IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 8, Issue 8 Ver. II (Aug. 2015), PP 101-105
www.iosrjournals.org

Amoxicillin as Corrosive Inhibitor of Iron in Presence of Acidic Medium.

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Abstract: *Recently research works have been done on the use of antibacterial drugs as a corrosion inhibitor for metal alloy. Amoxicillin which is an antibacterial drug has been proved as a good metal alloy corrosion inhibitor in acidic media. This paper presents an experimental study on the amoxicillin as inhibitor has been investigated by weight loss, Potentiodynamic polarization, electrochemical impedance spectroscopy , all these techniques reveal that inhibition efficiency increases with an increase in the concentration of inhibitor in acidic medium (HCI, H_2SO_4, HNO_3). In these experiments Potentiodynamic polarization measurements after zero hr. showed a shifting in corrosion potential (Ecor) towards positive direction and a decrease in corrosion current density (Icor), and the corrosion rate (CR) with increasing inhibitor concentration in acidic medium (HCI, H_2SO_4, HNO_3) .*

Keyword*: Metal corrosion, Amoxicillin, Potantiodynamic polarization, electrochemical impedance.*

I. Introduction:

Corrosion is naturally occurring phenomenon commonly defined as the deterioration of Substance (usually a metal).The mechanism of the metallic corrosion can be described as follow, when a piece of a metal is immersed in a corrosive solution[1-4]; it starts dissolving and forms its ions in the solution. Considering that the solution contain plenty of hydrogen ions and oxygen, the Reaction by hydrogen is as follow,

$$1H+ + 2e- \longrightarrow \frac{1}{2} H_2 \text{ (gas)} \ldots\ldots (1)$$

And the reaction caused by oxygen is

$$O_2 + 2H_2O + 4e- \longrightarrow 4\ OH^- \quad \text{or}$$

$$\frac{1}{2} O_2 + H_2O + 5e- \longrightarrow 2OH^- \ldots\ldots (2)$$

Reaction (1) and (2) are electron consuming represent the reduction process. The overall net Reactions are:

$$M + 2H^+ \longrightarrow M^{2+} + H_2 (g) \ldots\ldots (3)$$

$$M + \frac{1}{2} O_2 + H_2O \longrightarrow M^{2+} + 2\ OH- \ldots\ldots (4)$$

Inhibitor is a chemical compound that, when added in small concentration stops or slows down Corrosion of metals and alloys. It is well known in surface chemistry that surface reactions are Strongly affected by the presence of foreign molecules. Corrosion processes being surface Reaction, can be controlled by compounds known as inhibitors which adsorb on the reacting Metal surface [5-8], The term adsorption refers to molecules attached directly to the surface, normally only one molecular layer thick, and not penetrating into the bulk of the metal itself. The technique of adding inhibitors to the environment of a metal is a well known method of controlling corrosion in many branches of technology. A corrosion inhibitor may act in a number of ways; it may restrict the rate of the anodic process or the cathodic process by simply blocking active sites on the metal surface. Alternatively it may act by increasing the potential of the metal surface so that the metal enters the passivation region where a natural oxide film forms [9-12]. A further mode of action of some inhibitors is that the inhibiting compound contributes to the formation of a thin layer on the surface which stifles the corrosion process. Generally, organic inhibitors adsorb on the entire metal surface impede corrosion reaction [13-15]. Organic inhibitors consist of broad classes of organic compounds. For example, aliphatic organic amines adsorb by the surface active – NH_2 group which forms a chemisorptive bond with the metal surface. The hydrocarbon tails orient away from the interface toward the solution [16-18], so that further protection is provided by the formation of a hydrophobic network which excludes water and aggressive ions from the metal surface.

II. Material And Methods:

Material:

Iron sheet (Jindal Iron Limited, India) were purchased from local market.

Solutions:

All the chemicals used in the present investigation, for the preparation of solutions were of analytical grade. Glass doubly distilled water was for the preparation of all the solutions.

