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COMPARATIVE INHIBITIVE EFFECT OF HYDROXYETHYLCELLULOSE ON MILD STEEL AND ALUMINIUM CORROSION IN 0.5M HCL SOLUTION

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ABSTRACT

The inhibitive effect of HEC on Mild steel and Aluminium corrosion in 0.5M HCl solution under atmospheric exposure was studied using weight loss method. From the results obtained, it was observed that the corrosion rate was higher in Aluminium than in Mild steel. Inhibition efficiency and surface coverage were however, found to be higher in Mild steel than in Aluminium. In addition, corrosion current was determined. From our results, the corrosion current was higher in Mild steel than in Aluminium.

Keywords: Aluminium; Hydroxyethylcellulose; corrosion inhibition; corrosion current; Inhibition Efficiency.

INTRODUCTION

The deterioration of metal pipes, tanks and other component parts etc used in oil and gas, ship building, construction and fabrication, electrical and electronics and other engineering industries has been a major problem. So many lives have been lost and many persons displaced, all as a result of corrosion damage. Considering the severity of these corrosion damages in various engineering fields, there is need to at least reduce the rate of corrosion attack on metals if not prevent it completely (Aramide, 2009).

There are various methods of preventing corrosion. Some methods are meant to create a barrier between the metals and the corrodent while others are used in such a way that the attacking strength of the corrodent is reduced by adjustment or alteration of chemical composition (Umoren, et al., 2009). The various methods of preventing corrosion include cathodic protection (Subasria et al., 2005; Kim et al., 2006), anodic protection (Cecchetto et al., 2007), coating (Praveen et al., 2007) and the use of corrosion inhibitor (Orubute-Okorosaye, 2007; Eddy et al., 2009; Kumpawat et al., 2009; Oguzie, 2008)

Corrosion inhibitors are substances which when added in small concentrations to an aggressive corroding environment decrease the corrosion rate considerably (Aramide, 2009). Several inhibitors in use are either synthesized from cheap raw materials or chosen from compounds having hetero atoms in their aromatic or long chain carbon system (Ameer et al., 2000; Quraishi and Sharma, 2005).

However, most of these inhibitors are toxic to the environment (Umoren et al., 2006). This has prompted the search for non-toxic, eco-friendly corrosion inhibitors.

The present study seeks to investigate the inhibitive behaviour of hydroxyethylcellulose(HEC) for mild steel and aluminium corrosion. HEC is a modified non-ionic, water soluble cellulose polymer widely used as a gelling and thickening agent.

MATERIALS AND METHODS

Mild steel sheet of thickness, 0.2cm and composition (wt.%) C = 0.18, Mn = 0.5, P = 0.35, Si = 0.03, and the remainder Fe, was obtained from delta steel company, Delta state, Nigeria. The Aluminium sheet with thickness 0.05cm is of the type AA1060 and purity of 98% with composition. (wt. %) S_i = 0.12, Fe = 0.02, Mn = 0.04, and the remainder AL, was obtained from System Metal industries limited Calabar, Nigeria.

The two metals were mechanically press cut into 4cm x 2cm coupons. A small hole was drilled at one side of the coupons to support the hook. The coupons were polished mechanically using silicon carbide papers of grade no. 166, washed thoroughly with distilled water and degreased with ethanol and acetone and air dried. Stock solutions of 0.0005M, 0.0010M, 0.0015M, 0.0020M and 0.0025M of HEC (Hydroxyethylcellulose) were prepared. Similarly, Stock solution of 0.5M HCl was prepared using serial dilution principle.

Weight loss measurements

The weighed mild steel and aluminium coupons were suspended in the 250 ml beaker containing the prepared solutions, with the aid of glass rods and hooks and placed where it was exposed to atmosphere. The coupons were retrieved at 24-hour interval, progressively for 7 days (168hours); washed by immersion in distilled water and ethanol. At the end of the test, the coupons were carefully washed in absolute ethanol and nitric acid to quench further corrosion. The weight losses of coupons were evaluated in grammes as the difference between the initial weight before immersion and weight after immersion. From the results obtained the following corrosion parameters were evaluated:

Corrosion Rate: This is expressed in millimeter per year (mm/yr) **(Vipin et al. 2009)**

$$\text{Corrosion rate (mm/yr)} = \frac{87600W}{\rho At}$$

Where W = weight loss in grammes (g)

ρ = density of the coupon (g/cm^3)

A = area of coupon in cm^2

t = time of exposure (hours)

Inhibition Efficiency (IE%): This is the percentage by which corrosion rate is reached in the presence of inhibitor compared with the rate in which corrosion occurs without inhibitor ie

$$IE\% = [1 - (W_1/W_0)] \times 100$$

Where W_1 = weight loss in the presence of inhibitor

W_o = weight loss in the absence of inhibitor

Surface coverage (θ):- This is the area covered by the inhibitor.

$$\theta = [1 - (W_1/W_0)]$$

Corrosion Current

Corrosion current is determined from the expression (Jonnes, 1996):

$$I_{corr} = \frac{CR \times \rho \times A}{K \times Ew}$$

Where I_{corr} = corrosion current in Amps.

