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Data Article

Data on the corrosion Inhibition Property of Rosemary on High Carbon Steel in dilute sulphuric acid, citric acid and sodium chloride solution

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ABSTRACT

The data of electrochemical analysis of *Rosmarinus officinalis* (RO) essential oil effect on high carbon steel (HCS) in three different corrosive environment of sodium chloride, sulphuric acid and citric acid solution was achieved via weight loss method. Results revealed that *Rosmarinus officinalis* (RO) organic compound performed excellent well on high carbon steel samples with the optimum inhibition value occurring in NaCl solution with 97.87% after 504 h. The corrosion rate values were significantly high at 0 ml RO organic compound for all the three (3) corrosive environments as the time of immersion moves down to 504 h. It was clearly observed that time of immersion and concentrations of RO are the main determinant factor for the excellent adsorption performance of RO organic compound within the range of 504 h. Also, *Rosmarinus officinalis* (RO) organic compound retarded the severe corrosion rate of high carbon steel samples in other corrosive solutions with average range inhibition values between 40 and 78% after 504 h.

Specification table

Subject area	Chemistry
Specific subject area	Material Science, Corrosion
Type of data	Tables
How data was acquired	The Ohaus analytical balance was used to determine weight loss of each sample from which the corrosion rate and inhibition efficiency was calculated
Experimental factors	The steel samples were cut mechanically and grounded with abrasive paper (silicon carbide), rinsed with distilled water and acetone and dried for weight loss measurement.
Data format	Analysed
Experiment features	Corrosion rate and inhibition efficiency data were obtained at every 24 h with the period of 504 h of the high carbon steel in sodium chloride, sulphuric acid and citric acid solution at specific concentrations of *Rosmarinus officinalis* (RO) organic compound for the complete time of 504 h
Data source location	Ota, Ogun State, Nigeria
Data accessibility	The data is with this research article

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Table 1
HCS composition [21].

Element	C	Mn	P	S	Fe
% Content	0.90	0.50	0.04	0.05	98.51

Table 2
Chemical Composition of RO essential oil [22].

Component	%
Tricyclene	0.1
α-Pinene	9.6
Camphene	2.9
Oct-1-en-3-ol	0.2
β-Pinene	3.4
Myrcene	1.3
α-Terpinene	0.4
p- Cymene	1.7
Limonene	1.5
1,8-Cineol	52.1
γ -Terpinene	0.5
Terpinolene	0.2
Linalol	0.9
Camphre	14.0
δ -Terpineol	0.9
Borneol	2.9
Terpinen-4-ol	1.3
α-Terpineol	4.8
Verbenone	0.1
(E)- β-Caryophyllene	0.4
Caryophyllene oxide	0.1
Total composition	99.3

1. Rationale

The use of acids, alkaline and salts solutions in industries causes serious corrosion attacks on metallic structure surface, such as carbon steel, stainless steel and aluminum [1–4]. This has caused tremendous financial misfortunes to the industries. These issues had inspired researchers to look for ways of controlling corrosion which had led to the utilization of corrosion inhibitors as a recognizable strategy to control corrosion [5]. Inhibitor molecules are absorbed by metal surface [6,7]. The excellent anticorrosion potential for metal surface were the chemical compounds having in their structure atoms

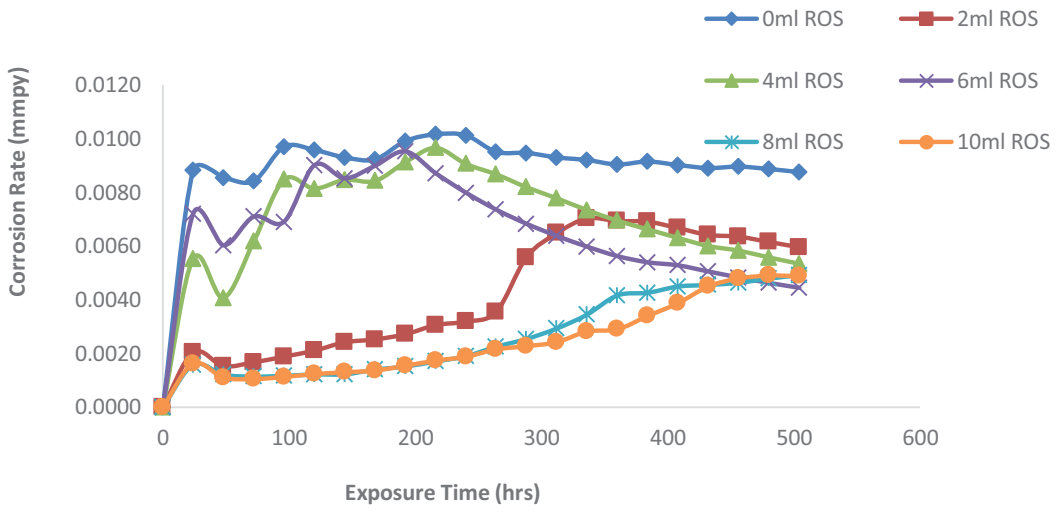

Fig. 1. Corrosion rate for Citric acid solution and RO within 504 h.

