

## **Polarization studies on zinc in hydrochloric acid solution containing some organic solvents**

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### **RÉSUMÉ**

Le comportement de corrosion du zinc métallique dans certains solvants organiques a été testé électrochimiquement en utilisant les mesures de polarisation galvanométrique. Les résultats ont montré que les solvants organiques étudiés agissent comme des inhibiteurs de type mixte. L'inhibition semble se produire par l'adsorption physique des molécules inhibitrices selon une isotherme de Temkin. L'efficacité d'inhibition des solvants augmente dans l'ordre suivant : glycérol>éthylène glycol>DMSO>dioxane. Cet ordre n'est pas affecté par une variation de température dans l'intervalle compris entre 35 et 55°C. La corrosion augmente avec la température, en absence ou en présence d'inhibiteurs. Certains paramètres thermodynamiques d'adsorption ont été calculés et discutés.

**Mots-clés :** Certains solvants organiques, corrosion acide, zinc.

### **ABSTRACT**

The corrosion behaviour of zinc metal in some organic solvents was tested electrochemically using galvanometric polarization measurements. The results showed that the studied organic solvents act as mixed type inhibitors. The inhibition was assumed to occur via physical adsorption of the inhibitor molecules fitting a Temkin's isotherm. The inhibition efficiency of the solvents increase in the order: glycerol>ethylene glycol>DMSO>dioxane. This order is not affected by the variation in temperature in the range 35-55°C. The increase in temperature was

found to increase the corrosion in absence and in presence of inhibitors. Some thermodynamic parameters for adsorption were also computed and discussed.

**Key words:** Some organic solvents, acid corrosion, zinc.

## INTRODUCTION

Because of the wide spread use of zinc, the study of its corrosion has turned to be an outstanding subject in corrosion with the industry of today. Researchers of the corrosion of zinc in hydrochloric acid has been accumulated in the literature [1-8]. The investigation of the dependence of the corrosion rate on the solvation of the metal surface and the physicochemical properties of the medium is extremely limited. The acid corrosion of metals in organic solvents was studied by Schwabe [9]. Further work involving the use of organic solvents was done by Heitz [10,11]. Among nitrogen containing compounds, quinoline [12], aniline [13] and ephedrine, narcotine, brucine, strychnine, etc. [14], have shown good inhibition towards zinc in acidic medium.

The present study was undertaken to investigate the inhibition of corrosion of zinc in hydrochloric acid using some organic solvents and also to throw some light on their mechanism of inhibition.

## EXPERIMENTAL

The zinc used having the following composition in weight percent: Fe 0.0015, Pb 0.001, Cd 0.0004, Sn 0.0003, Cu 0.0001, Zn remainder. All chemicals used were of A.R. grade. The solutions were made from bidistilled water. The test electrodes were cut from zinc sheet. The surface were abraded successively with 4/0 emery paper before degreasing with methanol and washing with bidistilled water.

Polarization experiments were carried out under unstirred conditions with a fine luggin capillary to avoid ohmic polarization. Galvanostatic condition was maintained using an Amel galvanostat - potentiostat (model 549). A saturated calomel electrode and platinum electrode were used as reference and auxiliary electrodes, respectively. The potential were recorded using an Orion digital ionalyzer (model 701 A). For each experiment a new specimen was used. All experiments were carried out in thermostat at  $35 \pm 0.2^\circ\text{C}$ .

The protection efficiency (%P) and the degree of coverage ( $\theta$ ) of the investigated surface by the adsorbed molecules were calculated using the formulae:

$$\%P = \frac{I - I'}{I} \times 100 \quad \text{and} \quad \theta = \frac{I - I'}{I} \quad (1,2)$$

where  $I$  and  $I'$  are the corrosion currents without and with inhibitor, respectively. Equation 2 can be used to calculate the degree of coverage  $\theta$ , assuming that the adsorbed molecules mechanically screen the coated part of the electrode surface and therefore protect it from the action of the corrosive medium. But the degree of surface coverage calculated from this equation is inaccurate. This is due to the fact that the adsorption on the electrode depends not only on the adsorptive power of the organic compound and the character of the metal but also on the electrode potential and on the potential drop in the diffuse part of the double layer. The adsorbed molecules can change the charge of the electrode and consequently also its potential, and as a result inaccurate values of  $\theta$  calculated from equation 2 are obtained. For accurate  $\theta$  values some additional conditions must be fulfilled: changes in electrode potential caused by adsorption of the inhibitor, the heterogeneity of the metal surface and the choice of concentration of the electrolyte, which made the potential drop in the diffuse part of the double layer; all these parameters must be small.

## EXPERIMENTAL RESULTS AND DISCUSSION

The logarithmic current density - potential curves shown in Fig. 1 were obtained when zinc electrodes were allowed to react with 1M HCl in presence of DMSO with varying composition (0-30% by volume). The cathodic and anodic polarization curves exhibited Tafel-type behaviour. The results obtained for other organic solvents were quite similar. The electrochemical parameters of zinc in 1M HCl are given in Table I. It is clear that the corrosion current and consequently the corrosion rate declines with increasing concentration of DMSO in the medium. This indicates that the presence of DMSO retards the dissolution of zinc and the extent of corrosion depends on the concentration of DMSO. The slope of cathodic and anodic Tafel lines remains almost unchanged on increasing the concentration of DMSO. This indicates that the adsorbed molecules have no effect on the mechanism of either zinc dissolution or hydrogen evolution reaction. Behaviour of this type has been observed for iron in sulphuric acid solutions containing aliphatic sulphide [15] and for iron in hydrochloric acid containing benzene sulphonyl hydrazone derivatives [16].

The corrosion of zinc in hydrochloric acid is an electrochemical process, the anodic reaction of which is:  $Zn \rightarrow Zn^{2+} + 2e$

and the cathodic reaction is:  $H^+ + e \rightarrow H_{ads}$ .

followed by:  $H_{ads} + H_{ads} \rightarrow H_2$ .

From Table I, it was observed that there is no change in the corrosion potentials. Therefore the inhibition is mainly due to an increase in the polarization of cathodic and anodic processes.