CR = corrosion rate in mm/yr

ρ = density of metal coupon in g/cm^3

A = Area of coupon in cm^2

K = Constant that defines the units for the corrosion rate

Ew = Equivalent weight of corrodent in grams/equivalent

RESULTS AND DISCUSSIONS

The weight loss of the mild steel and aluminium in 0.5M HCl with and without different concentrations of HEC was determined after 24-hour interval progressively for 7 days (168 hours) under atmospheric exposure. The corrosion rates, inhibition efficiencies, surface coverage and corrosion current values were evaluated and presented in Tables 1.0 and 2.0.

Corrosion rates increased with increase in acid concentration (Figure 1). It was also observed that corrosion rates decreased with increase in concentration of the inhibitor (HEC). However, the corrosion rate was higher in Aluminium than in Mild steel. Similarly, the inhibitor efficiency was higher in Mild steel than in Aluminium (Figure 2). This could because the surface area covered by the (HEC) was larger in Mild steel than in Aluminium (Figure 3). The corrosion current determined was found to be higher in Mild steel than in Aluminium as shown in Figure 4. Again, it also decreased with increase in inhibitor concentration.

Table 1.0

Calculated values of corrosion rate (mm/yr), inhibition efficiency (IE %), degree of surface coverage (θ) and corrosion current (Amps)for Hydroxyethylcellulose (HEC) in 0.5M HCl corrosion of Mild steel from weight loss data.

Inhibitor Concentration	Corrosion Rate (mm/yr)	Inhibitor Efficiency (I.E. %)	Degree of Surface Coverage (θ)	Corrosion Current (Amps)x 10^{-5}
Blank	1.598	-	-	7.633
5.0×10^{-4}M	1.255	11.966	0.120	6.700
1.0×10^{-3}M	1.213	31.410	0.314	5.245
1.5×10^{-3}M	1.116	33.547	0.335	5.097
2.0×10^{-3}M	0.876	49.145	0.491	3.881
2.5×10^{-3}M	0.512	67.949	0.679	2.442

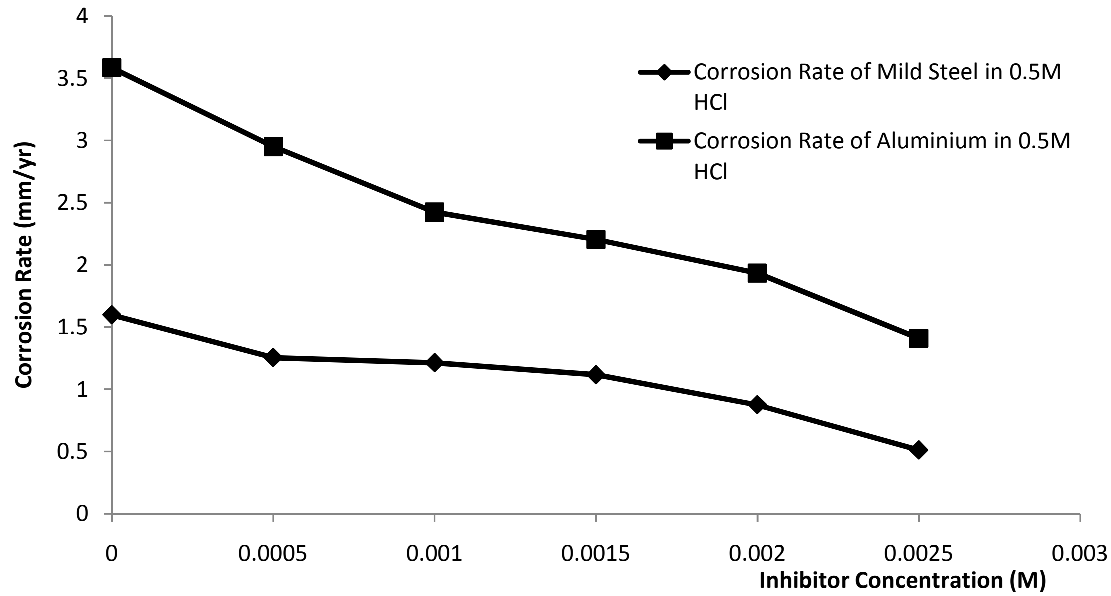

Fig. 1: Plot of Corrosion Rate against Inhibitor Concentration for MS and Al in 0.5M HCl

