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A Novel Corrosion Inhibitor for Improvement of C-Steel Resistance

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Abstract

Impacts from ditiocarb sodium trihydrate inhibitor on corrosion of the carbon steel in saturated-CO_2 and deaerated 0.5 M H_2SO_4 acidic solution has been studied using potentiodynamic polarization and open circuit potential procedures. The conclusion suggests that redundancy effectiveness of the evaluated ditiocarb sodium trihydrate compound depends on the concentration and the nature of the corrosive media: the corrosion current density (i_{corr}) decreases with incrementing ditiocarb sodium trihydrate inhibitor concentration. Increasing the ditiocarb sodium trihydrate concentration leads not only to an increase in the efficiency of the inhibitor, but a reduction in the rate of corrosion. The corrosion potential becomes slightly more positive. Polarization results indicate that this compound behaves as a mixed-type inhibitor and it works best in deaerated, acidic media. On the basis of the data, ditiocarb sodium trihydrate is recommended for use as an effective inhibitor.

Keywords: ***C-steel; Ditiocarb sodium trihydrate; Corrosion inhibition; Mixed inhibitors***

Introduction

Corrosion is a common problem encountered in the oil and gas industry, as refineries, pipelines and petrochemical plants suffer considerable corrosion problems. Internal corrosion in industrial equipment is commonly caused by exposure of the surfaces to water, hydrogen sulfide, and carbon dioxide, and also can be provoked by unchecked microbiological activity in the system [1]. The rate of corrosion is mainly governed by the flow management of the multiphase fluids encounter. For example, under lower flowing, decay is observed more commonly, whilst greater flowing indicates flow-accelerated corrosion, as well as erosion-corrosion, may occur. The degree of corrosion observed is generally associated with the amount and nature of the residues present. Low velocity permits residues to settle at the bottom, whereas, flow with greater velocity inclines towards swaying residues away from the pipeline, thus reducing the potential sites for pitting and corrosion [2]. The subject of corrosion, and its elimination, is particularly serious in the oil and gas industries, since the economic damage suffered by these industries, due to corrosion, is especially high [3].

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Corrosion due to carbon dioxide has been an acknowledged problem associated with oil and gas manufacture and conveyance for many years [4], as the gas collects in the equipment following ingress. Dry carbon dioxide gas does not contribute to corrosion at the operating temperatures experienced commonly within gas and oil manufacturing systems, but when it subsequently comes into contact with both the aqueous phase and carbon steel, it promotes electrochemical reactions [5]. When dissolved in the water, carbon dioxide forms carbonic acid making the fluid acidic. Thus, corrosion due to carbon dioxide is particularly favored when there is an increase in the hydrogen scale value; at elevated temperatures, a change in the configuration of the aqueous stream, dissociation metal conditions and when acidic phases are present [6,7]. Consequently, it is the predominant form of corrosive attack encountered in gas and oil manufacture [8]. At high temperatures, scoring occurs on the iron carbide gas and oil pipes, which are used for their higher performance, and the metal begins to corrode under these circumstances. Carbon dioxide corrosion can have observed in two based forms: pitting [9] and a form of localized carbon dioxide corrosion under average-flow settings [10].

Of the different approaches used to control corrosion in the gas and oil sectors, the utilization of decaying materials is amongst the most efficient procedures [11,12]. There are many kinds of inhibitors of corrosion, and they are widely classified into cathodic, anodic or mixed corrosion inhibitors. There are also more subtle arrangements based on their chemical structure, with the greatest inhibitors being organic compounds, having one or more polar groups, which may be adsorbed strongly on the surfaces of metals [13-15]. The above inhibitors, which include examples containing moieties incorporating nitrogen (N), phosphorus (P) and/or sulfur (S) atoms, mitigate the response corrosion rate under solution-metal interface lacking the need for complicated measurement of the reaction rate. It is widely considered that organic inhibitors act through adsorption at interface of the solution-metal. The inhibitors decrease the corrosion current and the change in corrosion potential is attained by disrupting the process necessary for electrochemical procedures. The decay initiation on carbon steel under hostile acidic solution has been lengthily evaluated [16-39] and in the other studies, *Eucalyptus globulus* "Myrtaceae" has been investigated using surface analysis and electrochemical measurements as decay initiator for C38 steel in H_2SO_4 solution [40]. The inhibition in gas and oil fields is brings an additional level of complexity and needs certain ecological initiators based on the characteristics of implementation, i.e., wells, salvage units, pipelines, factories etc. Destructive compounds, alike H_2S, CO_2, and acids organic have the potential to deceive the error of initiation in wells [41]. Corrosion inhibition of X-70 pipeline steel in salt water saturated with carbon dioxide at 50°C with carboxyamidoimidazoline has been assessed by using electrochemical techniques [42] for its potential to inhibit the corrosion of C-steel alloy, along with other imidazoline derivatives [43]. The present work studies the inhibitory influence of ditiocarb sodium trihydrate on the corrosion of carbon steel (C-steel), which is used extensively in Iraq's oil equipment, in 0.5 M H_2SO_4 in dearated and saturated carbon dioxide solutions using electrochemical procedures.

