

EFFECT OF POLYAMINO POLYCARBOXYLIC ACIDS ON  
THE CORROSION OF ALUMINIUM IN ALKALINE MEDIUM

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ABSTRACT

The corrosion rate of aluminium, in 0.15 N NaOH solution, in presence of some polyamino polycarboxylic acids (chelating agents) was studied by weight loss techniques. The corrosion rate of aluminium was found to be initiated in presence of such chelating agents. The dissolution of aluminium increased as the donor atoms increased. A proposed mechanism was given to explain this phenomenon.

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## INTRODUCTION

The inhibition of the corrosion of some metals such as aluminium and zinc, in aqueous solutions of alkalis, whose hydroxides are amphoteric have been thoroughly investigated<sup>1,2</sup>. The behaviour of the inhibitors in this case is strictly related to the solubility of the surface oxides or hydroxides at various pHs. The action of the inhibitors is explained by assuming that they have an effect in repairing the pores in oxide and hydroxide films. The inhibitors can no longer exercise any effective action in a clearly alkaline medium in which the oxides and hydroxides of aluminium and zinc are soluble.

The efficiency of inhibitors depends on their molecular structures<sup>3</sup>, their molecular area<sup>4</sup> and their molecular weights<sup>5,6</sup>. Therefore, it is of great interest to study the effect of some polyamino polycarboxylic acids having different functional groups as well as various molecular weights on the corrosion of aluminium in alkaline medium. The polyamino polycarboxylic acids used in the present investigation are: ammonia triacetic acid (TTW), ethylene glycol - bis - ( $\beta$ -amino ethyl ether) - N,N - tetra acetic acid (EGTA), ethylene diamine tetraacetic acid (EDTA) and diethylene triamine pentaacetic acid (DTPA).



## EXPERIMENTAL

Polyamino polycarboxylic acids (TTN, EGTA, EDTA and DTPA) were of the highest purity available. Their structures and dissociation constant values<sup>7</sup> are given in Table 1. The concentration of the chelating agent studied varied between  $0.38 \times 10^{-4}$  and  $0.54 \times 10^{-2}$  mole. Aluminium sheets of spectroscopic purity (Johnson and Matthey, London) were used in these investigations. The metallic sheets had an apparent surface area of  $100 \text{ cm}^2$  each. Determination of the corrosion rate was performed by weight loss techniques. Measurements were made in 0.15 N sodium hydroxide free carbonates at  $32 \pm 0.5^\circ$  using bidistilled water. The results were obtained in duplicate and no significant discrepancies were observed.

## RESULTS AND DISCUSSION

Figs. 1,2,3 and 4 show the corrosion rate of aluminium at different concentrations of TTN, EGTA, EDTA and DTPA in 0.15 N sodium hydroxide solution, respectively. It was observed that corrosion of aluminium increases in presence of polyamino polycarboxylic acids. Also as the concentration of the chelating agent increases the corrosion rate increases. These results indicate that the studied chelating agents act as accelerators for the corrosion of aluminium in alkaline medium.

Polyamino polycarboxylic acids form complexes with metal ions such as aluminium, iron, cobalt, nickel and copper<sup>8,9</sup>. The formation of such complexes depends on the acidity as well as the alkalinity of the medium. The normal complex is stable in the pH range 4—10. At pH >10 hydroxo complex is formed, while at pH <3.5 protonated complex is formed which decomposes at pH <1.5 to free metal and chelating agent. Since the experimental work was done at pH >10, it may be expected that hydroxo aluminium complex is formed at such medium.

Therefore, one can suggest the effect of the studied polyamino polycarboxylic acids on the alkaline corrosion of aluminium. The hydroxyl ions react with aluminium forming sodium aluminate. Simultaneously, polyamino polycarboxylic acids react with the aluminium surface forming hydroxo complex. This leads to an increase in the corrosion rate of aluminium.

Also, it was experimentally observed that, the corrosion rate of aluminium in alkaline medium increases in the order:



This can be explained by the increasing number of the donor atoms of the chelating agents which increase the probability of forming the soluble hydroxo compound.

It can be concluded that TTN, EGTA, EDTA and DTPA act as accelerators for the alkaline corrosion of aluminium.