1.1: Weight loss method:

Iron, 1 cm × 1cm plates were used to determine the corrosion rates using the weight loss method. The surfaces of the plates were cleaned by a chemical process, including a $3HNO_3{:}1H_2SO_4{:}1H_2O$ mixed solution, followed by pure water and CCl_4. The cleaned specimens were held in a furnace to a fixed mass. Masses of the fixed mass specimens were determined and recorded. The specimens were immersed in H_2SO_4, HCl, and HNO_3 solutions, with inhibitor (Amoxicillin) and without inhibitor. The specimens were taken from each solution at specified times (24, 48, 72, 96, h). Specimens were taken and then rinsed with pure water. These specimens were later dried again at 110 ^{o}C in a furnace and weighed. Using this process, weight losses were determined and corrosion rates were calculated using the following formula:

$$\text{Corrosion rate} = \frac{\text{weight loss}}{\text{Surface area of metal} \times \text{time}}$$

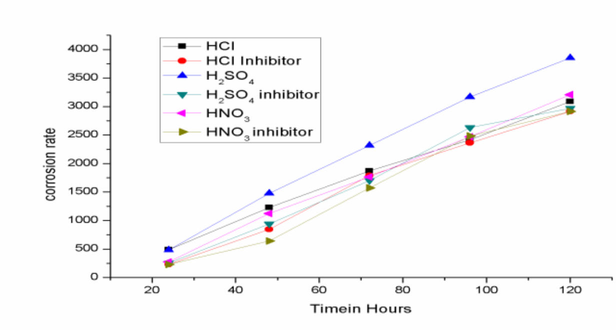
1.2: Electrochemical method:

Electrochemical measurements were made by ZiveSP5 potentiostat/Galvanostat. In the electrochemical measurements, platinum was used as the counter electrode, saturated calomel electrode (SCE), as the reference electrode, and Iron as the working electrode. The surfaces of the working electrode were covered with polyester, except for the parts connected to the solutions. Before measuring, the surface of the working electrode was polished to a mirror finish with a polishing device using, 800 and 1200 mesh sandpaper. Polarization curves were obtained between −1.00 and +1.00 Vat a 1 mV/s scan rate. During the measurement, the solutions were mixed with a magnetic mixer. All the above experiments were carried out using freshly polished specimens in aerated solutions.

III. Result And Discussion:

2.1: Weight loss test results:

Result obtains from weight loss measurement corrosion rate decreases in presences of inhibitor (Amoxicillin).



2.2: Electrochemical method results:

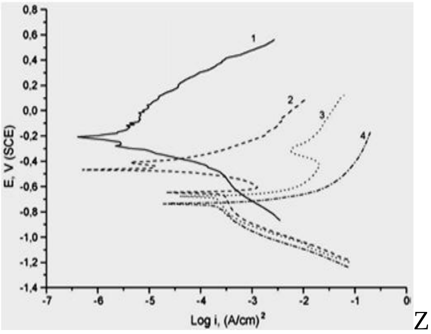


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Fig. 3.Potantiodynamic polarization curves Iron in HCl.

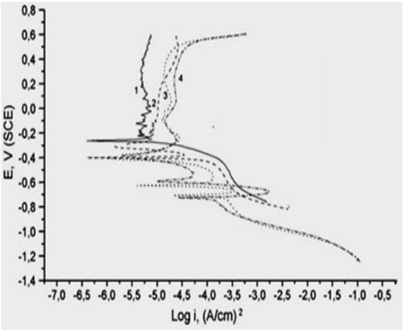


Fig. 4.Potentiodynamic polarization curves of Iron in H_2SO_4.

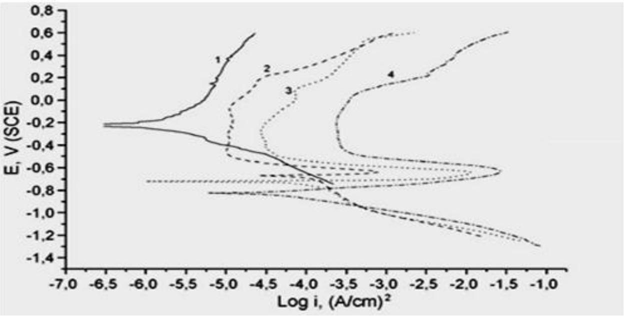


Fig. 5.Potantiodynamic polarization curves of Iron in HNO_3.