Experimental

Chemicals and solutions

C-steel was used as the working electrode to investigate the corrosion inhibition in dearated (passing N_2) and saturated carbon dioxide acidic solution at 298.15 K in both the nonattendance and attendance of ditiocarb sodium trihydrate inhibitor. The chemical compositions of carbon steel obtained from Iraq's oil fields were confirmed by analysis using optical emission spectroscopy (OES) (PMI MASTER Pro 2 Oxford, UK) and the data are shown in TABLE 1. The samples were cut to dimensions (1 cm × 1 cm and thickness 0.5 cm) and polished to mirror finish by using emery paper and followed by immersion in aqueous alumina suspensions to make the surface very soft. Then, the surface of carbon steel was cleaned using hot benzene (N.B., caution this is a cancer suspect agent) and acetone with distilled water and finally dried by passing a flow of nitrogen gas.

TABLE 1. **Chemical composition of carbon steel by optical emission spectroscopy.**

Elements	C	Si	Mn	Cr	Mo	Ni	Cu	Fe
Wt.%	2.18	3.1	1.36	0.1	0.12	0.21	0.59	Balance

The working C-steel specimen retrieved from carbon steel pipes were covered using epoxy, as to establish a cross-sectional vicinity, 1 cm^2, as was under was interaction of the acid compound. A consistent temperature was maintained for all instances, 298.15 K through implementing thermostat bath circulator (ex HYSC company, Korea). All solutions were established freshly using distilled water mixed with sulfuric acid (obtained through Scharlau company). Solutions of 0.5 M H_2SO_4 were established through mixing of analytical reagent grade 97% H_2SO_4 in the water.

Corrosion inhibition study

The inhibitory action of ditiocarb sodium trihydrate (which supplied from SIGMA-ALDRICH Company, FIG. 1) towards the corrosion of C-steel in dearated and saturated carbon dioxide acidic solutions under nonattendance as well as attendance of various concentrations by ditiocarb sodium trihydrate at over range from (1×10^{-3} M to 3×10^{-3}).

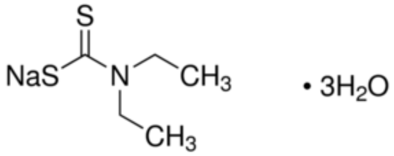

FIG. 1. **The chemical structure of ditiocarb sodium trihydrate.**

Electrochemical measurement

The electrochemical measurement assortment utilized was a standard five necked Pyrex glass cells (250 ml), housing three-electrodes, including a working electrode (carbon steel), platinum electrode as auxiliary, furthermore a saturated Calomel electrode ($Hg \mid Hg_2Cl_{2\,(s)} \mid KCl$) as a reference. The remaining two necks, allow the gas to enter and exit. The working electrodes with a square surface of 1 cm^2 were held using epoxy resin. The auxiliary electrode constituted a platinum foil and coated with black platinum to increase a large surface area and confer high catalytic activity, constructed the Saturated Calomel electrode constituting a precise Luggin capillary tube placed under vicinity to the functioning electrode surface for the purpose of mitigating Ohmic potential drop (I × R). Then, the working electrode, platinum electrode and cited electrode using precise Luggin capillary were immersed in the saturated carbon dioxide solution and connected by Potentiostat/Galvanostat/ZRA Interface 1000 which obtained from the GAMRY company, USA) for measuring the open circuit potential (OCP) and obtained on the potentiodynamic curves, After that, using an Echem Analyst (version 6.23) to estimate the electrochemical parameters for Tafel polarization curves at a polarizing value ± 100 mV under respect towards free corrosion potential.

Results and Discussion

Open circuit potential

The variation of open circuit potential (OCP) against time provides an idea of cathodic and anodic procedures of corrosion reaction [44]. Fluctuation of OCP as a task of immersion time has to potential to be used as display the development processes of the shielding films [45], i.e., the open circuit potential is the steady state potential at which a carbon steel equilibrates in a given test solution and there is no external source polarizing or shifting the potential from the equilibrium value. The study was performed by immersing the carbon steel in deaerated or in carbon dioxide 0.5 M sulfuric acid solution and measuring the potential with time. The OCP was estimated when the potential becomes constant with respect to time [46]. The changes in OCP of carbon steel under nonattendance as well as attendance of various concentrations (1×10^{-4} M to 3×10^{-3} M) of ditiocarb sodium trihydrate inhibitor in saturated CO^2 0.5 M H_2SO_4 and deaerated at 298.15 K are show in FIG. 2 and 3, respectively.