Table 3
Experimental data of Corrosion rate for HCS achieved during 504 h of immersion in Citric media at 0–10 ml RO concentrations.

Time (h)	Control	2ml	4ml	6ml	8ml	10ml
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24	0.0088	0.0020	0.0055	0.0072	0.0016	0.0016
48	0.0085	0.0015	0.0041	0.0060	0.0012	0.0011
72	0.0084	0.0017	0.0062	0.0071	0.0011	0.0011
96	0.0097	0.0019	0.0085	0.0069	0.0012	0.0011
120	0.0096	0.0021	0.0081	0.0090	0.0012	0.0012
144	0.0093	0.0024	0.0085	0.0085	0.0012	0.0013
168	0.0092	0.0025	0.0084	0.0090	0.0014	0.0014
192	0.0099	0.0027	0.0091	0.0095	0.0015	0.0015
216	0.0102	0.0031	0.0097	0.0087	0.0017	0.0017
240	0.0101	0.0032	0.0091	0.0080	0.0019	0.0019
264	0.0095	0.0036	0.0087	0.0074	0.0023	0.0022
288	0.0095	0.0056	0.0082	0.0068	0.0025	0.0023
312	0.0093	0.0065	0.0078	0.0064	0.0029	0.0024
336	0.0092	0.0070	0.0073	0.0060	0.0035	0.0028
360	0.0090	0.0069	0.0070	0.0056	0.0042	0.0029
384	0.0091	0.0069	0.0066	0.0054	0.0043	0.0034
408	0.0090	0.0067	0.0063	0.0053	0.0045	0.0039
432	0.0089	0.0064	0.0060	0.0051	0.0046	0.0045
456	0.0090	0.0064	0.0058	0.0048	0.0046	0.0044
480	0.0089	0.0062	0.0056	0.0046	0.0048	0.0046
504	0.0088	0.0060	0.0053	0.0044	0.0045	0.0049

Table 4
Experimental data of Corrosion rate for HCS achieved during 504 h of immersion in Sulphuric acid media at 0–10 ml RO concentrations.

Time (h)	Control	2ml	4ml	6ml	8ml	10ml
0	0	0	0	0.0000	0.0000	0.0000
24	0.0549	0.0432	0.0167	0.0338	0.0380	0.0226
48	0.0509	0.0430	0.0203	0.0304	0.0457	0.0219
72	0.0396	0.0365	0.0209	0.0238	0.0329	0.0210
96	0.0463	0.0275	0.0203	0.0229	0.0250	0.0184
120	0.0425	0.0222	0.0179	0.0214	0.0203	0.0155
144	0.0357	0.0186	0.0153	0.0201	0.0171	0.0128
168	0.0305	0.0161	0.0131	0.0184	0.0149	0.0112
192	0.0335	0.0143	0.0116	0.0162	0.0131	0.0098
216	0.0329	0.0130	0.0104	0.0144	0.0118	0.0088
240	0.0301	0.0139	0.0110	0.0130	0.0134	0.0095
264	0.0274	0.0127	0.0109	0.0119	0.0122	0.0090
288	0.0300	0.0117	0.0105	0.0110	0.0112	0.0083
312	0.0299	0.0109	0.0098	0.0102	0.0104	0.0077
336	0.0284	0.0102	0.0091	0.0095	0.0098	0.0072
360	0.0264	0.0096	0.0085	0.0089	0.0092	0.0068
384	0.0281	0.0113	0.0087	0.0084	0.0099	0.0072
408	0.0277	0.0106	0.0087	0.0080	0.0094	0.0072
432	0.0264	0.0101	0.0085	0.0083	0.0090	0.0069
456	0.0276	0.0098	0.0083	0.0081	0.0086	0.0065
480	0.0276	0.0093	0.0079	0.0078	0.0082	0.0062
504	0.0275	0.0090	0.0075	0.0076	0.0080	0.0059

