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CORROSION INHIBITION OF ZINC METAL IN ACID MEDIUM BY USING 2-ETHYL IMIDAZOLE

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Abstract: The corrosion inhibition effect of zinc metal in 1M Hydrochloric acid by 2-ethyl imidazole has been evaluated at room temperature using weight loss, gasometry methods. The corrosion inhibition efficiency increases with increase in concentration of an inhibitor. The corrosion rate decreases when increase in concentration of inhibitor. This is due to at the higher concentration of inhibitor solution which blocks the active site of a zinc metal and a protective film is formed over the zinc metal surface. This is further confirmed by surface analysis technique like scanning electron microscopy. Surface analysis of polished, corroded and inhibitor zinc metal surface has been evaluated by SEM.

Keywords - Acidic solutions, 2-ethyl imidazole, Gasometry, Scanning electron microscopy, Weight loss method and Zinc corrosion.

1. INTRODUCTION

Corrosion of metals and alloys consequence in the loss of many important characteristics such as malleability, flexible and conductance. The proposed action to be earning to control the corrosion process is to isolate the metals and alloys from the corrosive environments. Use of corrosion inhibitors is one of the methods available for sturdy metals against corrosion. Organic compounds with heteroatom, multiple bonds and aromatic rings proved to be effective corrosion inhibitors. Diversity of organic compounds were used as corrosion inhibitors for zinc metal in different environments [1-9]. These inhibitors restraint the corrosion action by adsorption on to the metal surface. In this work, it is investigated that 2-ethyl imidazole as a corrosion inhibitor for zinc metal in 1 N HCl acid solution by weight loss, gasometry methods. The ability of an organic compound to interact with a metal surface is closely connected with chemical adsorption. The efficiency of this field is correlated to the presence of polar functional groups with S, O or N atoms. ð-electrons in the molecule. Such compounds can absorb onto the metal surface and block the active surface sites, thereby reducing the electrochemical reactions involved in the charge transfer processes. The protective film formed over the zinc metal was characterized by SEM.

2. EXPERIMENTAL SECTION

2.1 Materials and Methods

Specimen preparation

Composition of zinc specimen: lead 0.03%, cadmium 0.04%, iron 0.001% and the quantity left over being zinc and size of 4x 2x 0.08cm were used for weight loss, and gasometry studies. Zinc metal specimens were polished with a sequence of emery papers of different grades from 400-1200, degreased with absolute ethanol and dried. The inhibitor compound, 2-ethyl imidazole was customary Alfa Aesar Chemicals United Kingdom. The working surface was at a subsequent time ground with acetone followed by double-distilled water, dried in warm air and then stored in moisture-free desiccators before ducking in a corrosive medium. For the electrochemical impedance measurements, metal specimens of a circular design of observable surface area 6.156 cm^2 were used as the working electrode. The direct and the back side of the specimen were coated with Perspex, leaving only the circular portion of the specimen without protection to the corrosive medium. The solution of 1 N HCl was prepared by the dilution of 35% HCl (Finar) with doubly distilled water. The area of the zinc metal plate for SEM was 3 cm × 3 cm [10].

2.2 Preparation of Organic inhibitor

2-ethyl imidazole was prepared by different concentration with 100 ml of methanol. Test solutions with different concentrations from 0.19 g/L to 1.32 g/L were prepared by diluting the stock solution in 1 N HCl [11, 12].

2.3 Weight loss measurements

Zinc specimens with dimensions of 3.0 cm x 3.0 cm were polished, degreased with acetone and dried. A Mettler balance – M5 type was used to weigh the zinc specimens to an accuracy of 0.0001 gm. The specimens were deep in a beaker containing 100 ml of 1 N HCl without and with 5,10,30,50,100 mM concentrations of the inhibitor (organic inhibitor) using glass hooks and rods. The effect of the temperature was also studied an contact period of 2 hours using a water-circulating thermostat (Equitron). All the test standard systems were open to the air. After 2 hours, the specimens were taken out, washed with distilled water and re-weighed [13,14]. To obtain good reproducibility, experiments were carried out in triplicate, and the average values were be given. The weight loss was recorded, and the inhibition efficiency as well as the surface area coverage was calculated using the following equation. Weight loss, and gasometry studies were carried out as investigated earlier [15,16]. The weight loss investigation the % inhibition efficiency (I.E) and the degree of surface coverage (θ) were considered by using the following equations.

$$I.E\ (\%) = [W_0 - W_i / W_0] \times 100$$

$$\theta = W_0 - W_i / W_0$$

Where W_o and W_i are the weight loss of the metal in the absence and presence of the inhibitor separatley.The corrosion rate (C.R) of the metal was formula by using the following equation.