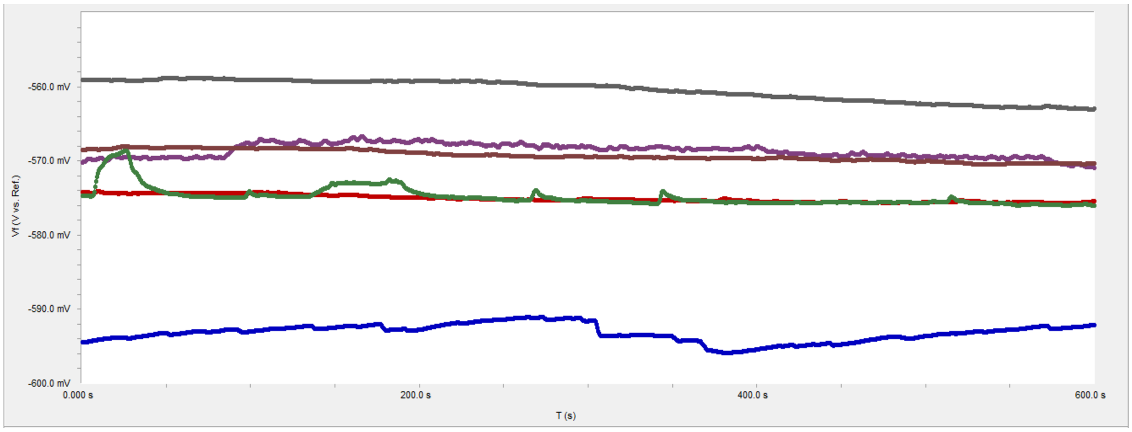

FIG. 2. **OCP curves of carbon steel CO_2 saturated 0.5 M H_2SO_4 corrosive solution with different concentrations of ditiocarb sodium trihydrate (blank, 1×10^{-4} M, 3×10^{-4} M, 6×10^{-4} M, 1×10^{-3} M and 3×10^{-3} M) at 298.15 K.**

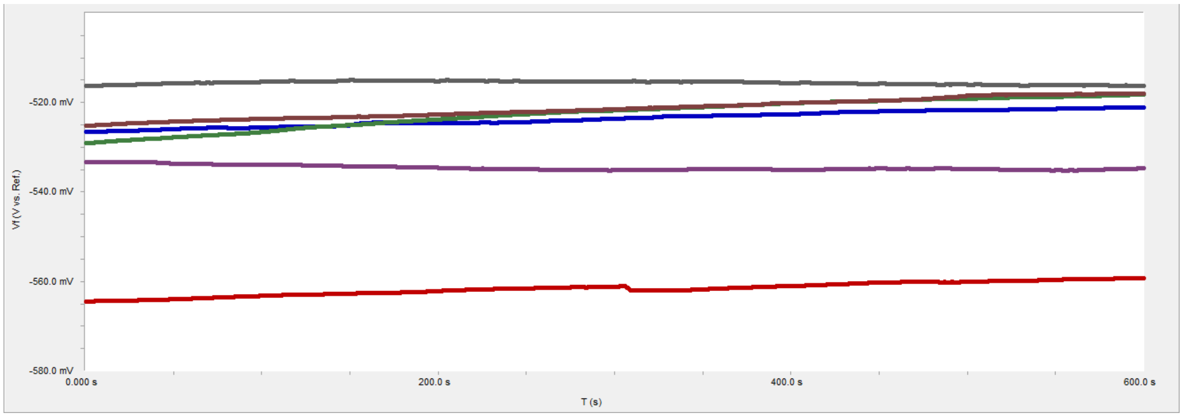

FIG. 3. **OCP curves of carbon steel in deaerated 0.5 M H_2SO_4 corrosive solution with different concentrations of ditiocarb sodium trihydrate (blank, 1×10^{-4} M, 3×10^{-4} M, 6×10^{-4} M, 1×10^{-3} M and 3×10^{-3} M) at 298.15 K.**

From the open circuit, potential curves shown in FIG. 2 and 3, it can been seen that the stable position was achieved under ten minutes introduction of carbon steel into the compound. In the absence of the ditiocarb sodium trihydrate inhibitor, the OCP drifts towards the noble direction during the initial 400s of immersion. Lacking ditiocarb sodium trihydrate, potential of the opened circuit turns negative given the dissolution of air that was present on the carbon steel prior to introduction into the compound [47]. Subsequently, an intermediate stage of the potential is observed in the range from -580.0 mV to -590.0 mV in saturated carbon dioxide and 525.0 mV to -530.0 mV in deaerated 0.5 M H_2SO_4 solution with respect to the saturated Calomel electrode then unit steady state. This disparity of OCP with time reveals the corrosivity of the sulfuric acid on the C-steel electrode. This indication explains passing in a potential of high frequency and low intensity, with an increase in their intensity towards the cathode direction, and the slow decay towards the anodic direction, in the special case of the material suffering from pitting corrosion [48,49]. If the anodic process of the corrosion process includes CO_2 corrosion in solution and pitting corrosion in deaerated solution, then a starting period can be anticipated prior to formation of the pit, therefore the first property of the potential turns positive of the pitting overall potential, follow that the OCP turns further in decline [50]. This observation indicates that in the absence of inhibitor the OCP of the saturated carbon dioxide is lower than in deaerated 0.5 M H_2SO_4 solution. Simultaneously, a progress in the value of the potential creates an increment in the rate of corrosion alongside fastened development of the film.

