

# Turk solution as corrosion inhibitor for mild steel in acid medium .

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**Abstract**— The corrosion inhibitive action of Turk solution on mild steel corrosion in 0.5 M H<sub>2</sub>SO<sub>4</sub> solution was studied using weight loss method, potentiodynamic polarization and EIS measurements. The results obtained indicate that the extracts functioned as good inhibitors in 0.5 M H<sub>2</sub>SO<sub>4</sub> solution. Inhibition efficiency was found to increase with solution concentration. The adsorption of constituents in the solution on the surface of the metal is proposed for the inhibition behavior..

**Keywords**— Weight loss, polarization, Impedance, Turk solution

## 1. INTRODUCTION

Aqueous solutions of acids are among the most corrosive media. The inhibition of iron corrosion by organic additives has been studied widely [1-4]. A considerable amount of interest has been generated in the study of organic compounds as corrosion inhibitors owing to their usefulness in several industries: during the pickling of metals, cleaning of boilers, acidification of oil wells, etc. [5, 6]. Most acid corrosion inhibitors are nitrogen, oxygen and / or sulphur containing organic compounds [7, 8]. But, unfortunately most of them are highly toxic to both human beings and environment. A survey of literature reveals that the applicability of organic compounds as corrosion inhibitors for mild steel in acidic media has been recognized for a long time. Compounds studied as inhibitors include triazole derivatives [9], bipyrazolic derivatives [10], surfactants [11] aromatic hydrazides [12], organic dyes [13], Poly (4-vinylpyridine) [14] and thiosemicarbazide-type organic compounds [15]. These compounds can adsorb on the mild steel surface and block the active sites decreasing the corrosion rate. In this investigation a Turk solution is tested as corrosion inhibitor for steel in tank water. Weight loss, electrochemical polarization and electrochemical impedance spectroscopy (EIS) measurements are used.

## 2. EXPERIMENTAL

### 2.1. Materials

Mild steel coupons of dimensions 4.0cm x 1cm x 0.2cm having the composition 0.084%C, 0.037%Mn, 0.026%P, 0.021%S and the remainder being Fe were used for weight loss studies. The mild steel coupons were polished mechanically using the emery papers of grades 220, 400, 600, 800 and 1200, then washed thoroughly with double distilled water. Finally, the specimens were rinsed in acetone and dried. A Teflon coated mild steel rod of exposed area 0.19625cm<sup>2</sup> and having the composition same as that of the coupons was used for both impedance and polarization studies.

### 2.3. Weight loss measurements

Weight loss measurements were carried out according to the procedure described in [16]. The mild steel specimens in triplicate were immersed for a period of 2 hours in 100ml of the corrosive media with and without inhibitors at room temperature. The average weight loss of the three specimens was used to calculate the inhibition efficiency employing the formula;

$$IE\% = \left( \frac{w - w'}{w} \right) \times 100$$

Where w and w' are the weight losses in the uninhibited and inhibited solutions respectively. In the present study, at room temperature the relative difference between replicate

experiments have been found to be less than 5% showing good reproducibility.

2.4. 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 a Pt foil as the auxiliary electrode and a saturated Calomel electrode as the reference electrode. The mild steel cylinder, with surface preparations done as mentioned in the weight loss method, served as the working electrode. The measurements were carried out in the frequency range 10<sup>6</sup> Hz to 10<sup>-2</sup> Hz at the open circuit potential by superimposing a sine wave ac signal of small amplitude of about 10mV . The double layer capacitance (C<sub>dl</sub>) and charge transfer resistance (R<sub>ct</sub>) were obtained from Nyquist plots as described elsewhere [17]. Since R<sub>ct</sub> is inversely proportional to corrosion current density, it was used to determine the inhibition efficiency (IE%) from the relationship;

$$IE\% = \left( \frac{R_{ct} - R'_{ct}}{R_{ct}} \right) \times 100$$

Where R<sub>ct</sub> and R'<sub>ct</sub> are the charge transfer resistance values in the uninhibited and inhibited solutions respectively.

