Study the Effect of Urea as Inhibitor for Corrosion in Mild Steel in 2204-Tank

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***Abstract*: The effect of urea as a corrosion inhibitor on mild steel in the present of water taken from the 2204-tank located in Al-Shaiba Crude Oil Refinery in Basrah was investigated by using potentiodynamic measurement. It is found that the inhibition efficiency (IE) and coverage ratio of urea at 1.5 g/L increase by increasing the concentration of urea until reach 99.46% and 0.994, respectively . The corrosion rate is reduced with increasing the concentration of inhibitor until 1.5g/L; however, after that the corrosion rate increases. Urea inhibitor acts as a cathodic inhibitor.**

Keywords-urea;inhibitor;mild steel, inhibitor efficiency

I. INTRODUCTION

One of the main corrosion problems in many industries is the corrosion of mild steel due to increasing the usage of mild steel, which is not expensive as compared to other types of material. Using organic inhibitor is one of the techniques used to control such corrosion [1].

Corrosion is an electrochemical reaction leading to destroy metals or alloys through anodic dissolution. Many studies are carried out to improve the durability of materials and structures. Indeed, corrosion is one of the main concerns in these studies [2-4].

Inhibitors are substances added in small amounts in order to prevent or reduce the corrosion reactions [5]. Decreasing the corrosion rate occurs by the adsorption of the inhibitors on the metal surface. Compounds containing π bonds are considered as the most efficient inhibitors. The electronic structures of inhibiting molecules, steric factor, aromaticity, electron density at the donor site, molecular area, and molecular weight of the inhibitor are factors that affect the adsorption of such compounds on the steel surface. It is important to mention that compounds containing functional groups, CHO, -CO, -N=N and R-OH, act as a good corrosion inhibitor [1,6,and 7].

Urea molecule contains nitrogen and oxygen atoms as shown in Figure 1. Therefore, urea and its derivatives consider as a significant corrosion inhibition of metals and alloys because of the present of the nitrogen and oxygen atoms in their structures [8].

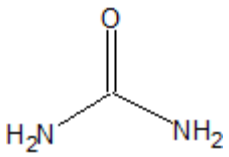

Figure 1: The chemical structure of urea

M. Manivannan studied the effect of urea as inhibitor on carbon steel in seawater and reported that the efficiency of urea increases by the addition of Zn^{2+} ion [8]. The 2204-tank water located in Al-Shaiba Crude Oil Refinery in Basrah (ACOR) is suffered from aggressive corrosion that leads to damage the body of the tank.

The aim of the present study is to investigate the effect of urea as corrosion inhibitor on mild steel in water taken from the 2204-tank at room temperature.

II.MATERIALS AND METHODS

A. Materials

Table I shows the chemical composition of mild steel ($1cm^2$) used in this study.

TABLE I. CHEMICAL COMPOSITION OF THE MILD STEEL

Element	**C**	**Si**	**Mn**	**P**
Wt%	0.18	0.13	0.44	0.013
Element	S	Cr	Cu	Fe
Wt%	0.019	0.12	0.24	Balance

B. Inhibitor Solution

The solutions of urea were prepared by dissolving a 2.5g of it in 1L of the water taken from 2204 tank , which has a parameters shown in Table II. The other concentrations (0.1 g/L, 0.2 g/L , and 1.5 g/L) are prepared by analytical dilution of stock solution.

TABLE II PHYSICAL – CHEMICAL PARAMETERS OF WATER

Parameters	**Value**	**Parameters**	**Value**
PH	7.9	**HCO_3 (mg/L)**	214
Conductivity (Us-cm-1)	4490	**Suspended solid (mg/L)**	4
$CaCO_3$ mg/L)	1058	**SiO3(mg/L)**	6
Ca^{+2} (mg/L)	232	**C.O.D (mg/L)**	21
Mg^{+} (mg/L)	116	**B.O.D (mg/L)**	9.7
CL^{-} (mg/L)	998	**Turbidity(mg/L)**	5.8
Na^{+} (mg/L)	638	**T.D.S (mg/L)**	3027

C. Potentiodynamic Polarization

Electrochemical measurements were carried out in the present of three electrodes, which are a working electrode is a sample of mild steel with geometric area of 1 cm^2, a saturated calomel electrode (SCE) is used as a reference electrode, and a platinum is used as a counter electrode. The capacity of the glass cell is 500 ml [9-11].

The working electrode was polished with silicon carbide paper starting from 180, 220, and 400 grade degreased with ethanol and rinsed with distilled water.

The corrosion parameters such as corrosion current (I_{corr}) and corrosion potential (E_{corr}) values are obtained from an electrochemical measurement. The scan rate was 0.01V s^{-1} during the polarization study. Starting from the open circuit potential with respect to saturated calomel electrode, the applied potential was manually increased in 10 mV steps in the anodic or cathodic direction.

III. RESULTS AND DISCUSSION

Table III shows that the values of Ecorr were shifted to lower values with reference to the blank in the presence of urea as a corrosion inhibitor. From this table, it can be indicated that the urea inhibits the corrosion mechanism by predominantly controlling cathodic reactions and blocking cathodic sides of the metal surface. The I_{Corr} values decrease with increasing the concentration of inhibitor and the optimum concentration of urea was 1.5 g/L. After that concentration, the counter current increased and that may be attributed to destroy the film forming on the steel surface. The potentiodynamic polarization curves for mild steel in the presence of different concentrations of the urea are shown in Figure 2.

TABLE III CORROSION PARAMETERS OBTAINED FROM POLARIZATION OF THE MILD STEEL WITH VARIOUS CONCENTRATIONS OF UREA AT 25°C FOR 3 HOURS.