with unoccupied electron pair like phosphorous, sulfur, nitrogen or oxygen incorporated in a resonance system and groups with electron efficiency that push electron by inductive effect. Recently, researchers have been working on green inhibitors (environmentally friendly) to stay away from the harmful impact of prepared inhibitors [8–10]. These inhibitors are found to be extremely active in corrosive solutions moreover they are financial valuable and eco-friendly [11–16]. For the same reason, different plant extracts are also investigated. To this end, the utilization of eco-friendly organic compounds with atoms having unpaired electron pairs or conjugated pi-system as inhibitors to reduce corrosion attack has gotten definite consideration [17–20]. These organic inhibitors act as anodic, cathodic or mixed type, thereby retarding and forming film protection/barrier on the surface of the steel samples for effective and efficient performance. This research reveals the data obtained from the experimental analysis of inhibitive mechanism of *Rosmarinus officinalis* (RO) essential oil on high carbon steel (HCS) in three different corrosive environment of sodium chloride, sulphuric acid and citric acid solution.

Table 5
Experimental data of Corrosion rate for HCS achieved during 504 h of immersion in Sodium chloride media at 0–10 ml RO concentrations.

Time (h)	Control	2ml	4ml	6ml	8ml	10ml
0	0	0	0	0	0	0
24	0.00318	0.00015	0.00045	0.00025	0.00038	0.00009
48	0.00241	0.00039	0.00028	0.00020	0.00012	0.00026
72	0.00261	0.00043	0.00051	0.00022	0.00014	0.00028
96	0.00152	0.00035	0.00023	0.00024	0.00018	0.00021
120	0.00181	0.00069	0.00033	0.00019	0.00017	0.00015
144	0.00167	0.00036	0.00037	0.00032	0.00020	0.00027
168	0.00146	0.00039	0.00041	0.00012	0.00018	0.00024
192	0.00138	0.00014	0.00040	0.00009	0.00015	0.00021
216	0.00144	0.00021	0.00042	0.00009	0.00007	0.00019
240	0.00126	0.00028	0.00045	0.00012	0.00014	0.00020
264	0.00161	0.00030	0.00048	0.00013	0.00021	0.00026
288	0.00212	0.00122	0.00084	0.00030	0.00011	0.00023
312	0.00238	0.00100	0.00092	0.00019	0.00014	0.00027
336	0.00301	0.00121	0.00092	0.00025	0.00013	0.00023
360	0.00370	0.00131	0.00103	0.00026	0.00015	0.00025
384	0.00486	0.00142	0.00092	0.00025	0.00015	0.00025
408	0.00544	0.00150	0.00081	0.00029	0.00016	0.00027
432	0.00609	0.00151	0.00087	0.00033	0.00017	0.00027
456	0.00648	0.00153	0.00083	0.00029	0.00012	0.00027
480	0.00671	0.00166	0.00080	0.00030	0.00015	0.00024
504	0.00726	0.00214	0.00075	0.00048	0.00015	0.00024

Table 6
Experimental data of Inhibitor efficiency for HCS achieved during 504 h of immersion in Citric media at 0–10 ml RO concentrations.

Time (h)	2ml	4ml	6ml	8ml	10ml
24	76.84	37.24	18.36	82.08	81.56
48	82.06	52.30	29.53	85.80	87.06
72	80.13	26.64	15.78	86.45	87.52
96	80.54	12.48	28.80	87.91	88.33
120	77.99	14.89	5.97	87.25	87.07
144	74.00	8.84	8.39	86.81	85.99
168	72.62	8.55	2.59	84.81	85.16
192	72.58	7.82	3.91	84.69	84.37
216	69.89	4.82	14.26	83.22	82.89
240	68.49	10.38	21.11	81.22	81.35
264	62.65	8.69	22.65	76.28	77.32
288	41.01	13.37	27.89	73.15	75.91
312	30.32	16.25	31.46	68.44	73.89
336	23.61	20.15	35.06	62.48	69.28
360	23.28	23.03	37.77	53.89	67.82
384	24.45	27.45	41.02	53.35	62.77
408	26.01	30.00	41.43	50.12	56.95
432	27.92	32.51	43.27	48.83	49.39
456	29.09	34.80	46.07	48.23	46.35
480	30.60	37.03	47.82	45.96	44.61
504	31.94	38.88	49.21	43.80	44.12

