EFFECT OF ALKALOIDS ON THE CORROSION OF ALUMINIUM

N. SUBRAMANYAN AND K. RAMAKRISHNAIAH,
(Central Electrochemical Research Institute Karaikudi-3, India).

Abstract

The inhibitive effects of five alkaloids, namely, brucine, strychnine, narcotine, ephedrineand papaverine, on the corrosion of aluminium in 1M hydrochloric acid and 0.1M sodium hydroxide have been investigated. These compounds are inhibitive in the acid medium but are not effective in alkali to any significant extent. This has been explained in terms of the relative potentials of aluminium in the respective media.

The polarisation experiments in hydrochloric acid reveal that aluminium is polarised cathodically in presence of these alkaloids but the anodic polarisation seems to be negligible.

The conjoint effect of these substances with calcium, barium, strontium or magnesium was not always beneficial,

Introduction:

It has been reported[1] early in the history of the subject of corrosion inhibitors that certain plant extracts bring about the suppression of the dissolution reaction of metals dipped in corrosive media. This inhibitive action has been attributed to the presence of certain alkaloids and other nitrogen containing compounds in the extracts which are considered to be adsorbed at metal-solution interfaces. Reference has been made by Eldredge and Mears[4] to the use of alkaloids as inhibitors of corrosion of aluminium in hydrochloric acid. Rama char and co-workers[5-7] have studied the action of strychnine and quinine hydrochloride on the corrosion of aluminium in hydrochloric acid by weight-loss and polarisation methods and have come to the conclusion that they are effective inhibitors and the dissolution reaction is electrochemical in character.

This paper reports the influence of some alkaloids, namely, brucine, ephedrine, narcotine, strychnine and papaverine hydrochloride on the corrosion of aluminium (2S) in acid and and alkaline solutions from weight loss and polarisation experiments. The influence of divalent metal ions like calcium, barium,magnesium or strontium on the performance of these alkaloids has also been examined.

EXPERIMENTAL

Materials:

(a) Metal specimens: Rectangular specimens (7.5x2.5x0.15 cm) of aluminium (not less than 99% purity) were used for determination of the corrosion rate.

(b) Circular specimens of 1 cm dia. with 10 cm long stem were used for polarisation experiments. The specimens were polished with Ronuk's emery compound and later with pumice powder and degreased with trichloroethylene.

2. Chemicals:

Sodium hydroxide and hydrochloric acid were of A.R. quality. The compounds of the alkaline earth metals were all of A. R. grade (BDH). All the organic compounds were of E. Merck L. R. grade. The solutions were made up with distilled water.

3. Procedure:

(a) Determination of corrosion inhibition:

Four rectangular specimens, weighed after cleaning and degreasing were suspended in 900ml. of solution in one litre beaker for two hours. At the end of this duration, they were taken out, thoroughly washed with running tap water and weighed. Taking the average value of the weight losses, the inhibition efficiency

was calculated employing the formula.

Inhibition efficiency (%)

$$\left(\frac{w - w_1}{w}\right) \times 100$$

where 'w' and 'w_1' were the weight losses without and with the added substance in the particular solution.

(b) Polarisation measurements:

The polarisation experiments were carried out with the polished and degreased circular specimens with one side and stem coated with Americo Lacquer and platinised platinum sheet of 6.25 sq. cm area as the auxiliary electrode immersed in 400 ml of electrolyte solution. After measuring the initial steady potential, the polarisation was carried out by impressing known values of current source through a series high resistance. The potentials were measured by means of a vacuum tube voltmeter (D.C. Microvoltmeter-Philips Model G. M. 6020) with reference to a saturated calomel electrode. The experiments were carried out at 30 + 1°C.

RESULTS AND DISCUSSION

The effects of these alkaloids on the corrosion of aluminium in 0.1M sodium hydroxide are shown in Table 1. It is seen that these compounds are not effective as corrosion inhibitors in the alkaline medium. From Table 2, which indicates the concentration effect of the alkaloids (0.01% to 1.0%) in 1M. hydrochloric acid, it is observed that with increasing concentration all the compounds with the exception of strychnine, bring about an increase in the inhibition efficiency, It may be noted that with narcotine and ephedrine at 1% concentration and with papaverine hydrochloride even at lower concentrations, an inhibition efficiency of 90% was obtained. For the same concentration of the alkaloids, strychnine and brucine give lower corrosion inhibition efficiency than ephedrine, narcotine and papaverine. This may perhaps be attributed to steric effects, as also the difference between narcotine and papaverine. The alkaloids are more effective in the acid than in the alkaline medium.

The effect of the chlorides of calcium, barium, magnesium and strontium (0.009M) on the efficiencies of the alkaloids at 0.1 % concentration, in the inhibition of corrosion of aluminium in 1M. hydrochloric acid is shown in Table 3. Firstly, it is seen that the salt of barium and magnesium have an inhibitive effect, and those of calcium and strontium give negative efficiencies. The calcium and strontium salts when combined with the alkaloids do not prove to be beneficial and the inhibition efficiencies are lower than those obtained with the alkaloids alone. With barium and magnesium chlorides also, similar results are obtained, but in the case of ephedrine the inhibition efficiencies increase from about 60% to 71% and 81% respectively.