Conc. (g/L)	Ecorr (mV)	Icorr (µA/cm2)	CR (mm/y)	%IE	Ɵ
Blank	-712.2	2.36×10-5	0.273	0	0
0.1	-831.5	1.61×10-7	0.0018	99.3	0.993
0.2	-823.1	1.43×10-7	0.0016	99.39	0.993
1.5	-841.4	1.27×10-7	0.0014	99.46	0.994
2	-736.6	1.79×10-5	0.208	24.02	0.24

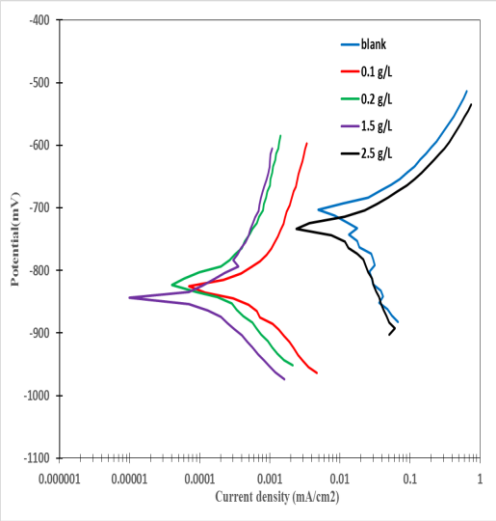

Figure 2: Potentiodynamic polarization curves for mild steel in the presence and absence of different concentrations of urea in 3 h and 25°C.

The variation of corrosion rates of mild steel with urea concentration is shown in figure 3. The corrosion rate reduced with increasing the inhibitor concentration until (1.5 g/L), after that the corrosion rate increase. Also, the inhibitor efficiency is evaluated as function to the concentration of urea as shown in figure 4.

The maximum efficiency was reported in concentration 1.5 g/L. Above that concentration, the efficiency decreased because the protective film on the surface of the metal may be destroyed.

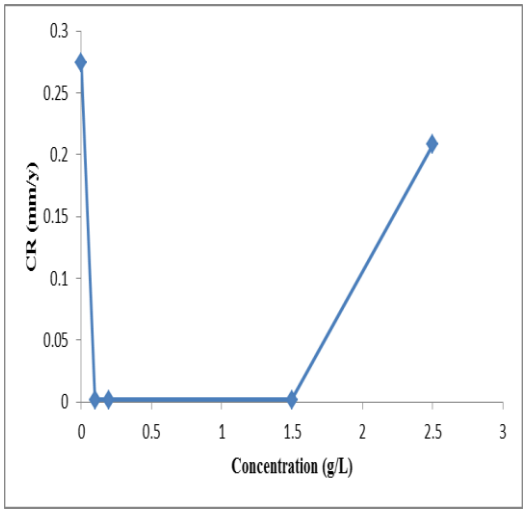

Figure 3: Effect of the concentration of inhibitors on corrosion rate.

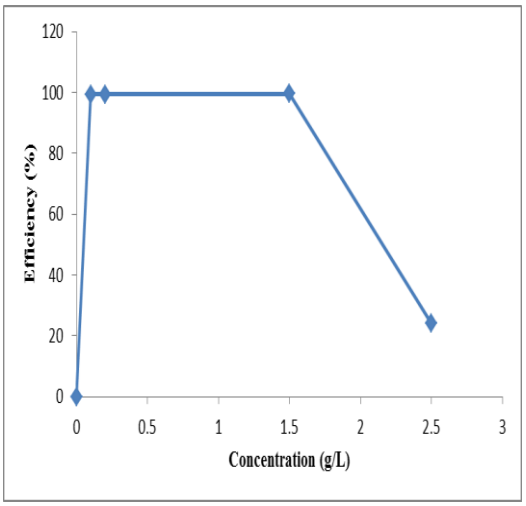

Figure 4: Efficiency of inhibitor at different concentrations of inhibitor.

Figure 5 shows the effect of immersion time on the polarization parameters (Icorr and Ecorr) for concentration of urea 1.5 g/L. Three hours of the immersion are enough for the formation of the protective film on the surface of metal and this clearly leads to reduce the corrosion current density .

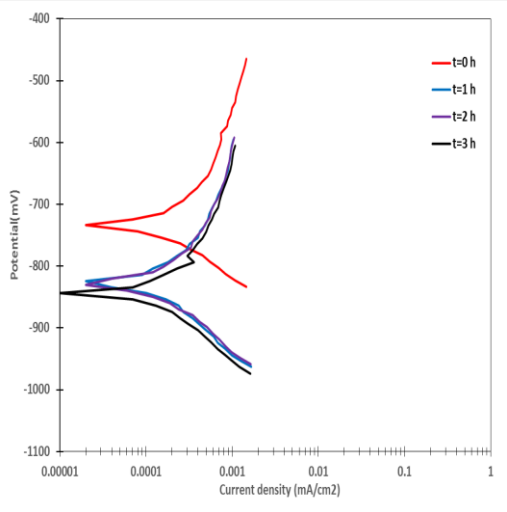

Figure 5: Current density at different immersion times.

CONCLUSIONS

The results of the present work are summarized as follows:

1. Urea is a significant inhibitor for mild steel and behaves as a cathodic inhibitor.
2. The maximum efficiency and coverage ratio are found 99.46% and 0.994 at 1.5 g/L and this is the optimum concentration.
3. The corrosion rate is reduced with increasing the concentration of inhibitors until 1.5g/L after that the corrosion rate increases.
4. Current density is reduced with increasing the time of immersion.

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