anode polarization values indicate that the effect of the inhibitor is predominatly on the cathodic reaction. The decrease in the exchange current density by the amine shows that the inhibitor functions by adsorption on cathodic regions[12]. The effect of the inhibitor on the corrosion potential also suggests the polarization of local cathodes due to its adsorption on the metal surface. The mechanism is similar for inhibition by n-, di-n-, and tri-n-butylamines for pure aluminium and aluminium-manganese alloy, n- and di-n-amines for aluminium-magnesium alloy, and also for tri-n-butylamine for steel in acid[9].

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