Potentiodynamic polarization curves of Iron in HCl, H_2SO_4 and HNO_3 acidic solutions with different concentrations of Amoxicillin are given in Figs. 3–5. As shown that the polarization curves decrease the corrosion current density with increasing the concentration of Amoxicillin, means that decrease the corrosion rate. In fig. 3, increasing the concentration of Amoxicillin in HCl solution was observed to decrease the corrosion current density from 4505A cm-2 to 38.19A cm-2. Fig. 4 Potentiodynamic polarization curves of iron in H_2SO_4,corrosion current density observed to be0.55V to 0.22in presence of Amoxicillin fig 5 Potentiodynamic polarization curves of iron in HNO_3, corrosion current density observed to be 0.26 to 0.5V in presence of Amoxicillin.

2.3: Electrochemical impedance spectroscopy:

Electrochemical impedance is a powerful tool in the investigation of the corrosion and adsorption phenomena. The correlation of the experimental impedance plot to an equivalent circuit enables the verification of the mechanistic model for the system. Such a correlation leads to the calculation of the numerical values corresponding to physical and/or chemical properties of the electrochemical system.The impedance data of Fe, recorded after 30 min immersion in acidic solution are presented as Nyquist plots in presence and absence of various concentrations of Amoxicillin are shown in Figures 6 to 8. The Nyquist plots show a single semi-circle shifted along the real impedance (Zr) axis, single capacitive loop, which is attributed to charge transfer of the corrosion process, and the diameters of the loops increase with the increase in the concentration of the drugs. This modification resultsin an increase of charge-transfer resistance. The Rctvalues increased with inhibitors concentrations may suggest the formation of a protective layer on the iron surface. This layer makes a barrier for mass and charge-transfer. The values of the charge-transfer resistance (Rct) were obtained from the difference in real component (Z\) of impedance at lower frequencies. Also the double layer capacitances (Cdl) decreases the concentration of Amoxicillin increase in acidic solution.