The addition of ditiocarb sodium trihydrate inhibitor (1×10^{-4} M) to saturated carbon dioxide and deaerated 0.5 M H_2SO_4 solution turns towards balanced state potential property towards decline, without impacting any fluctuations in the characteristics of E-t curve, which indicates that catalyze fastened film dissolution. Thus, the shifts increment alongside incrementing concentration of ditiocarb sodium trihydrate inhibitor. The incrementing turn towards fluctuation of OCP in the presence of the ditiocarb sodium trihydrate inhibitor indicates that ditiocarb sodium trihydrate has influenced the anodic reaction of carbon steel corrosion [51]. The OCP for carbon steel in saturated carbon dioxide 0.5 M sulfuric acid solution is 560.0 mV lower than the deaerated condition, which is 518.0 mv. The changes of the OCP to more positive direction could be deliberate in regard to the establishment of shielding layer of inhibitor on surface of the carbon steel [52]. Such conclusion could be comprehended on the basis of establishment of a steady Fe (II)-complexes alongside sulfur atom [53]. Thus, the protective layer becomes thicker at the higher concentration (3×10^{-3} M) of the ditiocarb sodium trihydrate inhibitor.

Potentiodynamic polarization curves

FIG. 4 and 5 depict the influence of ditiocarb sodium trihydrate inhibitor concentration (1×10^{-4} M to 1×10^{-3} M) towards carbon steel's polarization curves in the saturated and deaerated 0.5 M H_2SO_4 solution at 298.15 K. The potentiodynamic polarization measurements have been conducted scanning volume of 0.5 mVs^{-1}. Inspection of FIG. 4 and 5 reveal that either cathodic or anodic curves are turned to reduce present values under the attendance of ditiocarb sodium trihydrate inhibitor compared with the case in which the ditiocarb sodium trihydrate inhibitor is absent. This conclusion points towards the increase of ditiocarb sodium trihydrate mitigates the anodic mitigates and too obstructs the hydrogen evolution reaction for the corrosion process. Tafel lines constituting almost equal slopes were also acquired from the analytical data from the potentiodynamic scans, pointing towards the hydrogen fluctuation reaction was activation-administered [54]. This performance reflects the inhibitory action of ditiocarb sodium trihydrate. The range in the shifts in present density increments alongside incrementing ditiocarb sodium trihydrate inhibitor concentration. Therefore, the electrochemical structures, such as current corrosion density (i_{corr}), corrosion potential (E_{corr}), anodic Tafel slope (βa), and cathodic Tafel slope (βc), were obtained by Tafel extrapolation at the corrosion potential (E_{corr}) and the parameters are listed in TABLES 2 and 3.

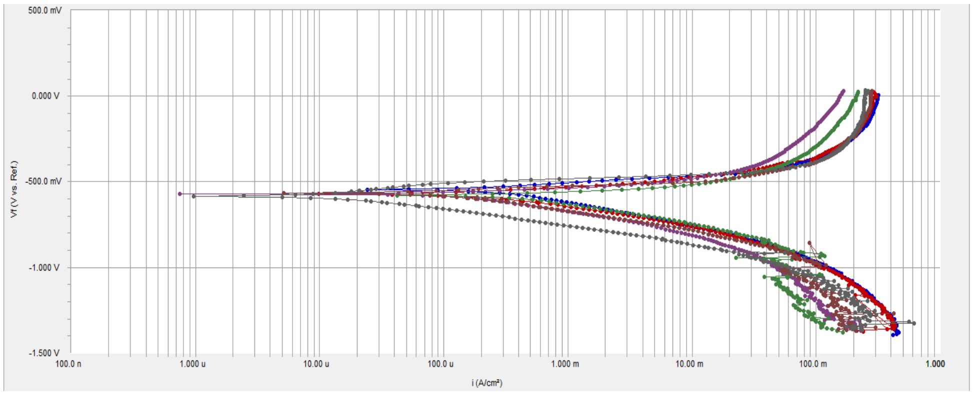

FIG. 4. **Potentiodynamic polarization curves for carbon steel in saturated CO_2 0.5 M H_2SO_4 when exposed to different concentrations of ditiocarb sodium trihydrate inhibitor (blank, 1×10^{-4} M, 3×10^{-4} M, 6×10^{-4} M, 1×10^{-3} M and 3×10^{-3} M) at 298.15 K.**