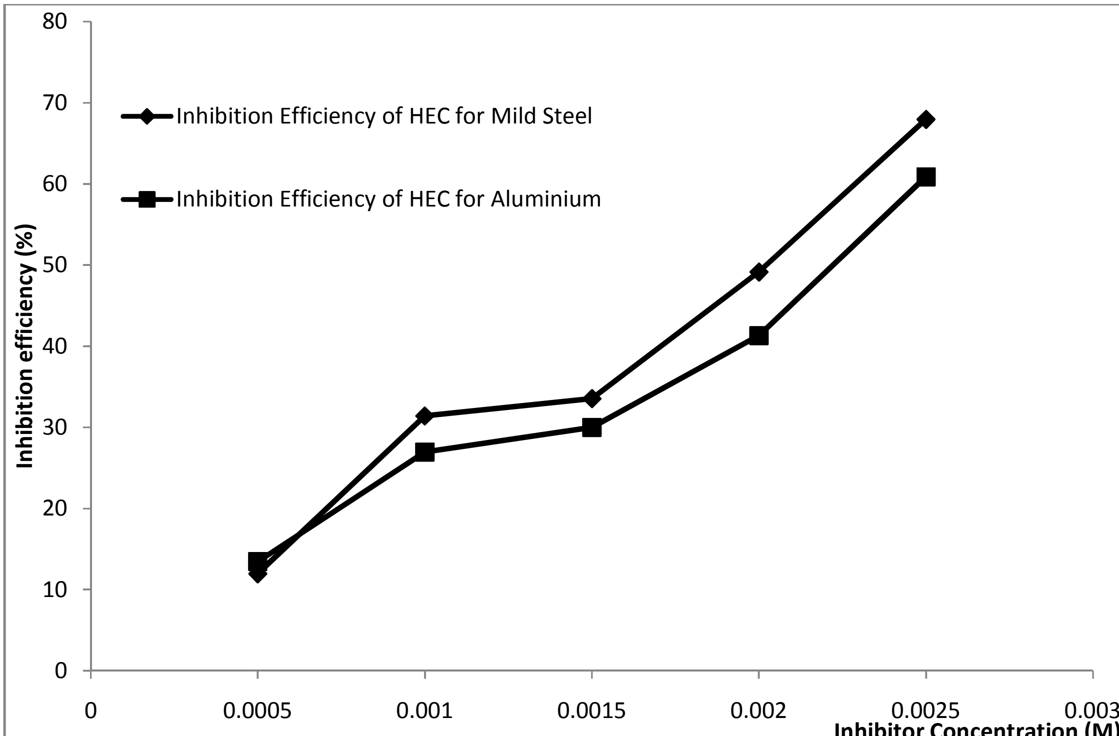

Fig.2: Plot of Inhibition Efficiency of HEC for MS and Al corrosion in 0.5M HCL

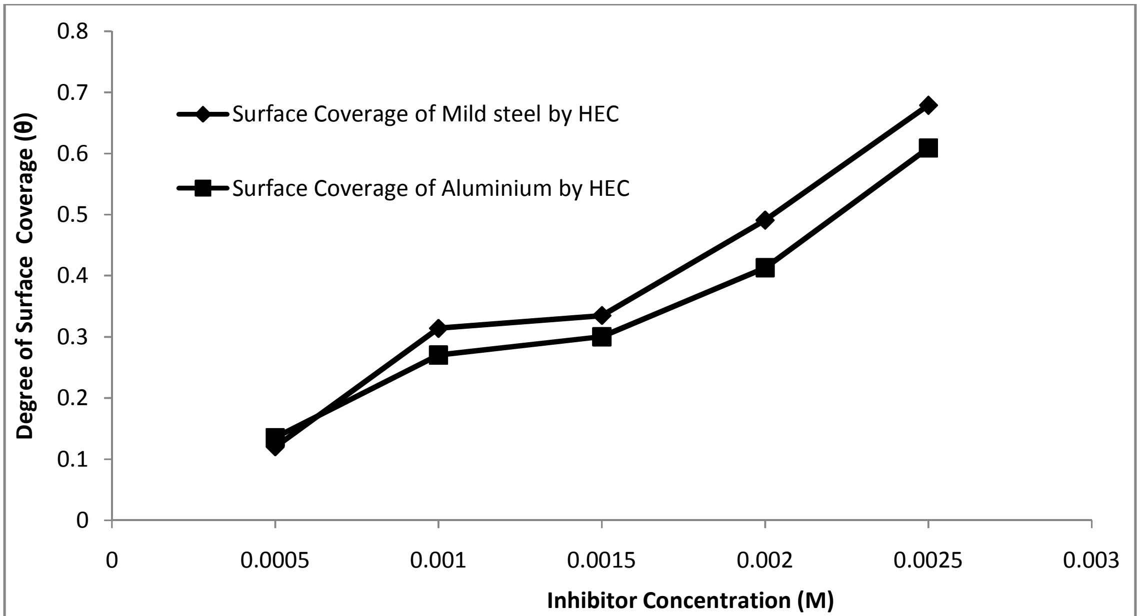

Fig.3: Plot of Surface Coverage against Inhibitor concentraion for MS and Al in 0.5M HCl