2. Experimental procedure

18 samples of high carbon steel (HCS) were cut into same size of cylindrical shape and prepared for three (3) corrosive environment of sodium chloride, sulphuric acid and citric acid solution. Emery paper was used to grind the surface of 18 samples with 120, 220, 800, 1000, 1200 grits before lowering them into the three (3) corrosive environment for weight loss measurement within 504 h. 0.5 M concentration were prepared for both sulphuric acid and citric acid solution and 3.5% w/v of NaCl solution was prepared by dissolving 3.5 g of the salt in 100 ml of distilled water. The corrosive environments were mixed with *Rosmarinus officinalis* (RO) essential oil as inhibitor in the proportion of 0 ml, 2 ml, 4 ml, 6 ml, 8 ml and 10 ml concentration. The samples were suspended into the corrosive solutions for weight loss analysis and measurement were recorded at the intervals of 24 has displayed in some of the tables below. The weight loss measurement was achieved by Ohaus weighing balance. The experimental analysis of the research was performed at ambient temperature (25 °C). The results obtained during the 504 h at 24 h interval recording was tabulated in Tables 3–8 below with both corrosion rate and inhibition efficiencies with initial weight of samples in each corrosive environment. The formulars used in achieving

Table 7
Experimental data of Inhibitor efficiency for HCS achieved during 504 h of immersion in Sulphuric acid media at 0–10 ml RO concentrations.

Time (h)	2ml	4ml	6ml	8ml	10ml
24	21.35	69.65	38.52	30.80	58.80
48	15.63	60.13	40.26	10.34	57.08
72	7.858	47.12	39.91	16.88	46.87
96	40.53	56.20	50.60	46.07	60.19
120	47.77	57.91	49.62	52.18	63.53
144	47.85	57.08	43.73	52.06	64.08
168	47.15	57.04	39.81	51.35	63.47
192	57.43	65.49	51.74	60.85	70.85
216	60.41	68.44	56.37	64.22	73.28
240	53.85	63.52	56.77	55.69	68.64
264	53.43	60.33	56.55	55.41	67.22
288	60.91	65.12	63.49	62.59	72.47
312	63.51	67.30	66.00	65.11	74.15
336	64.04	68.03	66.50	65.62	74.68
360	63.59	67.76	66.11	65.17	74.31
384	59.86	69.02	69.98	64.65	74.42
408	61.55	68.68	71.11	66.01	74.11
432	61.66	67.66	68.47	66.09	74.04
456	64.59	69.93	70.62	68.91	76.44
480	66.28	71.43	71.77	70.26	77.60
504	67.41	72.60	72.68	70.81	78.45

Table 8
Experimental data of Corrosion rate for HCS achieved during 504 h of immersion in Sodium Chloride media at 0–10 ml RO concentrations.

Time (h)	2ml	4ml	6ml	8ml	10ml
0	0.00	0.00	0.00	0.00	0.00
24	95.16	85.71	92.01	88.14	97.09
48	83.65	88.30	91.51	95.03	89.10
72	83.53	80.57	91.62	94.67	89.25
96	76.74	84.70	84.32	88.24	86.09
120	61.74	81.55	89.33	90.44	91.80
144	78.49	77.88	81.11	88.25	84.10
168	73.45	72.17	91.55	87.93	83.79
192	90.17	70.85	93.44	89.12	84.52
216	85.49	70.57	93.88	94.83	87.16
240	78.02	64.46	90.79	88.77	84.41
264	81.20	69.82	91.93	87.09	83.99
288	42.53	60.44	85.79	94.61	88.97
312	57.88	61.61	91.89	94.06	88.76
336	59.73	69.34	91.67	95.82	92.31
360	64.73	72.28	93.06	95.99	93.17
384	70.82	81.11	94.82	96.93	94.81
408	72.40	85.06	94.62	97.00	95.11
432	75.22	85.75	94.58	97.15	95.55
456	76.43	87.18	95.53	98.11	95.86
480	75.31	88.05	95.46	97.81	96.44
504	70.49	89.63	93.32	97.87	96.66

the data from the experiment for the 21 days analysis, such as weigh loss, corrosion rate and surface coverage are all stated below

WL= Wi-Wa, where Wi is the weight loss of the initial weight before immersion and Wa is the weight loss after immersion into the acidic solution

$$\theta_s = 1 - \frac{WL_n}{WL_i}$$

θ_s denotes the degree of the oil adsorbed for each gram of surface of steel. W_n is the weight loss of the sample in the non-inhibited solution and W_i is the weight loss of the sample in the inhibited solution.