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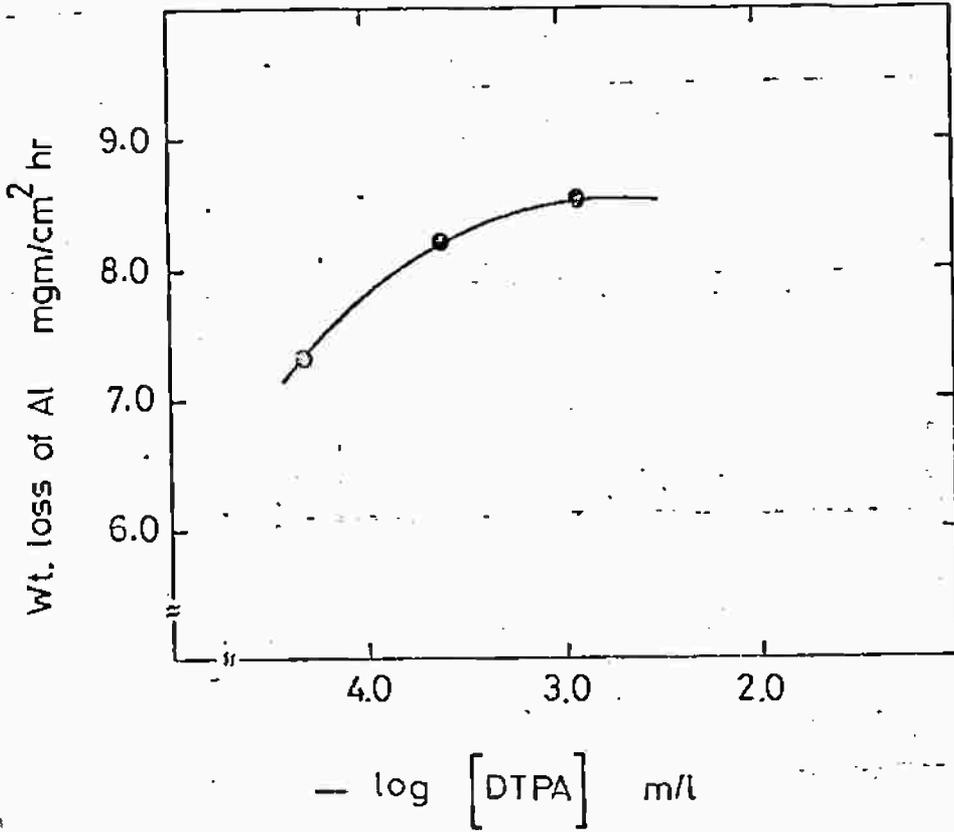