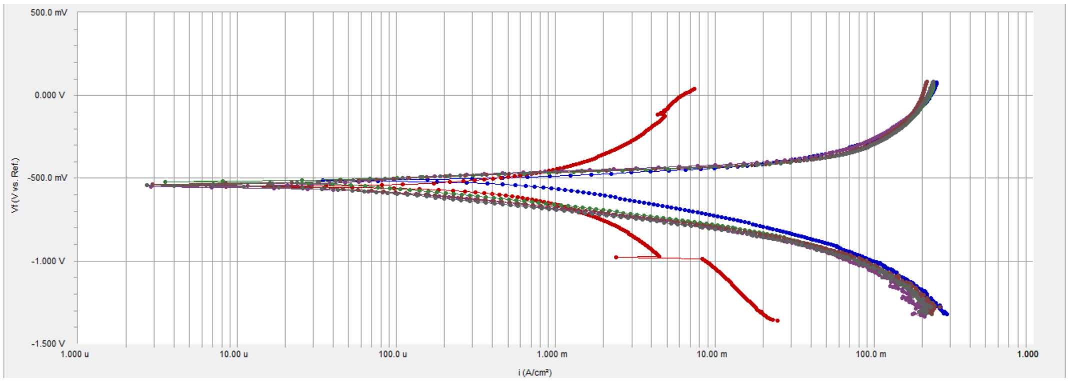

FIG. 5. **Potentiodynamic polarization curves for carbon steel in deaerated 0.5 M H_2SO_4 when exposed to different concentrations of ditiocarb sodium trihydrate inhibitor (blank, 1×10^{-4} M, 3×10^{-4} M, 6×10^{-4} M, 1×10^{-3} M and 3×10^{-3} M) at 298.15 K.**

TABLE 2. **Parameters of carbon steel corrosion in saturated CO_2 0.5 M H_2SO_4 when exposed to different concentrations of ditiocarb sodium trihydrate inhibitor at 298.15 K.**

Conc. (M)	i_{corr} μA/cm^2	E_{corr} mV	β_a mV/decade	β_C V/decade
0	285.0	-545.0	67.20	134.3
1×10^{-4}	146.0	-571.0	51.20	87.80
3×10^{-4}	135.0	-571.0	47.00	119.6
6×10^{-4}	128.0	-580.0	60.50	165.3
1×10^{-4}	51.50	-564.0	32.90	77.20
3×10^{-4}	7.970	-581.0	60.30	65.60

TABLE 3. **Parameters of carbon steel corrosion in deaerated 0.5 M H_2SO_4 when exposed to different concentrations of ditiocarb sodium trihydrate inhibitor at 298.15 K.**

Conc.(M)	**i_{corr} µA/cm^2**	**E_{corr} mV**	**β_a mV/decade**	**β_c mV/decade**
0	386.0	-512.0	52.40	127.6
1×10^{-4}	210.0	-560.0	160.7	165.0
3×10^{-4}	32.60	-551.0	77.60	83.50
6×10^{-4}	29.50	-522.0	36.90	79.70
1×10^{-4}	14.00	-539.0	40.30	54.70
3×10^{-4}	9.180	-543.0	39.30	51.10

TABLES 2 and 3 show that in the absence of inhibitor the corrosion current density i_{corr} is high: 285.0 µA/cm^2 for carbon steel in saturated carbon dioxide 0.5 M H_2SO_4 solution and 386.0 µA/cm^2 in deaerated solution; the increase in corrosion current density i_{corr} results from the increasing electrons pumps by anodic reaction for the corrosion reaction. In 0.5 M H_2SO_4 compounds, the anodic response of decay is the mitigation of Fe^{2+} ions inside the compound, and the cathodic reaction is the issue of hydrogen ions to constitute hydrogen gas, which initiates and increases the corrosion rate [55]. Nevertheless, the addition of ditiocarb sodium trihydrate inhibitor causes mitigations along the levels of corrosion current density the extent of corrosion with incrementing volumes of ditiocarb sodium trihydrate inhibitor. The value reaches 7.970 µA/cm^2 in saturated carbon dioxide acidic solution and 9.180 µA/cm^2 in deaerated solution at the optimum concentration 1×10^{-4} M. Generally, the reduction in corrosion current density for carbon steel samples is greater in deaerated solutions than in aerated 0.5 M H_2SO_4 solutions as show in FIG. 6. This is perhaps because the formation of the blockade film on carbon steel surface in deaerated solution is thicker than in the saturated-CO_2 in the 0.5 M H_2SO_4 acidic solution.