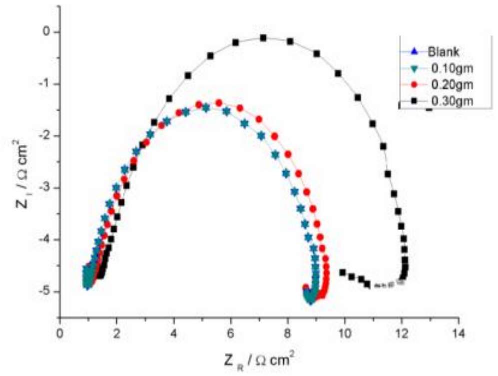


Fig: 6 Electrochemical Impedance Spectroscopy of iron in HCI

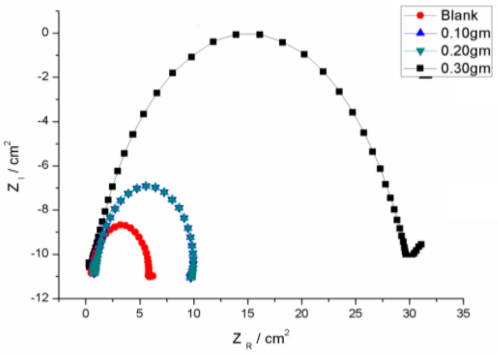


Fig: 7 Electrochemical Impedance Spectroscopy of iron in H_2SO_4

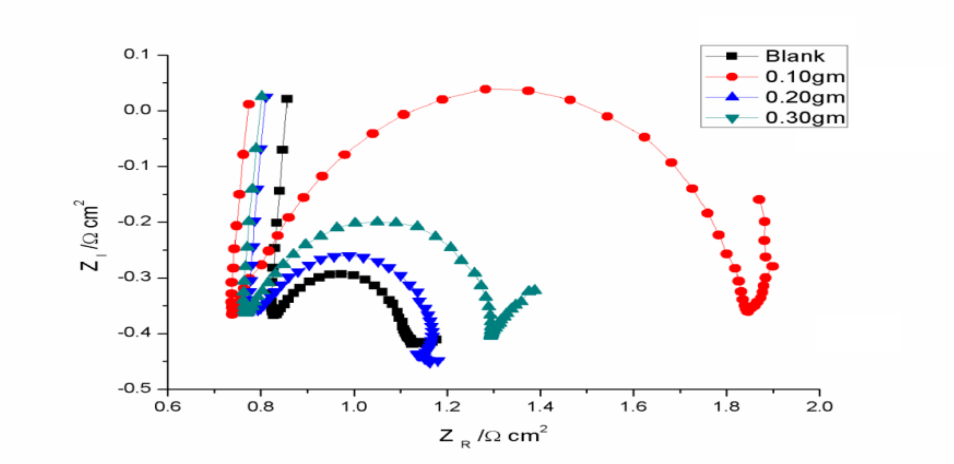
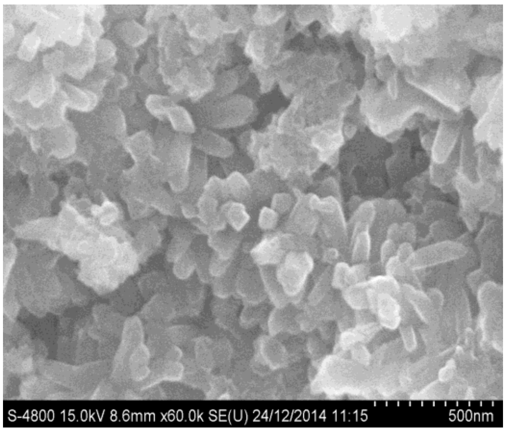


Fig: 8 Electrochemical Impedance Spectroscopy of iron in HNO_3

3: Scanning electron microscopy:

Fig. 9 to 12 shows the morphological images of iron after 1 hour in acidic solution presence and absence of Amoxicillin. It is clear that the corrosion attack was more pronounced in absence of inhibitor, while by the addition of inhibitors the film formed on iron surfaces becomes more protective.



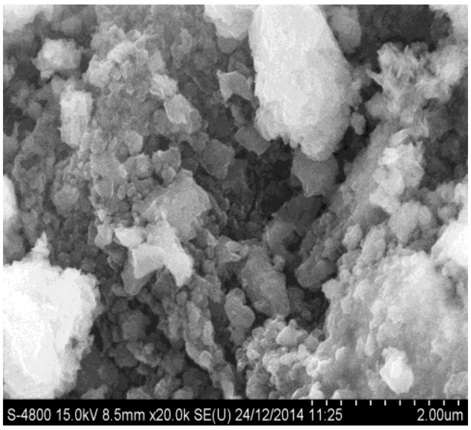
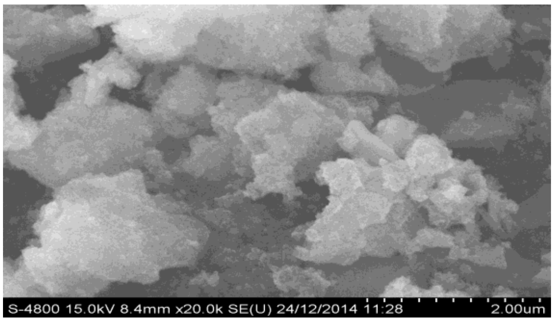


Fig 9: Field Emission Scanning Electron Microscopy of Iron in HCI Fig 10: Field Emission Scanning Electron Microscopy of Iron in H_2SO_4



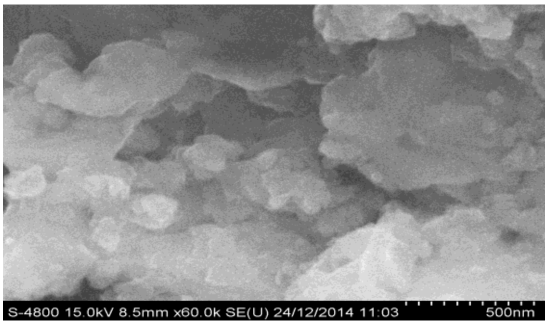


Fig 11: SEM of Iron in HNO_3 Fig 12: SEM of Iron in Acid Solution Presence of Inhibitor

IV. Conclusion:

The results obtain form weight loss measurement, potantiodynamic polarization method and electrochemical impedance spectroscopy explained that the inhibition efficiency of amoxicillin increased with the increasing the concentration in acidic medium (HCI, H_2SO_4, HNO_3), which indicated that amoxicillin maintained stable passivity even in the presence of the acidic medium (HCI, H_2SO_4, HNO_3). Amoxicillin act as good inhibitor in presence of acidic medium.

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