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Studies on Inhibitors of Aluminum in Alkaline Media. V. The Inhibitive Effects of Polycarbonic Acids as the Corrosion Inhibitors for Aluminum in Alkaline Media.

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In the previous papers, the inhibitive action of chelating agents on aluminum in alkaline media was clarified to be due especially to the formation of insoluble film on the metal surface. In this research, the chelating agents of polycarbonic acids --- ethylenediamine-tetraacetic acid, nitrilotriacetic acid, iminoacetic acid and glycine---which form easily soluble metal chelate compounds with aluminum were used. Experimental procedures were the measurements of corrosion potential and corrosion current density as described in the previous papers.

In the solution of $\text{pH} \leq 10.5$ these polycarbonic acids promoted corrosive action on aluminum and showed no inhibitive effects.

1. Introduction

In the previous papers^{1,2,3)}, the inhibitive action of chelating agents (o-

hydroxyazo derivatives, 8-hydroxyquinoline derivatives and β -diketones) on aluminum in alkaline media was clarified to be due especially to the formation of insoluble

film on the metal surface.

The inhibition is considered to depend on the solubility of the chelate film formed on the metal. In this paper are described experiments with polycarbonic acids with which aluminum easily forms soluble metal chelate compounds.

2. Experimentals

2.1 Equipment

Corrosion potential and corrosion current density were measured according to the method described in the previous paper. pH of the alkaline media used for the experiments was regulated adding sodium hydroxide solution after the introduction of the reagents.

Measurement of corrosion potential : Using a saturated calomel electrode, potential-time curves were obtained by the same method described in the previous papers.

Measurement of corrosion current density : 3 hrs. after the immersion of the aluminum specimen into the alkaline media, and when the current was almost steady, current density-potential curves were obtained by using a platinum electrode, by the method described in the previous papers.

2.2 Specimens and reagents

Aluminum strips of 99.8% purity, 0.3 mm thick and 2×3 cm² in area, were treated

Table 1 Polycarbonic Acids

Designation	Name	Structure	Stability Const. of Cu salts log K
EDTA	Ethylenediamine tetraacetic acid	$[\text{CH}_2\text{N}(\text{CH}_2\text{CO}_2\text{H})_2]_2$	18.3
NTA	Nitrilotriacetic acid	$\text{N}(\text{CH}_2\text{CO}_2\text{H})_3$	12.7
IDA	Iminodiacetic acid	$\text{NH}(\text{CH}_2\text{CO}_2\text{H})_2$	10.3
AA	Aminoacetic acid	$\text{CH}_2\text{NH}_2\text{CO}_2\text{H}$	8.0

as described in the previous papers and used as specimen.

Polycarbonic acids as listed in Table 1 were used as reagents, having structures which enable them to form metal chelate compounds with aluminum. All reagents used are of commercial grade.

3. Results and discussions

3.1 Corrosion potential

The results obtained are listed in Table 2.

Table 2 Corrosion Potential

Additive		Electrode Potential of Aluminium (V)		
Designation	Amount%	at pH 12.8	at pH 10.5	at pH 8
EDTA	0.01	-1.12	-1.18	-
	0.05	-1.11	-1.21	-0.81
	0.10	-1.15	-1.19	-
NTA	0.01	-1.12	-1.14	-
	0.05	-1.11	-1.18	-0.64
	0.10	-1.12	-1.19	-
IDA	0.01	-1.15	-1.07	-
	0.05	-1.13	-1.13	-0.41
	0.10	-1.12	-1.13	-
AA	0.01	-	-1.07	-
	0.05	-	-1.15	-0.34
	0.10	-	-1.11	-0.42
no additive	—	-1.15	-0.74	-0.28

At pH 12.8 : The plots of the potential showed no effect of inhibition by the addition of chelating agents.

At pH 10.5 : By the addition of chelating agents, the potential shifted towards more basic side, and especially by EDTA the shift was extraordinarily pronounced.

At pH 8 : As in the case of pH 10.5, the potential shifted towards more basic side by the addition of chelating agents, but the shift was small compared with the preceding case.

At pH 6 : The potential shifted a little towards more basic side by the addition of chelating agents.

3.2 Corrosion current density

Corrosion current densities obtained from the polarization curves are listed in Table 3.

Table 3 Corrosion Current Density

Additive		Corrosion current density ($\mu\text{A}/\text{cm}^2$)		
Designation	Amount %	at pH 12.8	at pH 10.5	at pH 8
EDTA	0.01	1300	23	0.24
	0.05	1250	38.5	2.1
	0.10	1530	75	-
NTA	0.01	2150	6.6	-
	0.05	1000	17	2.2
	0.10	1200	34.3	-
IDA	0.01	1630	4.6	-
	0.05	1650	14	0.31
	0.10	1400	24	-
AA	0.01	-	8.5	-
	0.05	-	28	0.23
	0.10	-	3.9	0.33
no additive	-	1820	1.6	0.2

At pH 12.8 : By the addition of chelating agents, the corrosion current density was diminished, but the change was small.

At pH 10.5 : Corrosion current density increased with the addition of chelating agents, especially in the case of EDTA.

At pH 8 : Corrosion current density increased with the addition of chelating agents, but the change was smaller than in the case of pH 10.5.

3.3 Discussion of the results obtained

In the range of pH 8 ~ 10.5, by the addition of the polycarbonic acid reagents the electrode potential shifted towards more basic potential side, the corrosion current density increased and corrosion was concluded to be promoted especially by the addition of EDTA.

The corrosion current density increases with contents of polycarbonic acids, and the addition of polycarbonic acids shows a negative effect on the inhibition. The gradient of the line increases with increasing stability constant of the formed aluminum chelates.

4. Conclusion

From the results obtained, it was concluded that polycarbonic acids which are able to form easily soluble chelate compounds with aluminum in alkaline solution ($\text{pH} \leq 10.5$) shows no inhibitive action, but on the contrary promotes the corrosion of aluminum.

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