Asian Journal of Chemistry Vol. 18, No. 1 (2006), 365–370

Effect of Dimethyl 2-(2-hydroxy phenyl amino)-3-(triphenyl phosphor anilidene)butanedioate on Corrosion Parameters of SS_{321} in C_2H_5OH-H_2SO_4 Solution

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Dissolution behaviour of stainless steel type 321 was studied in mixture of C_2H_5OH-H_2SO_4 solution using dimethyl 2-(2-hydroxy phenyl amino)-3-(triphenyl phosphor anilidene)butanedioate, [LOH], as inhibitor by potentiostatic method. The effect of temperatures (20–50 ± 1°C) on corrosion parameters of this alloy was investigated. The open circuit potential values in the presence and absence of [LOH] were noted before and after experiments that show a passive film is formed on the surface of the samples. The cathodic current density increased with increasing cathodic potential and temperature. The shapes of the cathodic curves are similar. The cathodic Tafel values ranged between (80–125 mV/dec I), indicating hydrogen evolution reaction taking place on the surface of the working electrode. In anodic region, active-passive behaviour was observed in all experimental solutions. The corrosion current density decreases with addition of [LOH]. The critical current density for passivation decreases with increasing [LOH] up to 10 ppm. Passivation current density and passivation potential vary irregularly with increasing concentration of [LOH]. The passive region vanished around 1100 mV and thereafter current density increased sharply. SEM taken from the surface of the sample after polarization reveals reduction of pits with using [LOH].

Key Words: Corrosion, Stainless Steel, Inhibitor.

INTRODUCTION

Dissolution studies of stainless steels in non-aqueous media have been a subject of interest, because of the wide use of organic solvents in different industries and other places. The pitting of different metals and stainless steel during anodic polarization has been reported in alcoholic solution containing acids[1–4]. The effectiveness of organic compounds containing sulphur, oxygen, nitrogen as corrosion inhibitors for steel in sulphuric acid is well known[5, 6]. They suppress the anodic and/or the cathodic reactions involved in the corrosion process by adsorbing on the metal surface and the efficiency of inhibition is, in general, directly proportional to the amount of inhibitor adsorbed or the surface coverage. The functional group and the structure of the inhibitor molecule play significant roles in the adsorption process. Even though a lot of research work has been reported on the pitting and corrosion behaviour of stainless steel, but there is no report about dimethyl 2-(2-hydroxy phenyl amino)-3-(triphenyl phosphor anilidene)-butanedioate [LOH], which is used as inhibitor. This compound contains oxygen, phosphorus, nitrogen and three aromatic rings so that we thought this compound can work as an inhibitor. This compound has large size and some rings. Adsorption of neutral organic compounds at metal surfaces takes place by electron transfer, through the loosely bound electrons of the π-bonds or the aromatic rings.

In the present work we have checked the corrosion parameters of SS_{321} in 4 M C_2H_5OH-H_2SO_4 solution using [LOH] as inhibitor.

EXPERIMENTAL

The investigations were carried out with annealed foils of stainless steel type 321 (Goodflow, England). Electrodes of 1 cm^2 area were employed in this study. The electrodes were mechanically polished with different grades (400, 600 and 1500) of emery paper in sequence. The electrode was dipped in soap solution which emulsified the particulate material sticking to the surface and edges. After washing several times with distilled water and acetone the electrode was dried by filter paper. Corrosion studies were carried out potentiostatically (Gs, CV and PG system, ZAG Chimi). The experiments have been done in three electrodes assembly in which a platinum electrode of 2 cm^2 area was used as counter electrode. The potentials were recorded *vs.* SCE. The experiments were performed at different temperatures (20–50 ± 1°C). The solutions were prepared with addition of different concentrations (5, 10, 15, 20 and 25 ppm) of [LOH] to 4 M C_2H_5OH-H_2SO_4. The inhibition efficiency, I%, at different quantities of inhibitor was calculated from the equation:

$$I\% = [(i_0 - i_c)/i_0] \times 100$$

where i_0 and i_c were the corrosion currents for the uninhibited and inhibited solutions[6]. Micrographs were taken from the surface of the samples after polarization using scanning electron microscope (SEM).

RESULTS AND DISCUSSION

The open circuit potentials were noted before and after polarization. The said values before polarization lay between –340 to +70 mV *vs.* SCE, whereas these values after the experiment ranged from 320 to 500 mV possibly due to the formation of passive film on the surface of the samples. The cathodic and anodic polarization curves for SS_{321} in 4 M C_2H_5OH-H_2SO_4 solution using different amounts of [LOH] at 40 ± 1°C is shown in Fig. 1.

