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Open Circuit Potential, Polarization and Thermometric Study of Guar Gum as Corrosion Inhibitor on Mild Steel by in Acidic Media

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Authors' contributions

This work was carried out in collaboration between both authors. Author RK designed the study, performed the statistical analysis, wrote the protocol and managed the literature searches and wrote the first draft of the manuscript. Author RKP managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

The influence of guar gum as inhibitors for mild steel (MS) dissolved in 1.0 M H_2SO_4 had been investigated via various electrochemical tests at 298 K. Open circuit (OC), Tafel plots had been examined. At first OCP shift found to be more negative values which clarify that guar gum having high efficiency as corrosion inhibitors. The inhibition efficiency (IE%) can be improved with improvement of concentration of inhibitor reaching maximum efficiency up to 89.37% at 298 K. The Tafel plots had been illustrated that a maximum difference of E_{corr} 68 mV, that shows that the guar gum worked as mixed type inhibitor. Thermometry investigation shows maximum IE is found to be 86.99.

Keywords: Guar gum; 1.0 M H_2SO_4; corrosion; mild steel; Tafel plots; thermometry.

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1. INTRODUCTION

Mild steel (MS) has been utilized in industrial purpose, building and more in petroleum manufacturing, Army equipment,fertilizers and extra industries. So the mild steel protection in aqueous as well as in acidic solutions is worldwide requested, environmental, cost effective and aesthetical important [1]. The use of inhibitor has been very essential way to reduce the mild steel corrosion.

The organic compounds are commonly utilized as corrosion inhibitors as it includes heteroatom for example O and N atoms. But the organic compounds are hazards and unfriendly environment inhibitors [2]. So the search for alternative friendly environment inhibitors are more important. mild steel is an iron alloy, which undertake dissolution smoothly in acid intermediate. Acid, intermediate is commonly applied in synthetically laboratories in addition to various industries like acid cleaning, acid descaling, acid pickling and oil wet cleaning, etc. In other hand CS has been utilized via dissimilar states in chemical and associated industries for acid treating, basic and salt solutions [3]. The organic inhibitors adsorb on metallic surface and then the lower rate of corrosion [4]. It has been noticed that adsorption be controlled largely on definite physicochemical attributes of the inhibitor groups, as electron density, function groups t donor to s, π-orbital manner and molecular electronic structure [5-10]. Generally, organic inhibitors having oxygen and/or nitrogen as conjugated double bonds and polar groups in their structures which have been noticed as good corrosion inhibitors for a lot of metallic elements and alloys in different media [11-27].

The organic inhibitors inhibiting job are commonly referred towards their contacts with metallic surfaces via their adsorption. The polarity of functional groups has been considered as the reaction center that settle down adsorption process. On the other hand, the inhibitor adsorption on a metal surface be controlled via scant reasons, for example the nature and surface charge of metal, adsorption manner, the chemical composition of inhibitors and electrolyte solution [28].

2. EXPERIMENTAL

2.1 Carbon Steel Sample

Tests were done on carbon steel of the composition having (wt. %): 0.09% C, 0.23% Mn, 0.07%. Si, 0.016% S, 0.022% P and the rest iron. Samples of 1x1 cm^2 were used.

2.2 Chemicals

The solution of 1 M H_2SO_4 was prepared by 98% H2SO4. Stock solutions of guar gum were prepared in 0.5 M H_2SO_4 and the required concentrations were made by appropriate dilution.

2.2.1 Inhibitor

Guar gum were used as a inhibitor in various concentration.

2.3 Electrochemical Tests

Electrochemical experiment had been done by utilizing a three electrode cell (a) Working electrode, The electrode dimensions are 1x1 cm^2 and had been fixed from one side of a copper wire by a paste of acetone and $AgNO_3$ and swelled in epoxy resin.(b) Saturated calomel electrode (SCE) taken as referance electrode,(c) Graphite rod (1.0 cm^2) used as auxiliary electrode. All electrochemical tests had been achieved in 1.0 M H_2SO_4 solution in the absence and presence of different concentrations of guar gum at 298 K under aerated and unstirred conditions.

For electrochemical test an assembly made by a power supply model number YX-1502 DD,calomal electrode having model number Korrsas calomal K13 and a multimeter UNI-T UT-33d.

2.3.1 Open circuit potential (OCP)

In this step in electrochemical experiment. Working electrode (sample) had been tested with time during the 15 minutes. This time required to achieve steady state and gain (OCP) value.