The open circuit potential of aluminium in 1M. hydrochloric acid was observed to be-0.76V versus saturated calomel electrode. On anodic polarisation, the electrode potential did not change even up to 128 mA/cm². Similar behaviour was also observed even in the presence of the alkaloids, and the alkaloids with calcium or magnesium. From these results, it is concluded that the anodic polarisation of aluminium in 1M. hydrochloric acid is negligible.

The results of the cathodic polarisation of aluminium in 1M. hydrochloric acid in the presence of the alkaloids, and the alkaloids with calcium or magnesium are shown in Fig. I A to F. It is seen that the alkaloids bring about cathodic polarisation which is not enhanced by the presence of calcium or magnesium.

Thus, it is concluded from the weight loss and the polarisation experiments that these alkaloids are effective in reducing the corrosion of aluminium in hydrochloric acid but not in sodium hydroxide. Since these alkaloids are organic bases, they can exist in the cationic form in the acidic medium, and it is possible that these cationic species are adsorbed on aluminium, by coulombic attraction. Since the observed potential of aluminium in hydrochloric acid coincides with the zero-charge potential for aluminium in potassium chloride solution, it may be considered that adsorption of these organic compounds are favoured even in this acidic medium. However, the cathodic polarisation behaviour in the presence of the alkaloids would suggest that it is the cathodic reaction that is affected.

In the alkaline medium, the alkaloids can exist as neutral entities and their adsorption on

negatively charged aluminium surface which is already covered by water dipoles, is unlikely.

In the combination with individual metal cations, the values of corrosion-inhibition efficiency in hydrochloric acid follow the same trend as the alkaloids themselves. The differences in their effects can, therefore, be explained on the same lines. On the other hand, the differences in the effects of each alkaloid when combined with different cations do not show any systematic trend and require further examination.

Acknowledgment :

The authors are grateful to Dr. H. V. K. Udupa, Director, Central Electrochemical Research Institute, Karaikudi-3, for his kind encouragement.

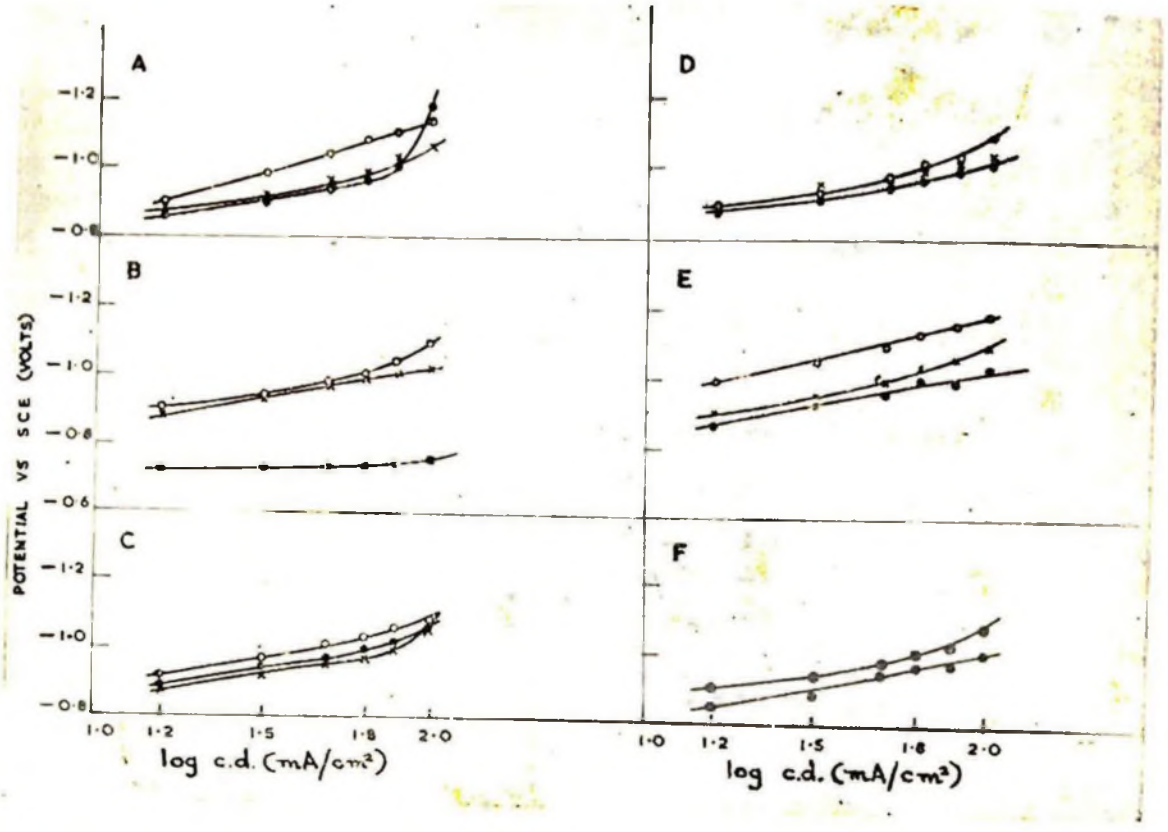


Fig. 1—Effect of Alkaloids and Cations on the Cathodic Polarization of Aluminium (2S) in Hydrochloric Acid (1M)