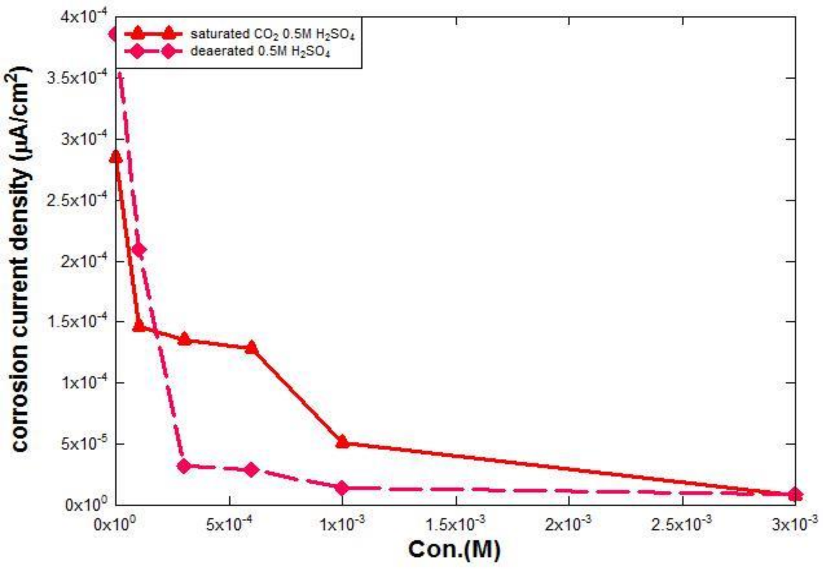

FIG. 6. **Corrosion current density for carbon steel in saturated-CO_2 0.5 M H_2SO_4 and deaerated acidic solutions when exposed to different concentrations of ditiocarb sodium trihydrate inhibitor at 298.15 K.**

It has been stated that if the dislocation in E_{corr} in the presence of inhibitor is greater than ± 85 mV when compared with E_{corr} in the absence of inhibitor, then the inhibitor could be assessed as a property cathodic or anodic variation [56-58]. Under the current research, though a slight nonconformity in E_{corr} is observed, the average dislocation is lower to 85 mV, indicating that ditiocarb sodium trihydrate could be a mixed-type inhibitor. The corrosion potential E_{corr} values shifted towards the direction of slightly more progressive properties, and such conclusion recommends that anodic and the hydrogen evolution reactions are promoted; hence the ditiocarb sodium trihydrate inhibitor might be classified as mixed-type inhibitor [59]. The anodic Tafel slopes (β_a) and the cathodic Tafel slopes (β_c) are nearly slight altered upon addition of ditiocarb sodium trihydrate inhibitor and are somewhat greater than that predicted for H_2 evolution according to the Volmer-Tafel mechanism [60]. The vicissitudes in either the anodic and cathodic Tafel slopes detected on introduction of ditiocarb sodium trihydrate inhibitor suggests that both responses are mitigated [61]. This can be interpreted by considering that the C-steel electrode is covered with iron oxide and the presence of the oxide film can evidently affect the surface reduction process, by forcing a barrier to undergo charge transfer through the oxide film. Thus, the values of the anodic Tafel slopes (β_a) and the cathodic Tafel slopes (β_c) are nearly equal in uninhibited and inhibited solutions. This explains that the inhibitor molecules might be adsorbed on the C-steel surface electrode and obstructive the reaction corrosion sites of the carbon steel surface lacking any influence on the anodic response instrument [62,63].

The inhibition efficiency may be calculated using the following equation (1) [64]:

$$\%\mathrm{IE}=\frac{(i_{corr})uninh.(i_{corr})inh.}{(i_{corr})uninh.}\times 100 \qquad (1)$$

Where (i_{corr})uninh and (i_{corr})inh are the uninhibited and inhibited corrosion current densities. The inhibition efficiency and corrosion rate values which are parameters derived from the output of the Echem analyst program for analysis potentiodynamic scan are given in TABLES 4 and 5.

TABLE 4. **Corrosion rate and inhibition effectiveness towards effectiveness of carbon steel in saturated-CO_2 0.5 M H_2SO_4 compound under attendance from various volumes of ditiocarb sodium trihydrate inhibitor at 298.15 K.**

Conc. (M)	**Corrosion rate (mpy)**	**% IE**
0	106	---
1×10^{-4}	54.2	48.77
3×10^{-4}	50.07	52.63
6×10^{-4}	47.2	55.08
1×10^{-3}	19.11	81.92
3×10^{-3}	2.958	97.2

TABLE 5. **Corrosion rate and inhibition efficiency for carbon steel in deaerated 0.5 M H_2SO_4 solution under attendance of various concentrations of ditiocarb sodium trihydrate inhibitor at 298.15 K.**