The corrosion parameters derived from these curves are given in Table-1. It is seen from the curves that the current density increases with increasing potential in the cathodic direction at each concentration; however, the nature of cathodic curves remains the same. On the other hand, the corrosion current density (i_{corr}) decreased with increasing [LOH] concentration. The corrosion potential (E_{corr}) shifted towards positive direction in the presence of [LOH]. The positive shift in corrosion potential shows this compound is an effective suppressor of the anodic dissolution reaction[7]. It is seen from Fig. 1 that the corrosion current in 10 ppm of [LOH] is least while the corrosion potential in this concentration is more than the other concentrations. The nature of cathodic curves is similar which shows that the cathodic reaction is same at all concentrations of [LOH]. The cathodic Tafel slope varies between (80–125 mV/dec I) which would suggest a simple blocking of active site by [LOH] to suppress the reaction; however, a careful look at the data in Table-1 shows that the value of Tafel slope in 10 ppm of [LOH] is highest and it can be suggested that the mechanism of hydrogen evolution may be altered. Similar results have been reported in the case of iron[8].

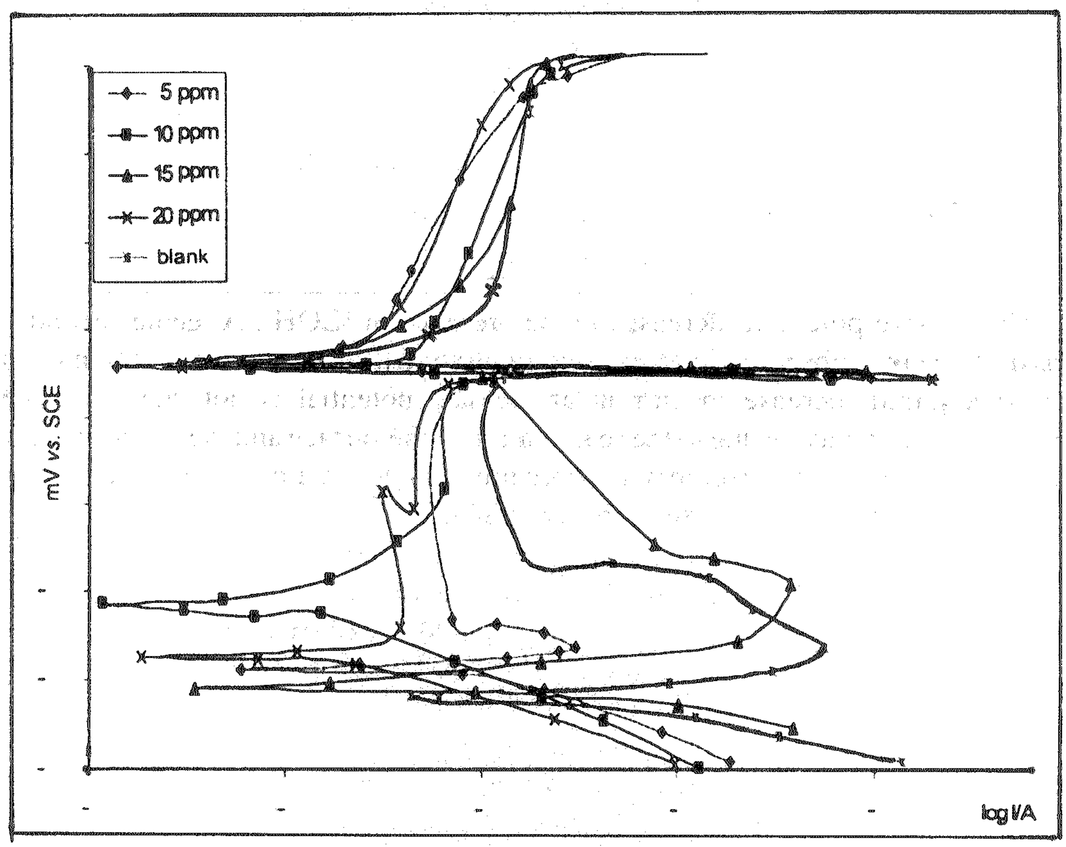


Fig. 1. Polarization curves of SS_{321} in 4 M H_2SO_4 C_2H_5OH solution using different concentration of [LOH]

Anodic polarization curves of SS_{321} in 4 M C_2H_5OH-H_2SO_4 at different concentrations of [LOH] revealed active-passive behaviour. The shapes of anodic polarization curves are similar, which shows that the inhibition mechanism of [LOH] taking place at all concentrations of [LOH] is the same but might have been proceeding at different rates.