Where W is the weight loss of the zinc metal (mg), A is the surface area of the metal specimen (cm^2), t is the frostbite time (h) and D is the density of the metal (g/cm^3).

$$C.R\ (mmy) = \frac{87.6 / W}{A\ t\ D}$$

2.4 Gasometric measurements

The acidic corrosion of Zinc is characterized by evolution of hydrogen and the rate of corrosion is proportional to the amount of hydrogen gas evolved [17]. Gasometric experiments were carried out respectively by varying the corrodent (5, 10, 30.50 and 100 mM) and inhibitor concentrations respectively. From the volume of hydrogen gas evolved per minute, Table1 resulted by plotting the volume of gas evolved against time in order to establish its corrosion rate. It can be observed fromTable1 that the higher the corrodent concentration the higher the volume of gas evolved per minute at room temperature. The results of the effect of temperature variation in the absence of 2-ethyl imidazole in 1 N HCl solution. It is evident that higher temperature of provided higher volume of hydrogen gas per minutes resulting into a higher rate of reaction. 2-ethyl imidazole systems were tested. To establish, regardless of temperature or corrodent concentration, the higher the volume of gas evolved per minutes the higher the rate of reaction.Concentration increases also inhibitor efficiency increases and corrosion rate decreases. Homogeneous results were be given from the weight loss experiments. It is also obvious from the plots that there is an abrupt increase in the volume of hydrogen gas evolved after the first five minutes. This may be attributed to the reaction of the oxide layer with the HCl solution [18].
From the gasometry investigation, the inhibition efficiency is calculated by using the following equation.

$$I.E\ (\%) = [V_0 - V_i / V_0] \times 100$$

Where V_o and V_i are the volume of hydrogen gas produce in the absence and presence of the inhibitor

2.6 Electrochemical measurements

Electrochemical impedance measurements were performed to study the electrochemical behavior of the inhibitor. EIS measurements were carried out using a standard three-electrode cell in which the zinc acts as a working electrode, saturated calomel electrode as a reference electrode, and platinum foil a counter electrode. All the measurements were performed using 1N HCl without stirring in atmospheric conditions. A stabilization period of 30 minutes was allowed prior to the electrochemical measurements, which has been proven to be sufficient to attain a stable open-circuit potential (OCP) [19]. To substantiable the data, each measurement was performed in triplicate. An electrochemical impedance spectroscopy (EIS) study was conduct by using AUTOLAB. Alternating current impedance measurements were carried out in open-circuit potential mode with amplitude of 0.01 V and a frequency ranging from 250 Hz to 80000 Hz. The experimental impedance spectroscopy data were fitting well using a frequency response analyzer (FRA).

2.7 Surface morphology

The surface micrographs of the zinc specimens in various test solutions were obtained by SEM. SEM provides a pictorial representation of the surface of the zinc metal to help understand the nature of the surface film in the absence and presence 2-ethyl imidazole inhibitor. The scanning electron microscopy photographs were recorded at 10,000 x magnification using SEM ULTRA-60 nanofab, and Hitachi scanning electron microscopes.

3. RESULTS AND DISCUSSION

Weight loss, gasometry studies were conducted and the inhibition efficiency (IE) values were calculated. Values of inhibition efficiency obtained from these experiments are presented in the table-1

Table 1 Varying of inhibition efficiency (I.E (%)) be given from various Weight loss experiments.

Method Employed	Values of I.E(%)different concentrations (mM) Of 2-ethyl imidazole inhibitor				
	5	10	30	50	100
Weight loss	34.0	44.5	60.1	69.5	76.2

It can be observed from the table 1 that there is very good accord between the values of inhibition efficiency be given from these three methods. The results also be visible that the inhibition efficiency increases with increase in the inhibitor concentration. The vulnerability of inhibition efficiency of the inhibitor on the concentration is shown in figure-1