2.5. Polarization measurements

The potentiodynamic polarization curves were recorded using the same cell setup employed for impedance measurements. The potentials were swept at the rate of 1.66mVs<sup>-1</sup>, primarily from more negative potential than E<sub>oc</sub> to the more positive potential than E<sub>oc</sub> through E<sub>corr</sub>. The inhibition efficiencies were calculated using the relationship [18];

$$IE\% = \left( \frac{i_{corr} - i'_{corr}}{i_{corr}} \right) \times 100$$

where i<sub>corr</sub> and i'<sub>corr</sub> are the corrosion current densities in the absence and in the presence of inhibitor respectively in the corrosive media.

3. RESULTS AND DISCUSSION

3.1. Analysis of results of Weight loss method

The corrosion rates and inhibition efficiencies (IE) of Turk solution in 0.5M H<sub>2</sub>SO<sub>4</sub> solutions, in the absence and presence of tetra butyl ammonium bromide (TBAB) are presented in Table 1 and 2 respectively. The corrosion inhibition values indicate that the Turk solution as a corrosion inhibitor for the corrosion of mild steel in acid medium. From Table 1, it is clear that the inhibition efficiency values increase from 58.82% to 81.18% with increase in inhibitor concentration. The maximum inhibition efficiency of 91.76% was observed at 10ml of Turk solution . However, interestingly, (Table 2), Turk solution -TBAB combination offers good corrosion inhibition(IE=91%). This suggests a synergistic effect of TBAB and Turk solution

Table1. Corrosion rates (CR) of mild steel in 0.5M H<sub>2</sub>SO<sub>4</sub> 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 <sup>-2</sup> h <sup>-1</sup> )	IE %
0	170	-
2	70	58.82
4	50	67.05
6	46	72.94
8	35	79.41
10	32	81.18

3.2 Influence if TBAB on the on the inhibition efficiency of turk solution

Inhibitor concentration (mL)	TBAB (25) ppm	
	CR (mg cm <sup>-2</sup> h <sup>-1</sup> )	IE %
10mL+25ppmTBAB	14	91.76

### 3.3. Analysis of AC Impedance spectra

Impedance spectra obtained for corrosion of mild steel in 0.5 M H<sub>2</sub>SO<sub>4</sub> contains a semicircle, representing the interaction of metal surface with the corrosive environment. The -R(CR) model best describes this situation. The 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<sub>2</sub>SO<sub>4</sub> in the absence and presence of inhibitor are given in Table 3. Said that sum of charge transfer resistance ( $R_{ct}$ ) and adsorption resistance ( $R_{ad}$ ) is equivalent to polarization resistance ( $R_p$ ).