The active region decreases in the presence of [LOH] so that in 10 and 20 ppm of [LOH] the critical current density is not seen. The anodic Tafel slope lay between (25–60 mV/dec I) so that the value of 25 mV/decI deal to blank solution. It has been reported that the Tafel slope values generally were higher in the presence of inhibitor[6]. An increase in Tafel slope suggests a mode of inhibition involving an interposition of the organics into the charge transfer process for the anodic reaction.

TABLE-1
CORROSION PARAMETERS OF SS_{321} IN 4 M H_2SO_4-C_2H_5OH USING DIFFERENT CONCENTRATIONS OF [LOH].

ppm	I_{corr} (A)	E_{corr} (mV)	I_{cr} (A)	I_p (A)	E_p (mV)	b_c	I%
0	4.3×10^{-5}	–342	5.6×10^{-3}	1.6×10^{-4}	18	75	—
5	6.0×10^{-6}	–274	3.0×10^{-4}	7.1×10^{-5}	–162	83	86
10	1.0×10^{-6}	–126	—	1.6×10^{-5}	–72	125	97
15	3.4×10^{-6}	–324	3.7×10^{-3}	1.1×10^{-4}	9	93	92
20	5.8×10^{-6}	–252	—	3.0×10^{-3}	–130	85	86
25	8.7×10^{-6}	–283	3.7×10^{-5}	2.2×10^{-3}	9	7	79

The passive potential increases in the presence of [LOH]. A feeble secondary passivity peak is observed in each solution mixture (Fig. 1) at around 400 mV. The observed rapid increase in current at the said potential is not due to oxygen evolution, but it may be due to the reactivation of the surface and then a more highly developed interfacial film composed of mainly Cr_2O_3 containing CrO_3 was formed. Such investigation was reported earlier for AISI 316.[9]

The effect of temperature (20–50 ± 1°C) was studied in the presence of 10 ppm [LOH], because the best inhibition efficiency occurs at this concentration. Cathodic and anodic polarization curves of SS_{321} in 4 M C_2H_5OH-H_2SO_4 using 10 ppm [LOH] is shown in Fig. 2. The results of these curves are given in Table-2. It is seen from the data of polarization that the corrosion current density increases with increasing temperature, so that the lowest current density values were observed at 20 ± 1°C, while the corrosion potential decreases with increasing temperature. The critical current density was not observed at 20 and 40 ± 1°C.

TABLE-2
CORROSION PARAMETERS OF SS_{321} USING 10 ppm OF [LOH] AT DIFFERENT TEMPERATURES

Temp. (°C)	I_{corr} (A)	E_{corr} (mV)	I_{cr} (A)	I_p (A)	E_p (mV)
20	1.2	–150	—	2.9×10^{-5}	–94
30	2.8	–140	4.5×10^{-4}	5.7×10^{-5}	81
40	1.1	–126	—	1.6×10^{-5}	72
50	1.2	–160	1.7×10^{-3}	4.2×10^{-5}	117

The passive potential increases with increasing temperature. The critical current density and passive current density were appreciably high at 50 ± 1°C in comparison to other temperatures, so that the film formed on the surface of samples seems to be better at 20 ± 1°C, which indicates that the best efficiency of [LOH] occurs at 20 ± 1°C.

Apparent activation energy in the passive region calculated from Arrhenius plot is shown in Fig. 3. The apparent activation energy obtained in the passive region for the alloy in this medium may be considered to be associated with the complex processes/mechanisms that occur in this region[10]. This value of activation energy in the passive region may be attributed to the formation of passive film on the surface of samples.