Conc. (M)	Corrosion rate (mpy)	% IE
0	143.1	---
1×10^{-4}	30.19	45.59
3×10^{-4}	12.10	91.70
6×10^{-4}	10.95	92.48
1×10^{-3}	5.190	96.37
3×10^{-3}	3.409	97.62

TABLES 4 and 5 show that the corrosion rate values are high in the absence of the ditiocarb sodium trihydrate inhibitor, but with the addition of the ditiocarb sodium trihydrate inhibitor the corrosion rate is decreased. Thus, the corrosion rate decreases with increasing of ditiocarb sodium trihydrate inhibitor concentration, which becomes 2.958 mpy in saturated-CO_2 0.5 M H_2SO_4 and 3.409 mpy in deaerated acidic solution at the optimum concentration (1×10^{-3} M). The reduction in the rate of corrosion with increasing concentration of the ditiocarb sodium trihydrate inhibitor in deaerated acidic solution is greater than the saturated-CO_2 as shown in FIG. 7. The formation of a protective film of a significant thickness on the carbon steel surface electrode leads to an enhancement in the resistance of C-steel for corrosive media. The inhibition efficiency increased with increasing the ditiocarb sodium trihydrate inhibitor concentration. Thus, the inhibition efficiency for carbon steel in deaerated solution is greater than in saturated-CO_2 0.5 M H_2SO_4, as show in FIG. 8.

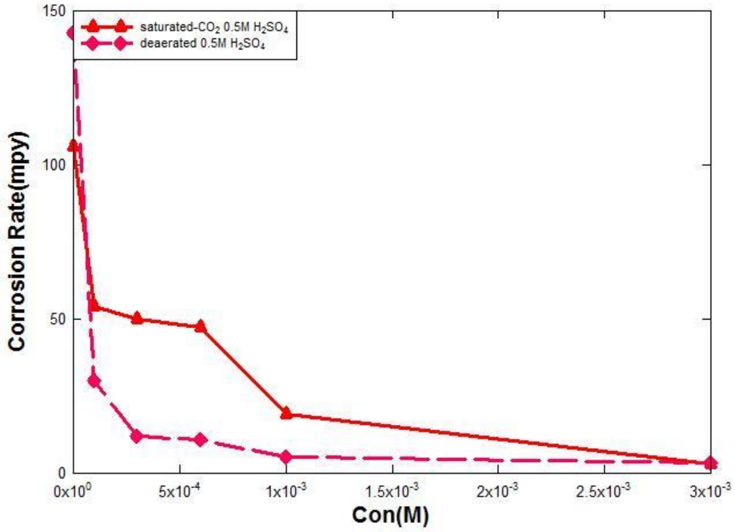

FIG. 7. **Corrosion rate for carbon steel in saturated-CO_2 0.5 M H_2SO_4 and deaerated solution in the presence of different concentrations of ditiocarb sodium trihydrate inhibitor at 298.15 K.**

The inhibition efficiency increased with increasing of ditiocarb sodium trihydrate inhibitor concentration even up 97.20% at (1×10^{-3} M) as show FIG. 4.

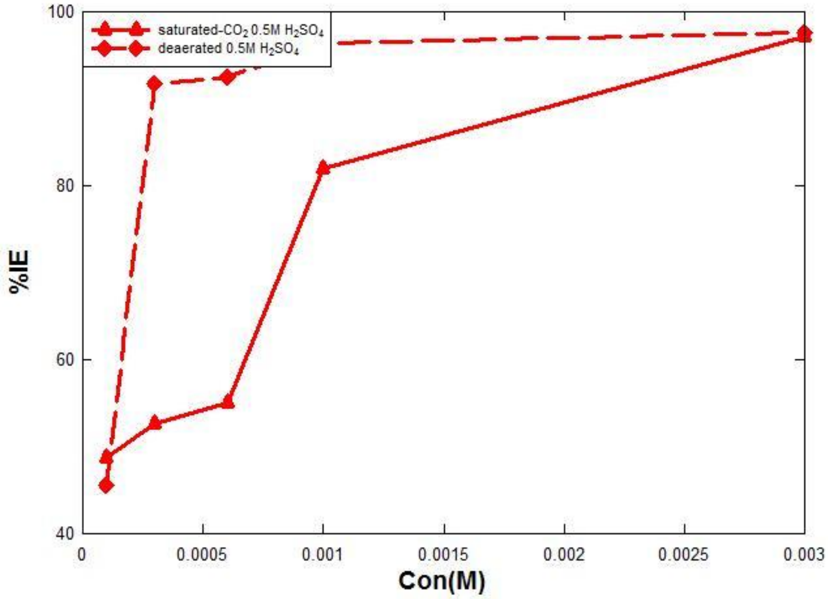

FIG. 8. **Shows inhibition efficiency of carbon steel in saturated-CO$_2$ 0.5 M H_2SO_4 and deaerated solution in the presence of different concentrations of ditiocarb sodium trihydrate inhibitor at 298.15 K.**

From the polarization data collected in TABLES 2 to 5, it is clear that both cathodic and anodic reactions are retarded when the ditiocarb sodium trihydrate inhibitor is added to the 0.5 M H_2SO_4 acidic solution. From a thermodynamic perspective, as the ditiocarb sodium trihydrate inhibitor molecule contains two pairs of electrons on the sulfur atom, it is adsorbed on the surface of carbon steel, which obstructs the attack of the sulphuric acid and emphasizes that the ditiocarb sodium trihydrate is an excellent inhibitor.