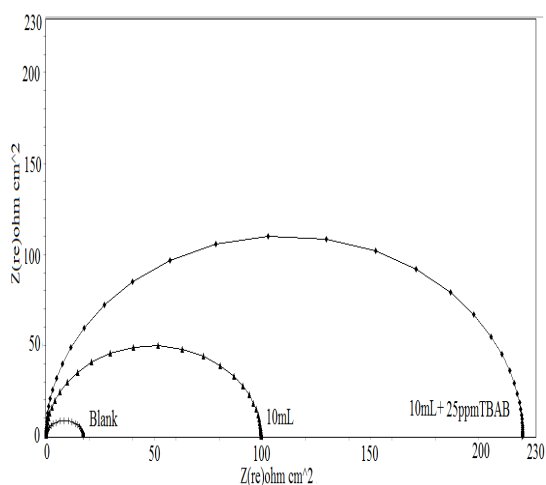


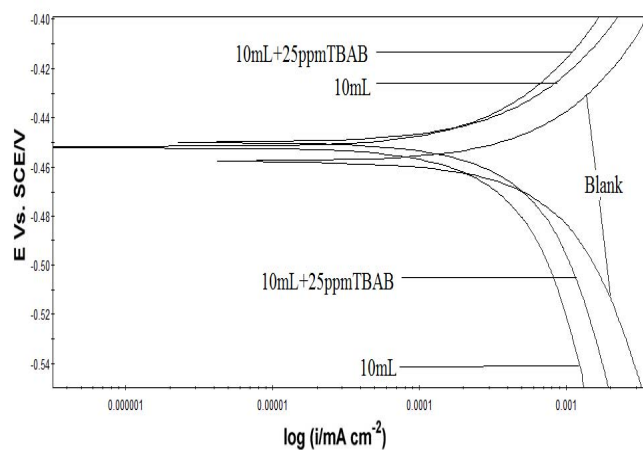
Fig.1. Nyquist plots for corrosion of mild steel in the inhibited and uninhibited 0.5M H<sub>2</sub>SO<sub>4</sub> solutions in the absence and presence of TBAB.

Table 3. Impedance parameters obtained from electrochemical impedance studies.

Inhibitor concentration mL	$R_{ct}$ Ohm cm <sup>2</sup>	$C_{dl}$ $\mu$ F	IE%
0	17.2	$9.2578 \times 10^{-3}$	-
10	99.42	$3.60 \times 10^{-7}$	82.7
10+ 25ppm(T BAB)	220.51	$0.531 \times 10^{-7}$	92.2

### 3.4. Analysis of Potentiodynamic Polarization studies

Fig 2. Potentiodynamic polarization curves of mild steel immersed in 0.5M H<sub>2</sub>SO<sub>4</sub> solution in the absence and presence of inhibitors



**Table. 4** Corrosion parameters in the presence and absence of inhibitor obtained from polarization measurements.

Inhibitor concentration ppm	$-E_{\text{corr}}$ (mV)	$\beta_c$ (mV/)	$\beta_a$ (mV)	$I_{\text{corr}} \times 10^6$ $\mu\text{A}$	IE%
0	457	127	60	1.35	-
10	461	151	71	0.243	82.0
10+ 25ppm(TBAB)	464	159	78	0.103	92.35

The polarization curves obtained for the corrosion of mild steel in the inhibited (10mL) and uninhibited 0.5M H<sub>2</sub>SO<sub>4</sub> solution in the absence and presence TBAB are shown in Fig.3. The potentiodynamic polarization parameters such as corrosion potential ( $E_{\text{corr}}$ ), corrosion current density ( $I_{\text{corr}}$ ), cathodic and anodic tafel slopes ( $\beta_c$  and  $\beta_a$ ) and the percentage inhibition efficiency according to polarization studies are listed in table 4. Here  $I_{\text{corr}}$  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  $\beta_c$  and  $\beta_a$  values (Table 4) change with an increase in inhibitor concentrations, a high  $\beta_c$  value also indicates that the cathodic reaction is retarded to a higher extent than the anodic reaction [19].

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  $E_{\text{corr}}$  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[20]. It has been reported that a compound can be classified as an anodic and cathodic type inhibitor on the basis of shift of  $E_{\text{corr}}$  value. If displacement of  $E_{\text{corr}}$  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 type [21]. In our study, maximum displacement in  $E_{\text{corr}}$  value was around 7 mV, indicating the inhibitor is a mixed type and more cathodic 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 [22]. The increase in inhibitor efficiency of inhibited (10mL) 0.5M H<sub>2</sub>SO<sub>4</sub> solution for the corrosion of mild steel after adding 25 ppm TBAB shows synergism between inhibitor molecules and TBAB.

#### 4. CONCLUSION

The following conclusions were arrived in the present study.

- i) The obtained results show the Turk solution can act as a good corrosion inhibitor for the corrosion of mild steel in 0.5M H<sub>2</sub>SO<sub>4</sub> solution.
- ii) The inhibition efficiency is improved by the addition of TBAB.
- iii) The electrochemical impedance measurements showed that the corrosion of mild steel sample is mainly controlled by charge transfer process.
- iv) Potentiodynamic polarization results indicate that Turk solution act as mixed type inhibitor.

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