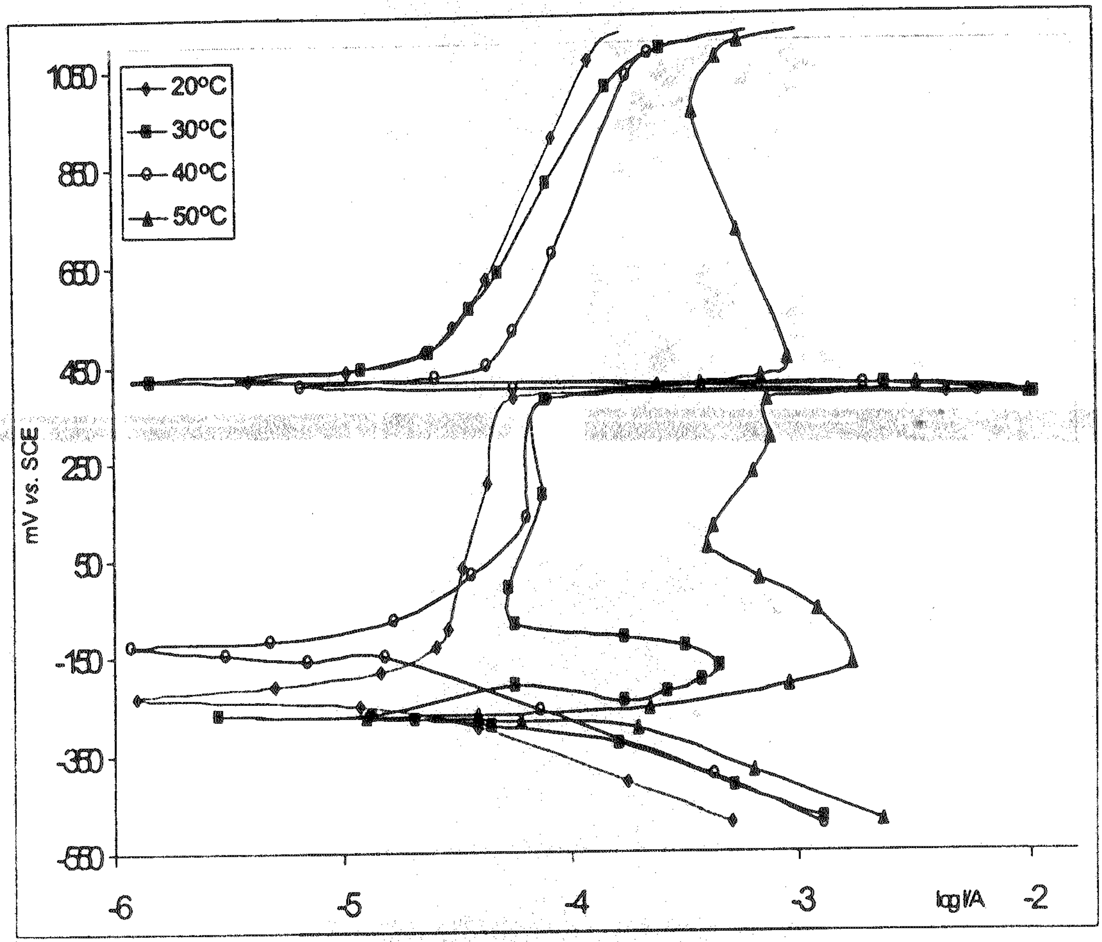


Fig. 2. Polarization curves of SS_{321} in 4 M H_2SO_4-C_2H_5OH solution using 10 ppm of [LOH] at different temperatures