Fig. 4

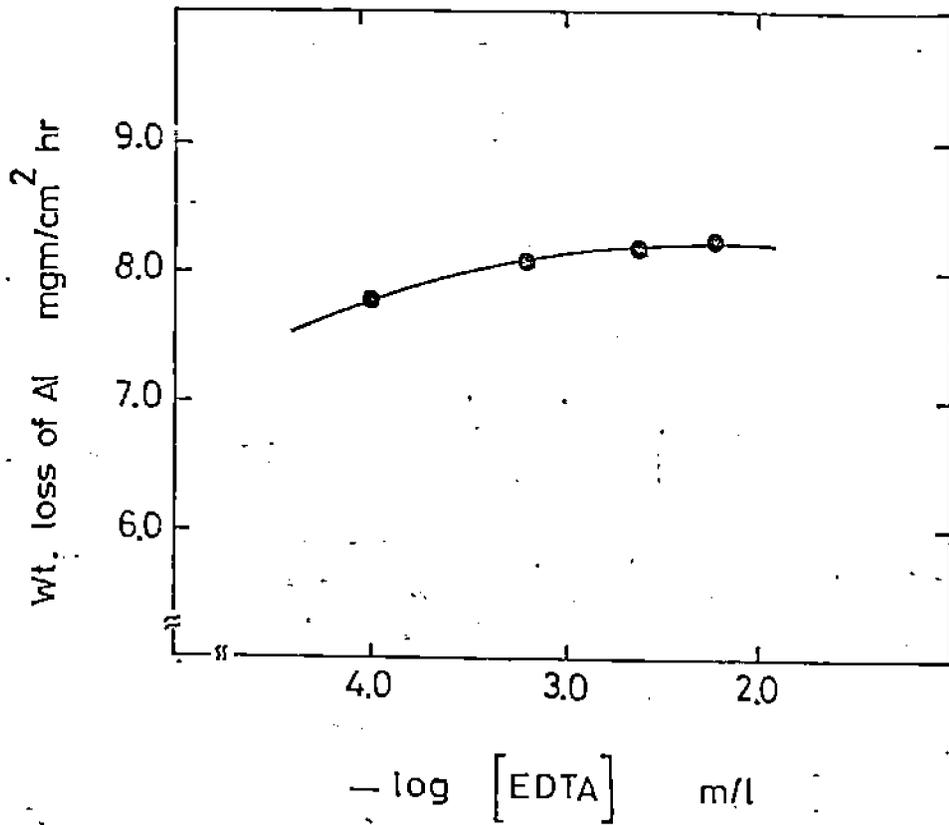


Fig. 3

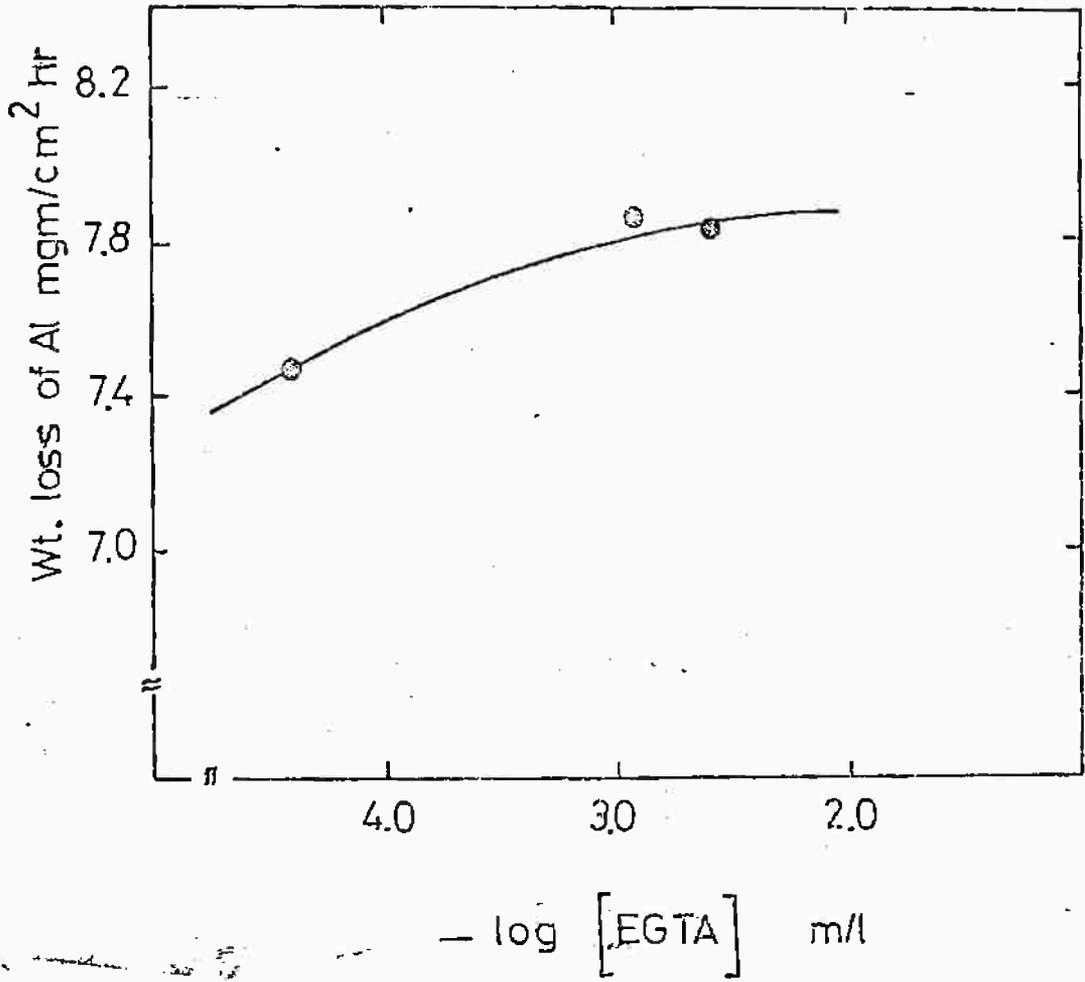


Fig. 2

Table. 1 : Dissociation Constants of some Polyamino polycarboxylic acids

Name and formula	Dissociation constants <sup>1</sup>				
	pK <sub>1</sub>	pK <sub>2</sub>	pK <sub>3</sub>	pK <sub>4</sub>	pK <sub>5</sub>
Ammonia triacetic acid (TTA). $\begin{array}{c} \text{CH}_2\text{COOH} \\ \diagdown \\ \text{N} \\ \diagup \\ \text{CH}_2\text{COOH} \\ \text{CH}_2\text{COOH} \end{array}$					
Ethylene glycol -bis-(B-amino ethyl ether)- N,N tetra acetic acid (EGTA). $\begin{array}{c} \text{HOOC-CH}_2 \\ \diagdown \\ \text{N} \\ \diagup \\ \text{HOOC-CH}_2 \end{array} \left[ (\text{CH}_2)_2\text{-O} \right]_2 \text{-} (\text{CH}_2)_2 \text{-} \begin{array}{c} \text{CH}_2\text{-COOH} \\ \diagdown \\ \text{N} \\ \diagup \\ \text{CH}_2\text{-COOH} \end{array}$	2.00	2.68	8.85	9.43	
Ethylene diamine tetraacetic acid (EDTA) $\begin{array}{c} \text{HOOC-CH}_2 \\ \diagdown \\ \text{N} \\ \diagup \\ \text{HOOC-CH}_2 \end{array} \text{-CH}_2\text{-CH}_2\text{-N} \begin{array}{c} \text{CH}_2\text{-COOH} \\ \diagdown \\ \text{N} \\ \diagup \\ \text{CH}_2\text{-COOH} \end{array}$	1.99	2.67	6.16	10.26	
Diethylene triamine pentaacetic acid (DTPA). $\begin{array}{c} \text{HOOC-CH}_2 \\ \diagdown \\ \text{N} \\ \diagup \\ \text{HOOC-CH}_2 \end{array} \text{-} (\text{CH}_2)_2 \text{-N-} (\text{CH}_2)_2 \text{-N} \begin{array}{c} \text{CH}_2\text{COOH} \\ \diagdown \\ \text{N} \\ \diagup \\ \text{CH}_2\text{COOH} \end{array}$	1.80	2.55	4.33	8.60	10.58