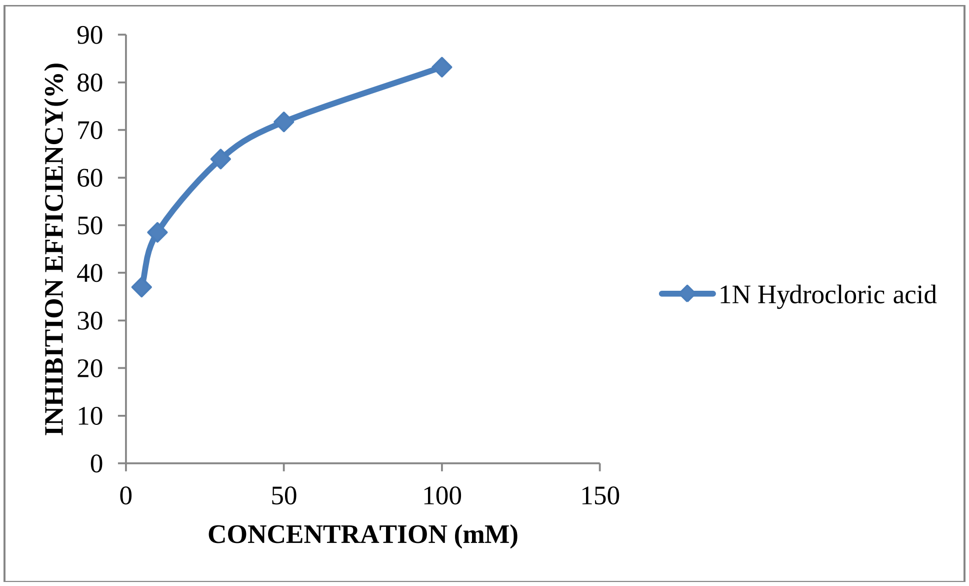


Figure 1 varying of inhibition efficiency with concentration of the inhibitor.

Values of corrosion rates obtained from the weight loss experiments for the inhibitor for the corrosion of zinc in 1N HCl in the presence of different concentrations of the inhibitor are presented in the table-2

Table 2 Values of corrosion rates be given from the weight loss experiments.

Values of corrosion rates and different concentrations(mM) Of 2-ethyl imidazole inhibitor				
5	10	30	50	100
90.0	77.2	52.1	40.6	29.5

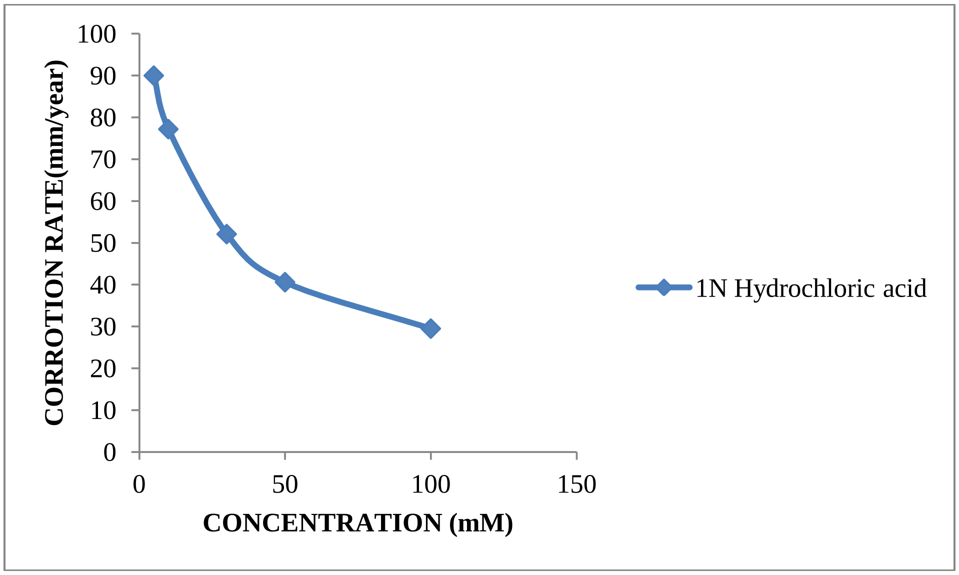


Figure 2 Varying of corrosion rates with concentration of the inhibitor.

Table 3 Values of inhibition efficiency (I.E (%)) be given from various gasometry experiments

Method Employed	Values of I.E(%)different concentrations (mM) Of 2-ethyl imidazole inhibitor				
	5	10	30	50	100
Gasometry	32.4	40.7	55.0	63.4	72.1