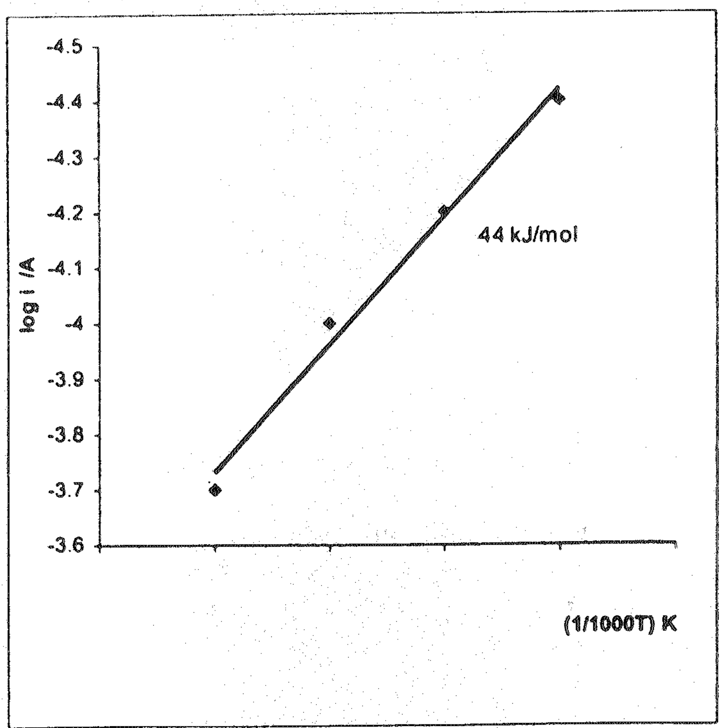
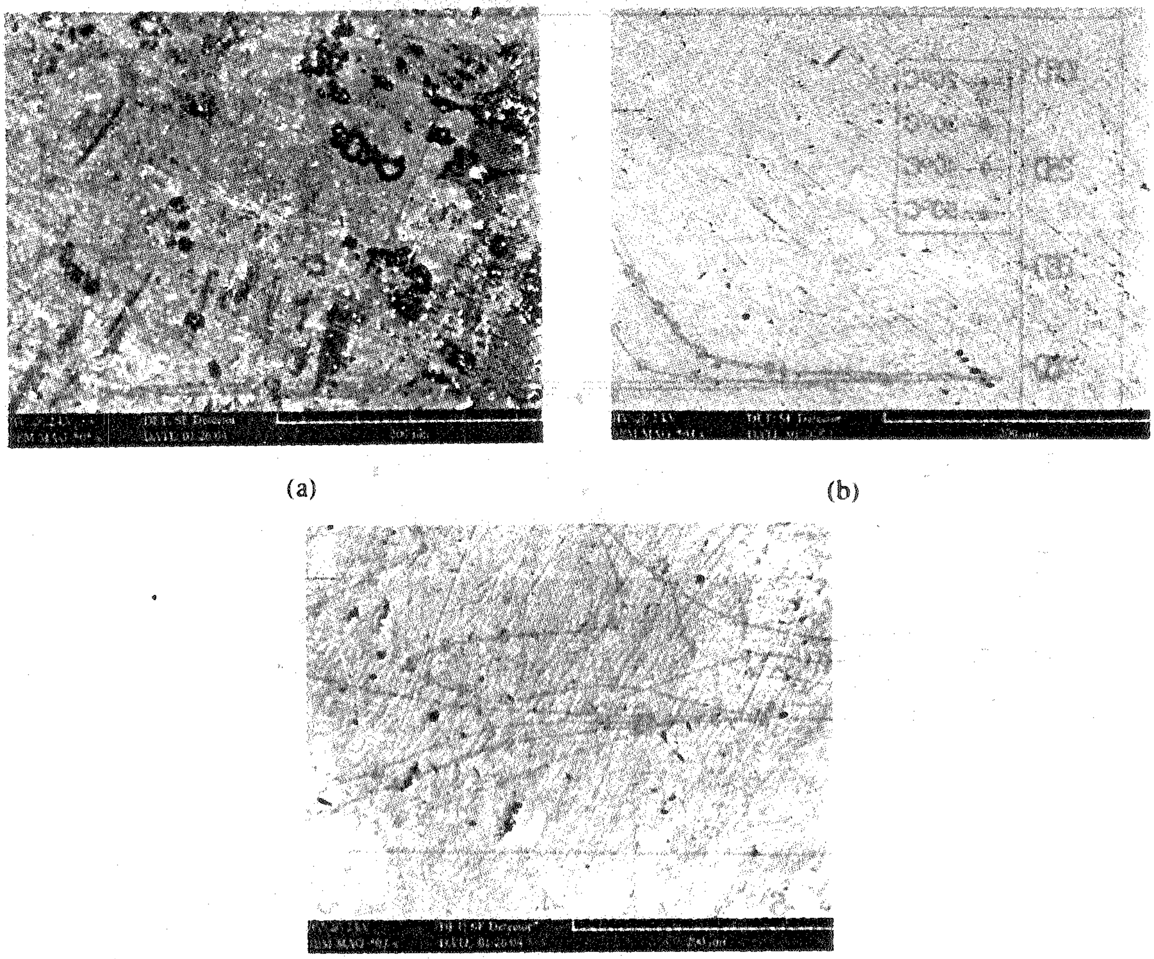


Fig. 3. Arrhenius plot for SS_{321} in 4 M H_2SO_4-C_2H_5OH using 10 ppm [LOH]



(a) (b)

(c)

Fig. 4. SEM from the surface of SS_{321} in 4 M H_2SO_4 C_2H_5OH: (a) blank (b) using 10 ppm [LOH] at 20°C (c) 10 ppm [LOH] at 40°C

Fig. 4 shows the micro-structures taken from the surface of the SS_{321} 24 h after polarization and exposure. They reveal that pitting and general corrosion decrease in the presence of [LOH].

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(*Received*: 21 February 2005; *Accepted*: 26 September 2005) AJC-4410