2.3.2 Polarization method

This method involve DC potentiodynamic polarization techniques that had been used to investigate current density of corrosion process under steady state conditions by applying the potential from-1300 to +1300 mV to plot the Tafel polarization curve and the resultant current had been plotted in logarithm scale *vs.* potential with respect to SCE, Extrapolating of two Tafel regions of plot gives (E_{corr}) and (i_{corr}) corrosion potential. By (i_{corr}) we able to calculate the rate of corrosion.

$$CR = [0.13\ (i_{corr})\ (\text{Equivalent weight})] / D \quad (1)$$

where, D= density in g/cm^3

$$I\ \% = \theta \times 100 = [1-(i_{corr} / i°_{corr})] \times 100 \quad (2)$$

2.3.3 Thermometric method

Eddy and Ebenso [29] describe temperature based method for corrosion rate. By the increase in temperature per unit of time, the reaction number (RN) and inhibition efficiency were calculated using following equations 4 and 5.

$$RN(°C/min) = [T_f - T_i]/T \quad (3)$$

$$\%\ IE = [(RN_{ab} - RN_{pr})/RN_{ab}] \times 100 \quad (4)$$

Where,

RNab is the reaction number in the without inhibitors, and RNpr is the reaction number of 1 M H_2SO_4 with guar gum as inhibitor.

3. RESULTS AND DISCUSSION

3.1 Electrochemical Tests

3.1.1 Open circuit potential (OCP)

Fig. 1 be evidence for influence of various concentrations of guar gum as inhibitors on the variation OCP of mild steel with time in aerated non-stirred 1.0 M H2SO4 solution at 298 K. The steady-state value of OCP is much negative than the inundation potential (OCP at t=0),it indicate that before the steady state the pre-inundation, air oxide local film formed has to break up [30]. The value of steady state potential (E_{corr}) which achieved quickly (after about 15 min of inundation), is in contact to the bare metal free corrosion [31]. It has been noteworthy that (E_{corr}) shifts to much negative value without the alteration general feature of E/t plot, while upon raising the concentration of guar gum as inhibitors.

Firstly, the OCP has been proceeding with lower negative potential values, then attend a maximum one. After assuring time relying on guar gum inhibitor concentrations, the value of potential decrease and obtain a reasonably constant value. The data obtained have been suggested that two counter-acting processes taken place, the first one being a formation of the sample electrode surface protective adsorbed layer, and as a result delayed-action corrosion process takes place moving the OCP to more noble data. Corrosion of metal has been occurring on the second one, that has been made value of potential back towards among these two counter-acting operations can possibly elucidate semblance of a peak in the OCP *vs.* time plot as shown in Fig. 1. The value of steady-state potential proceed towards more negative values with raising guar gum inhibitor concentrations. At first OCP shift to more negative values (as a result of corrosion inhibition process) accomplishing higher one [32,33]. These potential data clarify that guar gum having high efficiency as corrosion inhibitors.

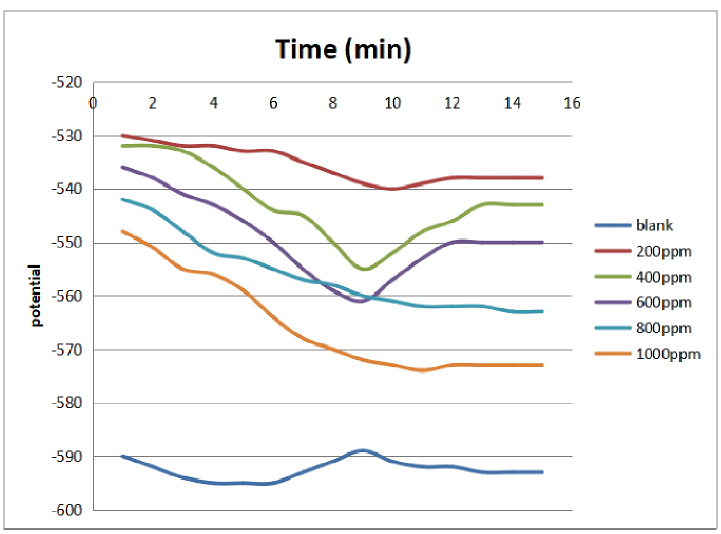

Fig. 1. Variation in open circuit potential (OCP) with time record for mild steel in 1.0 M H_2SO_4 in the absence and presence of various concentrations of guar gum inhibitors at 298 K