A: •—• 1M.HCl + 0.1% Brucine
x—x 1M.HCl + 0.1% Narcotine
o—o 1M.HCl + 0.1% Ephedrine

B: o—o 1M.HCl + 0.1% Strychnine
x—x 1M.HCl + 0.1% Papaverine hydrochloride
•—• 1M.HCl

C: •—• 1M.HCl + 0.1% Brucine + $CaCl_2$
x—x 1M.HCl + 0.1% Narcotine + $CaCl_2$
o—o 1M.HCl + 0.1% Ephedrine + $CaCl_2$

D: o—o 1M.HCl + 0.1% Strychnine + $CaCl_2$
x—x 1M.HCl + 0.1% Papaverine hydrochloride + $CaCl_2$
•—• 1M.HCl + $CaCl_2$

E: •—• 1M.HCl + 0.1% Brucine + $MgCl_2$
x—x 1M.HCl + 0.1% Narcotine + $MgCl_2$
o—o 1M.HCl + 0.1% Ephedrine + $MgCl_2$

F: o—o 1M.HCl + 0.1% Strychnine + $MgCl_2$
x—x 1M.HCl + 0,1% Papaverine hydrochloride + $MgCl_2$
(follows the above curve)
•—• 1M.HCl + $MgCl_2$.

References :

1 Putilova, I.N., Balezin, S.A. and Barannik, V. P., Metallic Corrosion Inhibitors, Pergamon Press, p. 2(1960)

2 Eldredge G. G. and Mears R. B., Ind. Eng. Chem. 37, 736 (1945)

3 Sheth, K. G and Rama Char, T. L., Corr. Technol. 8, 233(1961)

4 ,, ,, Chem. and Ind. (Lond), 1711, (1961)

5 ,, ,, Werkstoff Korrosion 14, 465 (1963)

6 ,, ,, J. Sci. Ind. Research 20D, 201 (1961)

7 ,, ,, Corr. 18, 218t (1962)

8 Jacuzewski, B and Kozlowski, Z., Rockniki Chem. 36, 1873 (1962) Chem. Res. 65, 635 (1965).

TABLE I

Corrosion of Aluminium (2S) in 0.1M. Sodium Hydroxide

Inhibition efficiencies of the alkaloids

1.	Papaverine hydrochloride (satd.)	17.0
2.	Strychnine (satd.)	0
3.	Ephedrine (0.1%)	0
4.	Brucine (satd.)	19.0
5.	Narcotine (satd.)	9.5

TABLE II

Corrosion of Aluminium (2S) in 1M. Hydrochloric acid

Inhibition efficiencies of the alkaloids

Alkaloid	Concentration of the alkaloid (W/V)			
	0.01%	0.1%	0.5%	1.0%
1. Brucine	35.6	38.3	50.9	57.5
2. Strychnine	40.1	26.1	*	*
3. Narcotine	62.3	73.6	86.2	89.2
4. Ephedrine	51.5	59.9	79.7	92.2
5. Papaverine hydrochloride	90.4	91.6	*	*

*insoluble at those concentrations.

TABLE III

Corrosion of Aluminium in Hydrochloric Acid (1M)—Effect of certain cations (Ca, Mg, Sr, Ba)

Values represent inhibition efficiencies

Alkaloid	Alkaloid at 0.1% concentration	0.009M of $CaCl_2$	$BaCl_2$	$MgCl_2$	$SrCl_2$
a. Hydrochloric	....	−22.5	7.2	23.1	−41.8
1. Brucine	38.3	16.5	11.6	−6.5	−65.1
2. Narcotine	73.6	71.4	55.1	60.8	32.6
3. Ephedrine	59.9	57.9	71.0	81.1	58.1
4. Strychnine	26.1	16.5	−23.2	20.3	7.0
5. Papaverine hydrochloride	91.6	80.4	63.8	82.6	76.7

Pyrene-Rai Metal Treatments Limited

OFFER

a complete range of **metal pretreatment processes** to meet all specific Industrial requirements.

Bonderizing — for bonding paint to metal

Parkerizing — for rust proofing

Parco-Lubrite — for reducing wear on moving parts

Bonderite / Bonderlube — for tube & wire drawing

Pyroclean / Preperite — for de-greasing and de-rusting

Manufactured in India in collaboration with The Pyrene Company Ltd., U.K.
Registered with DGS&D New Delhi

Pyrene-Rai Metal Treatments Limited

Belvandi House, 254-B, Dr. Annie Besant Road, Worli, Bombay 25 (DD)
Cables: Pyrene Rai ☐ Telephone: 457373

Pyrene

SUPPLIERS OF PRE-TREATMENT CHEMICALS OF WORLD RENOWN