Novel polymeric inhibitor for corrosion of 57S aluminium in 2M NaOH solutions

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Abstract

Purpose – The purpose of this paper is to show how to develop inhibition 57S aluminium in 2M NaOH solution.

Design/methodology/approach – The approach is used to measure gravimetric and polarization measurements.

Findings – The results of the paper clearly reveal that the 0.2 M ZnO with 700 ppm polyaniline in *N*-methyl-2-pyrrolidone solution is found to offer inhibition up to 71.2 per cent.

Originality/value – The paper deals with the development of newer inhibitor based on polyaniline. Gravimetric and galvanostatic methods were employed to evaluate inhibition efficiency.

Keywords Corrosion inhibitors, Chemical elements and inorganic compounds

Paper type Research paper

Introduction

In alkali solutions, corrosion of aluminium occurs at a high rate with the passivation of the metal accompanied by hydrogen evolution. Several organic compounds have been tried as corrosion inhibitors. The inhibition efficiency was brought down by the high-negative potential of the reaction, which would simply repel any organic compound in the electrical double layer (Antropov, 1961). Nevertheless, quite a large number of organic compounds inhibit corrosion in dilute solutions but eventually fail at higher concentrations. Carbonic acids (Horiguchi *et al.*, 1966), aliphatic and aromatic amines (Sarangapani *et al.*, 1984), diketones (Horiguchi *et al.*, 1966), phenolic compounds (Subramanyan *et al.*, 1971) alkaloids (Subramanyan and Ramakrishnaiah, 1971) alizarin derivatives were tried as inhibitors.

The present investigation aims at the development of polyaniline as corrosion inhibitor. Gravimetric and electrochemical measurements were carried out.

Experimental

Aluminium specimens (5 × 2 × 0.2 cm) were cleaned in dilute NaOH solutions at 30°C for 2-3 min, washed thoroughly well with distilled water finally with conductivity water and dried. Dried specimens were subjected to cloth buffing and then to polishing using pumice powder. Specimens were then degreased with trichloroethylene. Analar grade chemicals were used. Polyaniline synthesized in the laboratory was used after dissolving in *N*-methyl-2-pyrrolidone (NMP) solution.

For galvanostatic polarization, experiments were carried out on specimens of 0.8 cm diameter with an exposed area of 5 cm^2. Three-electrode cell assembly was used. Polished 57S aluminium was used as working electrode, a cylindrical platinum foil area of 16 cm^2 as auxiliary electrode and Hg/HgO/2 M NaOH as reference electrodes. Galvanostatic polarization measurements were made using a PARSTAT electrochemical analyzer. The current-potential curves were recorded after the specimens attained steady values.

Gravimetric measurements were made by exposing these specimens for 60 min. Losses in weight were followed:

$$\text{The percentage inhibition } \%\ \text{IE} = \frac{W_0 - W_1}{W_0} \times 100$$

where:

W_0 Loss in weight of aluminium without additives.
W_1 Loss in weight of aluminium in presence of additives.

Extrapolation of linear portion of anodic and cathodic polarization curves to corrosion potential was used to calculate corrosion current density:

$$\%\ \text{inhibition efficiency} = \frac{I_{corr} - I'_{corr}}{I_{corr}} \times 100$$

where, I_{corr}, I'_{corr} are corrosion current densities in absence and presence of additives, respectively.

Results

Table I presents, the percentage of inhibitor efficiency obtained in presence of 0.2 M ZnO. Addition of polyaniline enhanced the inhibition of aluminium corrosion. Increase of

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Table I Inhibition efficiency of 57S grade aluminium in 2 M NaOH by ZnO

Solution	Corrosion rate (mg/cm^2/min)	Inhibition efficiency (%)
2 M NaOH	0.9375	–
2 M NaOH + 0.2 M ZnO	0.766	18.3

polyaniline concentration increased the percentage of inhibition. Maximum inhibition efficiency was obtained in 700 ppm (Table II). Table III presents the parameters derived from galvanostatic polarization. Additions of polyaniline decreased the corrosion of aluminium. Shift of corrosion potentials to noble directions suggest the formation of passive film. 700 ppm polyaniline addition offered maximum inhibition efficiency of 45 per cent Figures 1-2.