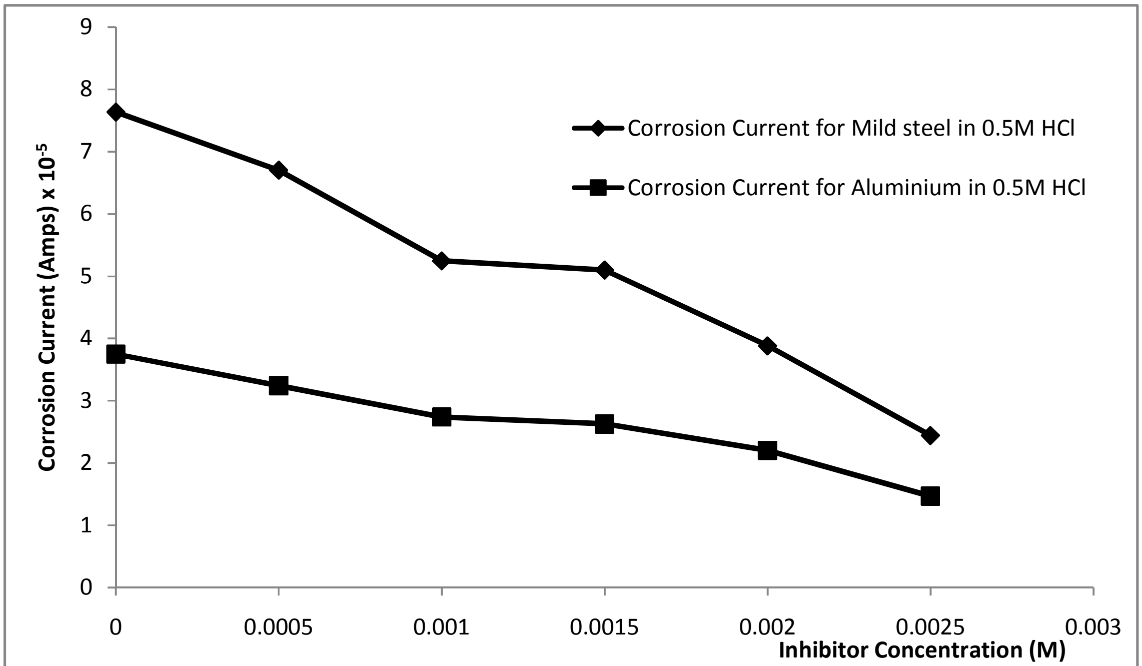

Fig.4: Plot of Corrosion Current against Inhibitor concentration for MS and Al in 0.5M HCl

Table 2.0

Calculated values of corrosion rate (mm/yr), inhibition efficiency (IE %), degree of surface coverage (θ) and corrosion current (Amps) for hydroxyethylcellulose (HEC) in 0.5M HCl corrosion of Aluminium from weight loss data.

Inhibitor Concentration	Corrosion Rate (mm/yr)	Inhibitor Efficiency (I.E. %)	Degree of Surface Coverage (θ)	Corrosion Current (Amps)x 10^{-5}
Blank	3.585	-	-	3.750
$5.0x10^{-4}$M	2.951	13.478	0.135	3.244
$1.0x10^{-3}$M	2.423	26.957	0.270	2.739
$1.5x10^{-3}$M	2.204	30.000	0.300	2.626
$2.0x10^{-3}$M	1.932	41.304	0.413	2.202
$2.5x10^{-3}$M	1.408	60.870	0.609	1.467

CONCLUSION

1. Hydroxyethylcellulose was found to be effective water-soluble, eco-friendly inhibitor for aluminium and mild steel in 0.5M HCl.
2. Corrosion rate increased with increase in corrodent (HCl) concentration but decreased as inhibitor concentration increased. However, corrosion rate was higher in Aluminium than in Mild steel.
3. The inhibition efficiency and surface coverage increased with increase in inhibitor concentration. It was also observed that both inhibition efficiency and surface coverage was higher in Mild steel than in Aluminium.
4. The corrosion current determined was found to be higher in Mild steel than in Aluminium. Again, it also decreased with increase in inhibitor concentration.

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