VITAMIN B-12 SOLUTION AS CORROSION INHIBITOR FOR MILD STEEL IN ACID MEDIUM

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ABSTRACT

The effect of addition of Vitamin B-12 on the corrosion of steel in 0.5M H2SO4 acid has been studied by weight loss measurements, potentiodynamic polarisation and Electrochemical Impedance Spectroscopy (EIS) measurements. The inhibition efficiency was found to increase with inhibitors content to attain 60.88 % and 78.33 % Vitamin B-12 and 25ppmTBA respectively. Data obtained from EIS studies were analyzed to determinate the model inhibition process through appropriate equivalent circuit models. Inhibition efficiency E (%) obtained from the various methods is in good agreement.

KEY WORDS: Inhibitor, Mass loss, Impedance, Polarization, Vitamin B-12

1. INTRODUCTION

The corrosion of iron and mild steel is a fundamental academic and industrial concern that has received a considerable amount of attention [1]. The use of inhibitors is one of them most practical methods for protection against corrosion, especially in acidic media [2]. The progress in this field has been phenomenal in recent years and is borne out by the output of literature [3]. Acid solutions are widely used in industry, the most important fields of application being acid pickling, industrial acid cleaning, acid descaling and oil well acidizing. Because of the general aggressively of acid solutions, inhibitors are commonly used to reduce the corrosive attack on metallic materials. Most of the well-known acid inhibitors are organic compounds containing nitrogen, sulphur and oxygen atoms. The influence of organic compounds containing nitrogen, such as amines and heterocyclic compounds, on the corrosion of steel in acidic solutions has been investigated by several works [4±7]. The existing data show that most organic inhibitors act by adsorption on the metal surface. The most important prerequisites for compounds to be ancient inhibitors are: substances should form a compact barrier ®lm, they should chemosorb on the metal surface, have high adsorption energy on the metal surface, and the barrier layer thus formed should increase the inner layer thickness [8]. In this paper, we have studied the effect of addition of Vitamin –B12 on the corrosion inhibition of mild steel in acidic media using gravimetric measurements, electrochemical impedance spectroscopy (EIS) and potentio dynamic polarization.

2. MATERIAL AND METHODS:

2.1 Preparation of Stock Solution:

Vitamin B-12 was purchased from NICE chemicals.0.1g of sample was dissolved in ethanol, and made up to 100 ml. The solution was used as corrosion inhibitor in the present study

2.2 Preparation of Specimens

Carbon steel specimens (0.022% S, 0.038% Mn, 0.027%P, 0.086 C) of dimension 1.0 cm *4.0cm*0.2cm were polished to a mirror finished with the emery sheets of various grades and degreased with trichloroethylene.

2.3 Weight Loss Method.

Carbon steel specimens in triplicate were immersed in 100 mL of the inhibited and uninhibited 0.5 M H_2SO_4 solutions in the presence and absence of KI for two hours. The weight of each specimen before and after immersion was determined using shimadzu balance, model Ay 62.The inhibition efficiency (IE) was then calculated using the expression;

$$IE\% = \left(\frac{W_1 - W_2}{W_1} \right) \times 100$$

Where W_1 and W_2 are the corrosion rates in the absence and presence of the inhibitor, respectively.

2.4 Electrochemical Impedance Measurements

The impedance measurements were performed using a computer –controlled potentiostat (model Solartron SI-1260) and the data were analysed using gain phase analyser electrochemical interface (Solartron SI-1287). A three electrode set up was employed with Pt foil as the auxiliary electrode and a saturated calomel electrode as the reference electrode. The Teflon coated mild steel rod, with the surface prepared as described in the weight loss experimental method, served as the working electrode. The measurements were carried out in the frequency range 10^6–10^{-2} Hz at the open circuit potential by superimposing sinusoidal AC signal of small amplitude, 10 mV, after an immersion period of 30 min in the corrosive media. The double layer capacitance (C_{dl}) and charge transfer resistance (R_{ct}) were obtained from the impedance plots as described elsewhere 25. Because R_{ct} is inversely proportional to corrosion current density, it was used to determine the inhibition efficiency (IE%) using the relationship;

$$IE\% = \frac{R_{ct} - R^0_{ct}}{R_{ct}} \times 100$$

Where R_{ct} and R^0_{ct} are the charge transfer resistance values in the inhibited and uninhibited solutions respectively.

