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Study of corrosion inhibition property of metal oxides for carbon steel in acidic medium by gravimetric analysis

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Metal oxides (MO) due to their basic nature have been selected as corrosion inhibitor for carbon steel in 1 *N* hydrochloric acid solution. Metal oxide such as ZnO, NiO, Eu_2O_3 are used as corrosion inhibitors and the corrosion inhibition efficiencies were compared. The behavior of metal oxide, MO as a corrosion inhibitor for carbon steel in 1 *N* HCl acidic medium has been investigated by weight loss method at room temperature. The corrosion inhibition efficiency (IE) increased with increase in concentration of MO except NiO.

Keywords: Carbon steel, metal oxides, corrosion inhibition, weight loss method.

Introduction

Pickling is a metal surface treatment used to remove impurities such as stains, inorganic contaminants, rust or scale from ferrous metals. Various chemical solutions are usually used to clean these impurities. Strong acids, such as hydrochloric acid and sulphuric acid are common. These solutions usually contain additives such as wetting agent and corrosion inhibitors. Metal oxides (MO) due to their basic nature have been selected as corrosion inhibitor for carbon steel in 1 *N* hydrochloric acid solution. Titanium(IV) oxide[1], reduced graphene oxide[2], octylphenol polyethylene oxide[3], were investigated for their corrosion inhibition property for carbon metal. Due to their nanosized particle nature, enhanced corrosion resistance was reported.

In the present work, metal oxide such as ZnO, NiO and Eu_2O_3 are used as corrosion inhibitors for carbon steel in 1 *N* HCl acid by weight loss method (Gravimetric analysis).

Experimental

Material preparation:

Mild steel coupons of 4×1×0.2 cm dimensions were taken for the study. They were polished with fine grade emery sheets and then degreased with trichloroethylene. They were dried with a drier and cooled in desiccator and subjected for weight loss study.

Weight loss determination:

In this method, the loss of metal due to corrosion is measured by exposing the metal specimen of know area to the environment for a period of 1 h and the difference in weight before and after exposure is calculated. Corrosion rate (CR), inhibition efficiency (IE) was calculated.

$$\text{Inhibition efficiency (\%)} = \frac{W - W_1}{W_1} \times 100$$

where, W and W_1 = weight loss in the absence and presence of inhibitor.

$$\text{Corrosion rate (mm/y)} = \frac{W \times K}{D \times A \times T}$$

where, W = weight loss in mgs, K = 87.6 (constant), D = alloy density (7.86 g/cm^3), A = exposed area (cm^2), T = exposure time (h).

Results and discussion

Analysis of weight loss method:

Different corrosion parameters such as corrosion rate and inhibition efficiency were studied for different concentration of metal oxide in 1 *N* HCl solution for 1 h at 303 K. The corrosion rate for the carbon steel in 1 *N* HCl in the absence of inhibitor is 14.0427 mm/y. It's observed that with the rise in concentration of the inhibitor, the weight loss decreased, and the inhibition efficiency had increased for nickel oxide and zinc oxide than with europium oxide. 250 ppm of ZnO showed maximum of 24.6% of IE compared to 19.8% with 250 ppm of NiO and –5.56% with 250 ppm of Eu_2O_3 (Table 1). Eu^{3+} ion will be reduced by metal in presence of HCl acid to give Eu^{2+} in solution[4]. Divalent europium is a mild reducing agent and hence CR for carbon steel was found to be high for Eu_2O_3 (Fig. 1).

Table 1. IE% obtained from weight loss measurements of mild steel in 1 *N* HCl solution containing various concentrations of metal oxides room temperature (Immersion period – 1 h)

Conc. of inhibitor solution	IE%		
(ppm)	ZnO	NiO	Eu_2O_3
0	–	–	–
50	2.38	36.5	–71.42
100	7.94	34.9	–42.86
150	8.7	25.4	–35.71
200	11.9	21.4	1.59
250	24.6	19.8	–5.56

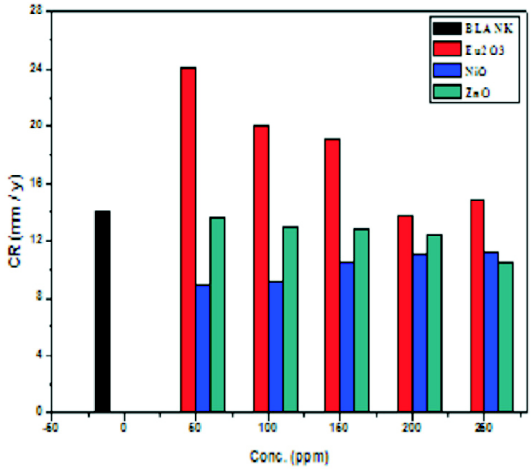

Fig. 1. Corrosion rate (mm/y) mild steel immersed in 1 *M* HCl at 303 K in the presence and absence of inhibitors (Immersion period – 1 h).

Conclusions

Corrosion rate of mild steel decreased with increase in concentration of the inhibitors. Inhibition efficiency increased with increase in concentration of inhibitors except NiO, which showed reverse effect with increase in concentration of NiO. Inhibition efficiency of metal oxide inhibitors on corrosion of mild steel in 1 *N* HCl is in the order of ZnO > NiO > Eu_2O_3.

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