FIGURES CAPTIONS

- Fig. 1 : Effect of the concentration of ammonia triacetic acid on the corrosion of aluminium in 0.15 N NaOH at 32°.
- Fig. 2 : Effect of the concentration of ethylene glycol - bis -(β - amino ethyl ether) - N,N - tetra acetic acid on the corrosion rate of aluminium in 0.15 N NaOH at 32°.
- Fig. 3 : Effect of the concentration of ethylene diamine tetraacetic acid on the corrosion rate of aluminium in 0.15 N NaOH at 32°.
- Fig. 4 : Effect of the concentration of diethylene triamine pentaacetic acid on the corrosion of aluminium in 0.15 N NaOH at 32°.

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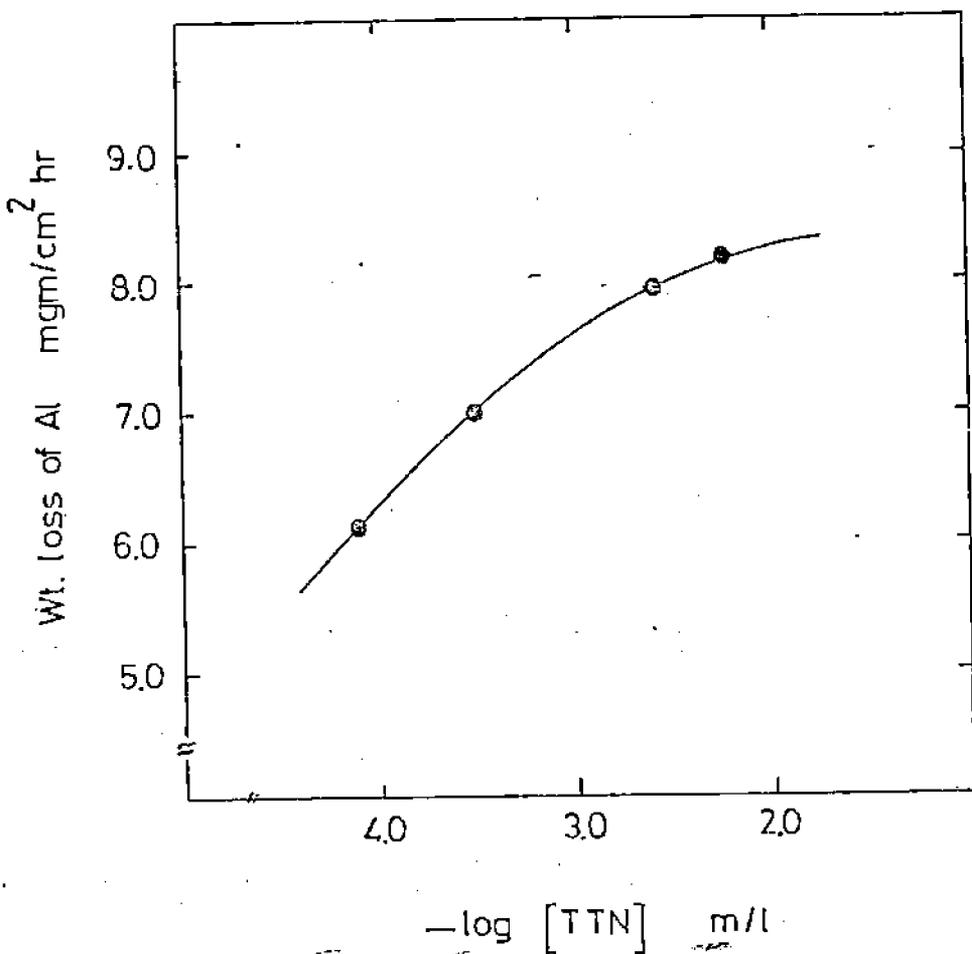


Fig.1