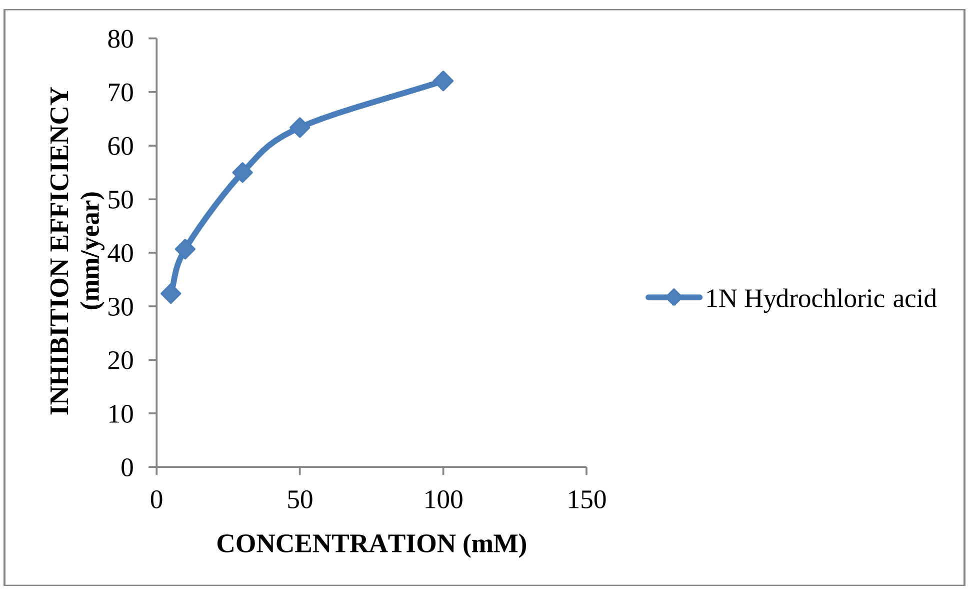


Figure 3 Varying of inhibition efficiency with concentration of the inhibitor

Table 4 Values of corrosion rates be given from the weight loss experiments.

Values of corrosion rates and different concentrations(mM) Of 2-ethyl imidazole inhibitor				
5	10	30	50	100
88.0	75.1	49.1	38.6	29.5

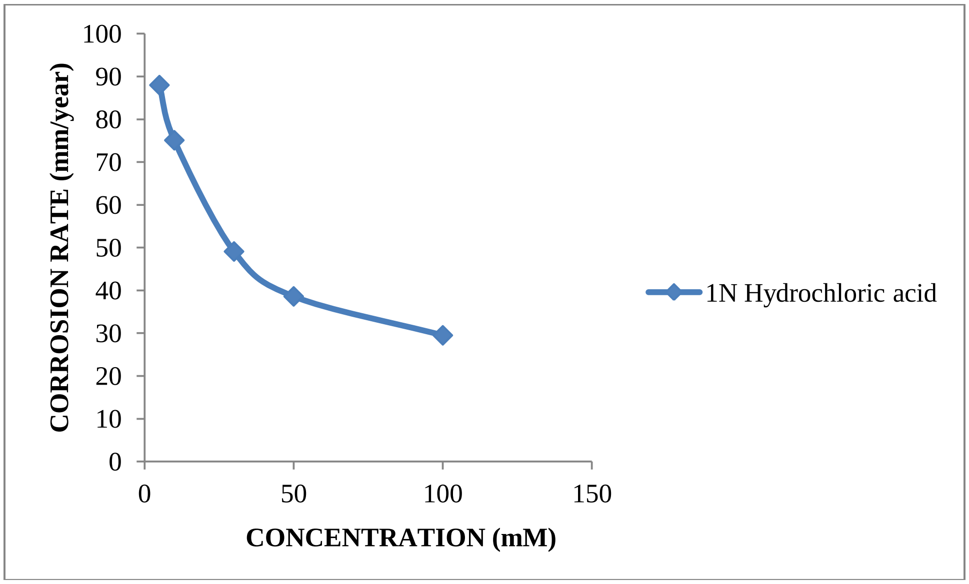


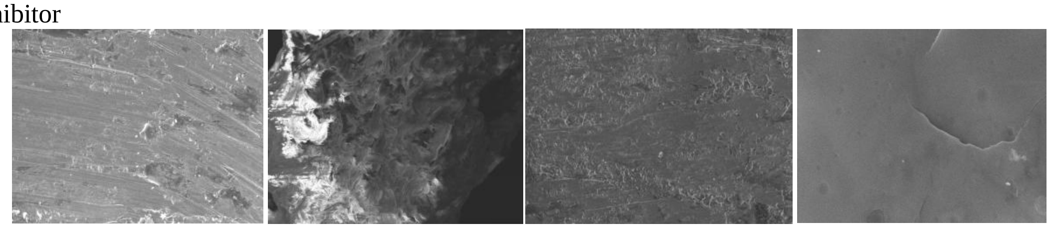
Figure 4 Varying of corrosion rates with concentration of the inhibitor.