3.1.2 Potentiodynamic polarization (PP)

The addition of guar gum in the solution taken for investigation makes a change in polarization curves at 298 K, that have been illustrated in Fig. 2. The value of corrosion current densities i_{corr} and the value of corrosion potentials E_{corr} has been obtained at the intersection point from the extrapolation of cathodic and anodic curves. Polarization curves tells that the addition of guar gum inhibitors to the solution used for test causes no change in the identity of polarization curves, but become more wider and extrapolated at a lower current density, indicating that the molecules of inhibitor interfere with reactive sites on working electrode surface. The polarisation parameters had been listed in Table 1 suggest that on increasing the inhibitor concentrations decrease in i_{corrr} reported since the ability of molecules of inhibitor has been enhanced to block more and more reactive sites which is necessary for corrosion process. In genral, if the absolute difference in *E*corr doesn't exceed with ± 85 mV, the inhibitors have been categorized as a mixed type inhibitor as found in this research work. From the polarization data , a little change in E_{corr} values in the presence of inhibitors, with a maximum difference of 68 mV, relative to the obtained value of E_{corr} from free acid solution. The value of IE% has been obtained from polarization studies via the subsequent equation (5):

$$IE\%= 1-[i_{corr}/i^{\circ}_{corr}]x100 \quad (5)$$

3.2 Thermometric Analysis

In thermometric analysis we pour the sample in 1 M H_2SO_4.Temperature of system increases due to exothermic reaction between acid and metal surface.we allow to stand system till it reaches steady state.Initial and final temperature of system noted carefully by digital thermometer.

Inhibitor efficiency obtained by thermometric analysis shows good agreement with potentiodynamic analysis shown in Table 2.

It is clear with above table that on increasing concentration of inhibitor value of reaction number decreases and value of inhibitor efficiency increases.

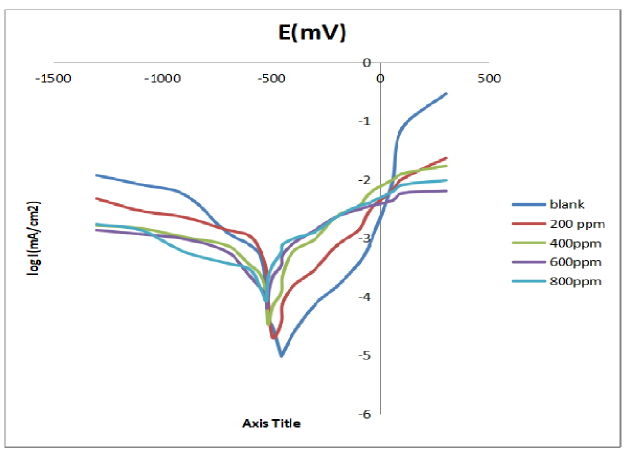

Fig. 2. Potentiodynamic cathodic and anodic plots of mild steel in 1.0 M H_2SO_4 in the presence and absence of various concentrations of guar gum inhibitors at 298 K

Table 1. Electrochemical parameters (i_{corr}, E_{corr},surface coverage and IE%) associated with polarization tests of mild steel in1.0 M H_2SO_4 solution in the absence and presence of different concentrations of guar gum at 298 K

Concentration of inhibitor(ppm)	(-)Ecorr mV	icorrx10(4)mA/cm2	CR	θ	%IE
blank	455	11.236	10.32	nil	nil
200	492	5.0312	4.62	0.55	55.22
400	513	2.956	2.71	0.73	73.69
600	519	1.563	1.43	0.86	86.32
800	523	1.194	1.09	0.89	89.37

Table 2. Reaction number and inhibitor efficiency of corrosion system in 1 M H2SO4 in absence and presence of various concentration of inhibitor

Concentration of inhibitor (ppm)	Reaction number	% IE
blank	0.062	nil
200	0.03	51.29
400	0.019	69.23
600	0.011	81.96
800	0.008	86.99

4. CONCLUSION

Open circuit potential, Polarization and thermometry have been utilized in order to study the corrosion inhibition process of mild steel in 1.0 M H_2SO_4 via corrosion inhibitors "guar gum". The major conclusion is:

1- The corrosion process reduces strongly with guar gum and inhibitor efficiency raised with rising concentrations of guar gum.
2- The value of open circuit potential has been reported more positive with raising inhibitor concentrations.
3- The corrosion current reduces on raising concentrations of guar gum.
4- The inhibition efficiency data resulted from the polarization and thermometry methods are compatible with each other.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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