2.5. Polarization Measurements

The potentiodynamic polarization curves were recorded using the same cell setup employed for the impedance measurements. The potentials were swept at the rate of 1.66mV/s, primarily from a more negative potential than E_{ocp} to a more positive potential than E_{ocp} through E_{corr}. The inhibition efficiencies were calculated using the relationship 26;

$$IE\% = \frac{I^0_{corr} - I_{corr}}{I^0_{corr}} \times 100$$

Where I^0_{corr} and I_{corr} are the corrosion current densities in the absence and in the presence of inhibitor, respectively

3. RESULTS AND DISCUSSION

3.1 Analysis of Results of Mass Loss Method

The corrosion rates and inhibition efficiency values, calculated using weight loss data, for various concentrations of Vitamin B-12 in the presence and absence of TBAB the corrosion of carbon steel in 0.5M H_2SO_4 solution are presented in Table.1. It is apparent that the inhibition efficiency increased with the increase in inhibitor concentration in the presence and absence of TBAB. This behavior can be explained based on the strong interaction of the inhibitor molecule with the metal surface resulting in adsorption. The extent of adsorption increases with the increase in concentration of the inhibitor leading to increased inhibition efficiency. The maximum inhibtion efficiency was observed at an inhibitor concentration of 100 ppm. Generally, inhibitor molecules suppress the metal dissolution by forming a protective film adsorbed to the metal surface and separating it from the corrosion medium. The corrosion suppressing ability of the inhibitor molecule originates from the tendency to form either strong or weak chemical bonds with Fe atoms using the lone pair of electrons present on the O and π

electrons in benzene ring. It is also seen from table.1 that the leaf extract of Vitamin B-12 at 10 ppm and 50 ppm concentrations shows 60.88 % and 74.83 % inhibition efficiencies respectively, Then the values increased to 93.20 % after adding 25 ppm of TBAB solution in 0.5M H_2SO_4 solutions containing 50 ppm of Vitamin B-12 respectively. This showed a good synergistic effect between Vitamin B-12 and TBAB.

Table1. Corrosion rate (CR) of mild steel in 0.5M H_2SO_4 solutions the absence and presence of inhibitor and the inhibition efficiency (IE) obtained by mass loss method.

. Inhibitor concentration (mL)	TBAB (0) ppm	
	CR (mg cm^{-2} h^{-1})	IE %
0	192.00	-
10	75.12	60.88
20	63.27	67.05
30	59.60	68.96
40	52.20	72.82
50	48.32	74.83

3.2 Influence of TBAB on the Inhibition Efficiency of Vitamin B-12

Inhibitor concentration (ppm)	TBAB (25) ppm	
	CR (mg cm^{-2} h^{-1})	IE %
50	13.05	93.20

3.3 Electrochemical Impedance Spectroscopic Measurements (EIS)

Impedance spectra obtained for corrosion of mild steel in 0.5 M H_2SO_4 contains two semicircles in which the second one represents the interaction of metal surface with the corrosive environment. The first semicircle represents the nature of the corrosive media .Since the conductivity of the corrosive medium is very low, this also behaves like a leaky capacitor. The CR-CR model best describes this situation. The second semicircle in the impedance plots contain depressed semicircles with the centre below the real axis. The size of the semicircle increases with the inhibitor concentration, indicating the charge transfer process as the main controlling factor of the corrosion of mild steel. It is apparent from the plots that the impedance of the inhibited solution has increased with the increase in the concentration of the inhibitor. The experimental results of EIS measurements for the corrosion of mild steel in 0.5 M H_2SO_4 in the absence and presence of inhibitor are given in Table 3. Said that sum of charge transfer resistance (R_{ct}) and adsorption resistance (Rad) is equivalent to polarization resistance (Rp).

Table 3. Impedance parameters obtained from electrochemical impedance studies.

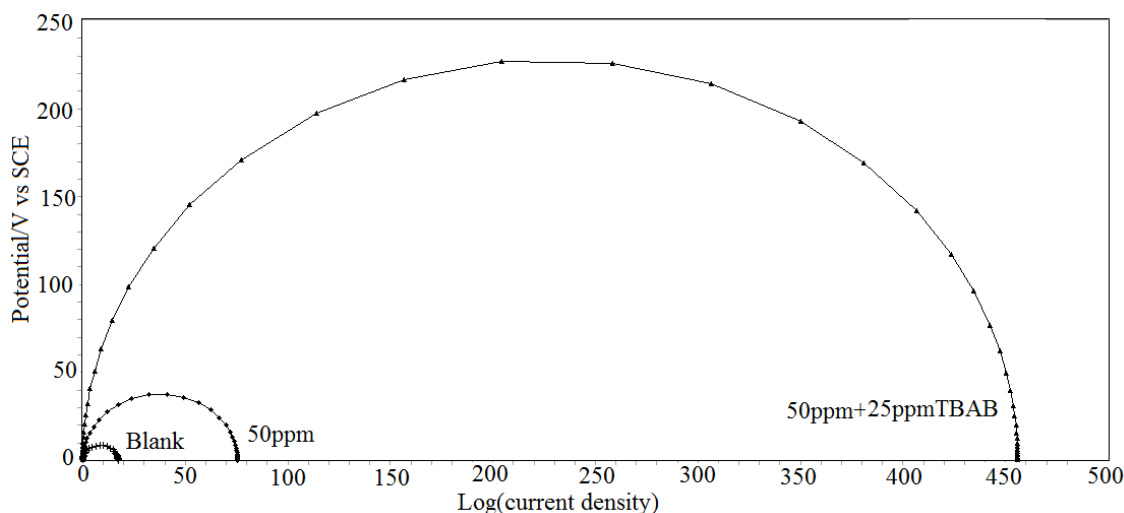| Inhibitor concentration mL	Rct Ohm cm^2	C$_{dl}$ µF	IE%
0	17.2	9.2578×10^{-3}	-
50	71.07	4.219×10^{-6}	75.8
50+ 25ppm(TBAB)	296.55	1.502×10^{-6}	94.25