The inhibitor molecules carry for four nitrogen atoms in its molecular structure. These nitrogen atoms possess lone pairs of electrons required for the adsorption process. On adsorption strongly adherent layer is formed on the metal surface. This layer move as a barrier between the metal and the environment giving protection to the metal. In summation to these, the amino groups present in the molecule can be easily protonated in acid medium to form the cationic form of the inhibitor. The chloride ions present in the acid medium obtain adsorbed specifically on the positively charged metal surface due to its lesser degree of hydration leading to the creation of excess negative charges on the metal surface which increase more adsorption and hence protection of the metal. Another factor responsible for the higher inhibition efficiency of the inhibitor is the large surface area of the inhibitor molecules which give higher surface coverage to the metal after getting adsorbed on to the metal surface.

3.1 SEM Analysis of Metal Surface

SEM provides a pictorial representation of the surface. The SEM images of zinc specimens immersed in 1N HCl for 30 min. in the absence and presence of 2-ethyl imidazole inhibitor systems are shown in Figures 5c and 5d, respectively.

The SEM micrograph of the polished zinc surface in Figure.5a show the smooth surface of the metal, with no corrosion products. The SEM micrographs of the zinc surface immersed in 1N HCl (Figure 5b) show the roughness of the metal surface, with highly corroded areas. However, Figure 5d shows that in the presence of 10mM 2-ethyl imidazole, the inhibition efficiency is enhanced, as seen from the decrease in the corroded areas compared to with the 5mM 2-ethyl imidazole inhibitor



(5a) (5b) (5c) (5d)

Fig. 5: Scanning electron micrographs of zinc immersed for 30 minutes (a) polished Zinc (b) in 1 N HCl (c) with 5mM 2-ethyl imidazole inhibitor and (d) with 10 mM 2-ethyl imidazole inhibitor

In the presence of the 5mM 2-ethyl imidazole inhibitor and 10mM 2-ethyl imidazole inhibitor, the surface is covered by a thin layer of inhibitor that effectively controls the dissolution of the zinc [20, 21].

From the weight loss measurements, the degree of surface coverage (θ) for different concentrations of the inhibitor were determined. Temkin's adsorption isotherm was investigated by plotting logC vs θ which gave a straight line thereby indicating that the adsorption of the inhibitor on the surface of zinc from 1N HCl obeys Temkin's adsorption isotherm. Figure -5 be seen the Temkin adsorption isotherm plot for zinc in 1N HCl involve varying concentrations of the inhibitor.

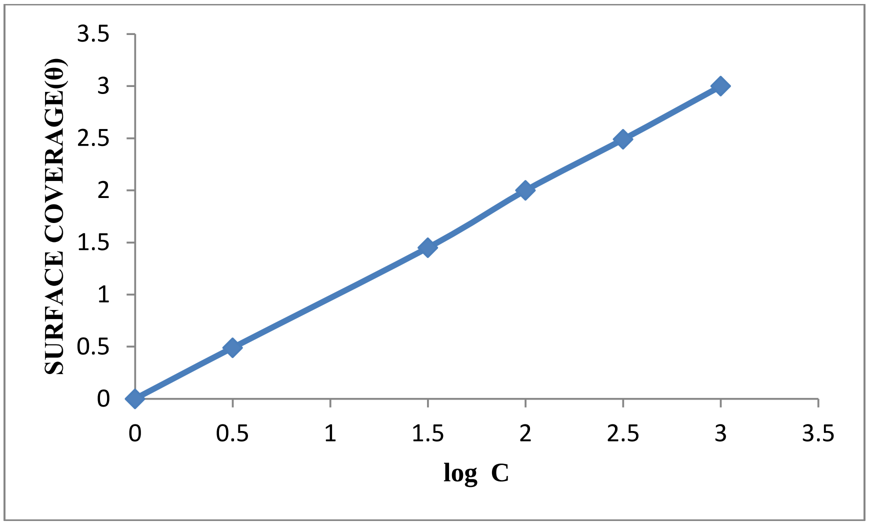


Figure 6. Temkin adsorption isotherm plot for zinc in 1N HCl involve the different concentrations of the inhibitor.

4. CONCLUSIONS

2-ethyl imidazole used as a corrosion inhibitor for zinc in 1N HCl performed well and gave high percentage of inhibition efficiency. The inhibition efficiency of the inhibitor elevate with the increase in the concentration of the inhibitor. The adsorption of the inhibitor on to zinc surface observe Temkin adsorption isotherm.

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