Mechanism of corrosion inhibition

Firstly, the mechanism of electrochemical cathodic reaction in saturated-CO$_2$ acidic medium [65-69] clarified in the following equations:

$$CO_{2(g)} \rightarrow CO_{2(aq.)} \tag{2}$$

$$CO_{2(aq.)} + H_2O \rightarrow H_2CO_3 \tag{3}$$

$$H_2CO_3 \rightarrow H^+ + HCO_3^- \tag{4}$$

$$HCO_3^- \rightarrow H^+ + CO_3^{2-} \tag{5}$$

$$H^+ + H^+ \rightarrow H_2 \uparrow \tag{6}$$

The overall of electrochemical reaction in carbon dioxide corrosion is explained in equation (7).

$$Fe+CO_2+H_2O \rightarrow FeCO_3+H_2 \uparrow \quad (7)$$

Conversely, the electrochemical reaction of carbon steel in deaerated acidic medium explained in shown in equations (8) and (9) [68-70].

$$Fe \rightarrow Fe^{2+}+2\ e\text{-}\ (8)$$

$$2H^{+}+2\ e\text{-} \rightarrow H_2\uparrow\ (9)$$

Furthermore, the inhibitory effect of the ditiocarb sodium trihydrate inhibitor in 0.5 M H_2SO_4 solution can be explained as follows. The chemical structure of the ditiocarb sodium trihydrate inhibitor (FIG. 1) contains a lone pair of electrons on the nitrogen atom, two lone pairs on the sulfur atom and a π-electron from double bond between the carbon and sulfur atoms. From electrochemical measurements, it was concluded that the ditiocarb sodium trihydrate inhibits the decay of carbon steel under sulphuric acid compound by adsorption at the C-Steel electrode solution interface. The possible adsorption of ditiocarb sodium trihydrate molecules on the metal surface through the electrostatic interactions [71-74] amidst charged molecules and metals. This leads to interaction of the unshared electron pairs (N, S) in the molecule inhibitor with the *d*-orbitals on the C-Steel surface to form Fe (II) complexes [75-77], as well as the interaction of π-electrons between the carbon and sulfur atoms with the carbon steel surface. From the mentioned conclusion, the provided procedure for corrosion inhibition is suggested for ditiocarb sodium trihydrate inhibitor:

1. After C-Steel is immersed in the acidic solution, the ditiocarb sodium trihydrate (Na-DDC) complexes diffuse from the bulk of the solution towards the metal surface.
2. On the metal surface Na^{+}-DDC complexes are converted into Fe^{2+}-DDC complexes on the anodic sites.

$$Na^{+}-DDC+Fe^{2+} \rightarrow Fe^{2+}-DDC+Na^{+} \qquad (10)$$

The released Na^{+} ions may combine with SO_4^{2-} to form Na_2SO_2 on the cathodic site.

$$2Na^{+}+SO_4^{2-} \rightarrow Na_2SO_2 \downarrow \qquad (11)$$

Conclusion

The open circuit potential values shift in a more positive direction with increasing ditiocarb sodium trihydrate inhibitor concentration and is discovered to mitigate both cathodic and anodic response that happen while the corrosion of carbon steel in the saturated -CO_2 and deaerated 0.5 M H_2SO_4 solutions. Thus, the corrosion in carbon dioxide under acidic compound in non-attendance of ditiocarb sodium trihydrate inhibitor increases the dissociation of carbon steel surface *via* an anodic reaction. However, the addition of ditiocarb sodium trihydrate inhibitor decreases the release of the iron ions to the solution. This confirms that the ditiocarb sodium trihydrate compound is an excellent inhibitor and fulfils functions of a mixed-type inhibitor. Furthermore, the conclusion acquired through electrochemical assessments suggests the inhibitory event increments with incrementing inhibitor concentrations and the inhibition is greater in deaerated 0.5 M H_2SO_4 solution than in the acidic saturated carbon dioxide medium. Both the corrosion current density and corrosion rate mitigate under incrementing ditiocarb sodium trihydrate inhibitor concentration. Therefore, the inhibition effectiveness increments with incrementing ditiocarb sodium trihydrate inhibitor concentration.

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