Fig.1 Impedance spectra obtained from electrochemical impedance studies
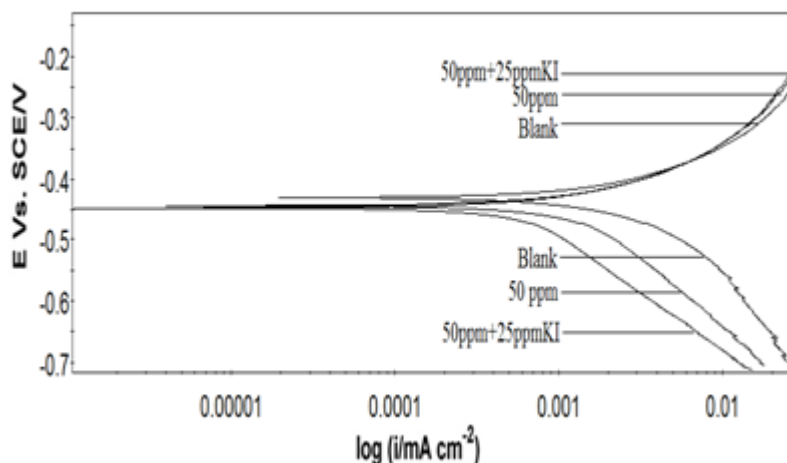
3.3 Polarization Measurements.

Fig 2. Potentiodynamic polarization curves of mild steel immersed in 0.5M H_2SO_4 solution in the absence and presence of inhibitors

Inhibitor concentration ppm	$-E_{corr}$ (mV)	β_c (mV/)	β_a (mV)	$I_{corr}\times10*6$ μA	IE%
0	457	165	69	1.35	-
50	465	229	84	0.336	75.11
50+ 25ppm (TBAB)	476	234	88	0.088	93.5

The polarization curves obtained for the corrosion of mild steel in the inhibited (100 ppm) and uninhibited 0.5 M H_2SO_4 solutions in Fig.2. Electrochemical parameters such as corrosion potential (E_{corr}), corrosion current density (I_{corr}), cathodic and anodic tafel slopes (β_c and β_a) and percentage inhibition efficiency according to polarization studies are listed in table 3. Here I_{corr} decreased with increasing inhibitor concentration. From the figures, it can be interpreted that the addition of this inhibitor to corrosive media changes the anodic and cathodic tafel slopes. The changes in slopes showed the influence of the inhibitor both in the cathodic and anodic reactions. However, the influence is more pronounced in the cathodic polarization plots compared to that in the anodic polarization plots. Even though β_c and β_a values (table.3) change with an increase in inhibitor concentrations, a high β_c value indicates that the cathodic reaction is retarded to a higher extent than the anodic reaction [11].

From Fig.2 it is also clear that the addition of the inhibitor shifts the cathodic curves to a greater extent toward the lower current density when compared to the anodic curves. The E_{corr} value is also shifted to the more negative side with an increase in the inhibitor concentration. These shifts can be attributed to the decrease in the rate of the hydrogen evolution reaction on the mild steel surface caused by the adsorption of the inhibitor molecule to the metal surface [12]. It has been reported that a compound can be classified as an anodic and cathodic type inhibitor on the basis of shift of E_{corr} value. If displacement of E_{corr} value is greater than 85 mv, towards anode or cathode with reference to the blank, then an inhibitor is categorized as either anodic or cathodic type inhibitor otherwise inhibitor is treated as mixed typ e[13,14]. In our study, maximum displacement in E_{corr} value was around 19 mV, indicating the inhibitor is a mixed type and more anodic nature and does not alter the reaction mechanism. The inhibition effect has occurred due to simple blocking of the active sites, thereby reducing available surface area of the corroding metal [15,16,17,18,].

ACKNOWLEDGEMENTS

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