Discussions

Inhibitors of aluminium corrosion in aqueous medium have been reviewed (Jayalakshmi and Muralidharan, 1997). In aqueous solution, the surface film formed on aluminium is of duplex in nature consisting of an inner amorphous Al_2O_3 and outer crystalline aluminium oxides. These films inhibit corrosion in the initial stages but weaken this film due to the incorporation of OH^- ions into this structure and

Table II Inhibition efficiency of 57S grade aluminium in 2 M NaOH + 0.2 ZnO

Effect of polyaniline concentration		
Concentration of polyaniline (ppm)	Corrosion rate (mg/cm^2/min)	Inhibition efficiency (%)
0	0.766	18.3
100	0.616	34.3
200	0.507	45.9
300	0.479	48.9
500	0.363	61.3
600	0.290	69.1
700	0.270	71.2

Note: Percentage of inhibition efficiency calculated with respect to 2 M NaOH

Table III Parameters derived from galvanostatic polarisation

Solution	Corrosion potential volt vs Hg/HgO	Tafel slope (mv/decade) Anodic	Cathodic	Corrosion current density μA/cm^2	Inhibition efficiency (%)
2 M NaOH + 0.2 M ZnO	–	40	90	290	–
2 M NaOH + 0.2 M ZnO + 600 ppm of polyaniline	−1.710	40	80	200	23
2 M NaOH + 0.2 M ZnO + 700 ppm of polyaniline	−1.630	40	60	160	45

Figure 1 E-logi curves for the corrosion of 57S aluminium in 2 M NaOH + 0.2 M ZnO

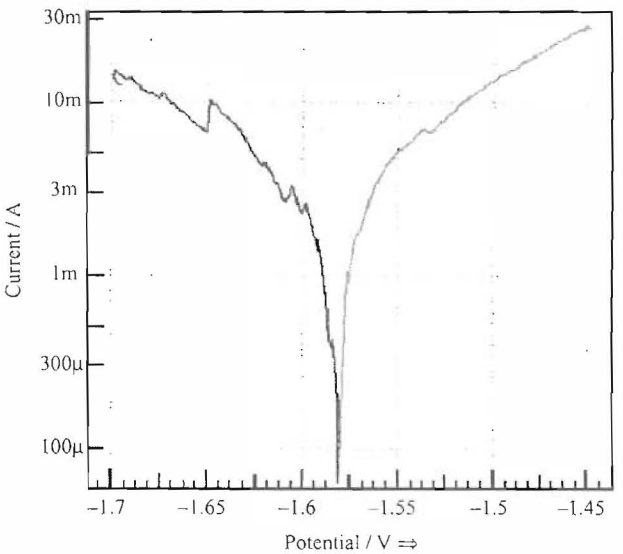
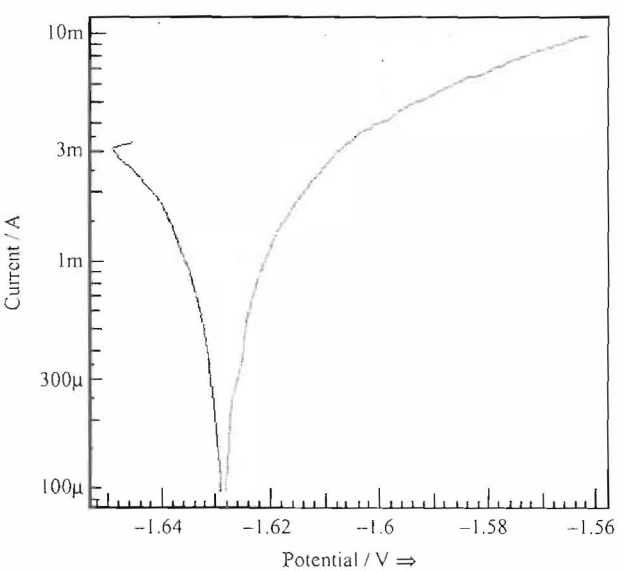


Figure 2 E-logi curves for the corrosion of 57S aluminium in 2 M NaOH + 0.2 M ZnO + 700 ppm polyaniline



accelerate corrosion. In presence of excess OH^- ions, aluminium dissolves to form aluminate. Additions of organic compounds inhibit to a lesser degree. Owing to the high-negative electrode potentials, they desorbe and accelerate corrosion. Most of the organic inhibitors inhibit hydrogen evolution reaction to some extent.

In the present study, addition of ZnO in solution shifted the corrosion potential to noble direction by forming a film. The conductivity of the film has been enhanced by incorporating polyaniline. The corrosion of aluminium has been inhibited by the combined action of polyaniline and ZnO. The formation of an oxide film encapsulated with polyaniline prevented the dissolution of aluminium.

Electrochemical measurements were made over a period of 20 min gravimetric measurements were carried out over

a period of an hour. The inhibition of aluminium corrosion was by the formation of polymeric film which was the time dependent. During the electrochemical measurements, the formation of three dimensional films has been complete and hence percentage of inhibitor efficiency obtained was lower compared to gravimetric measurements.

Conclusion

Additions of 0.2 M ZnO inhibited the corrosion of 57S aluminium in 2 M NaOH solution. Seven hundred parts per million polyaniline in NMP solutions and 0.2 M ZnO offered enhanced inhibition. The formation of ZnO incorporated with polyaniline inhibited the corrosion of 57S aluminium.

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