The inhibitor efficiency is calculated as:

$$\% IE = \theta_s \times 100$$

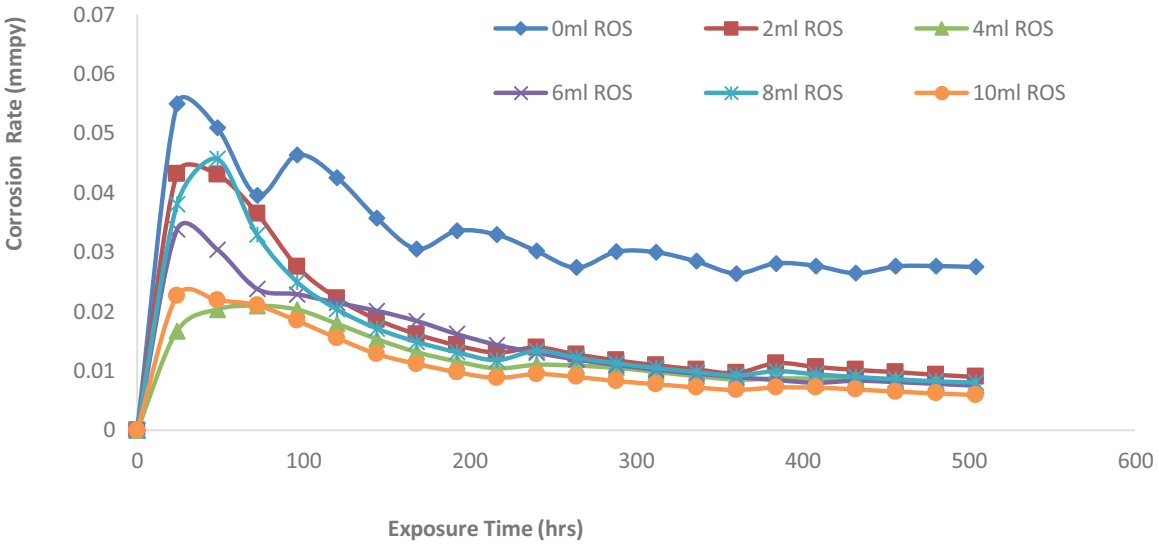

Fig. 2. Corrosion rate for Sulfur acid solution and RO within 504 h.

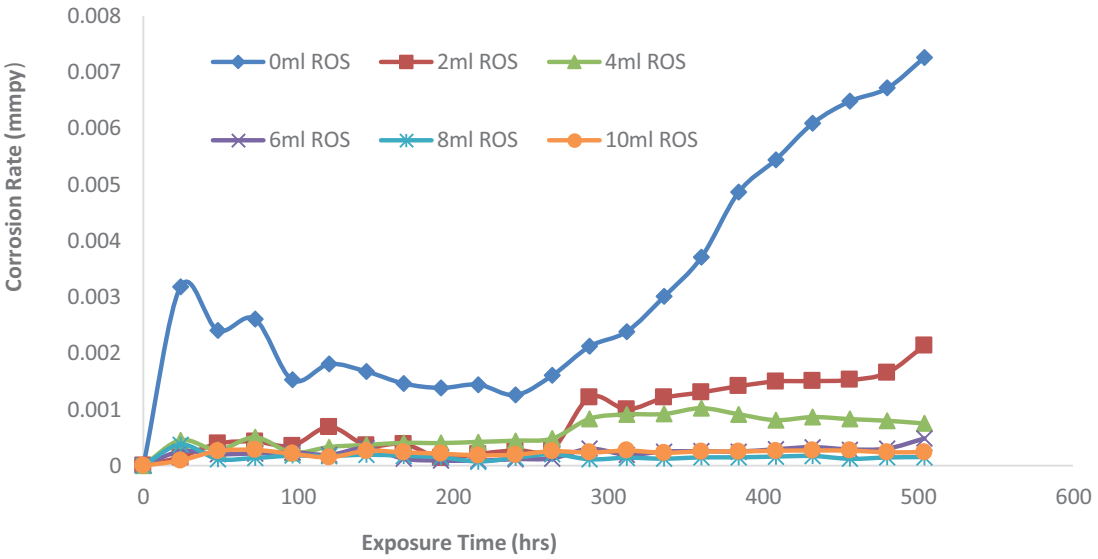

Fig. 3. Corrosion rate for Sodium chloride solution and RO within 504 h.

The rate of corrosion, C expressed in mm/y is calculated as:

$$C = \frac{87.6 * WL}{D * A_s * T_e}$$

where WL is the weight loss (g), T_e is the exposure time (h), A_s is surface area of steel surface (cm^2), D is the steel density (g/cm^2).

Fig. 7(a)–(s) shows the optical images of HCS samples: a) before immersion, b) in 0.5 M citric acid with no inhibitor, c) in 0.5 M citric acid with 2 ml inhibitor, d) in 0.5 M citric acid with 4 ml inhibitor, e) in 0.5 M citric acid with 6 ml inhibitor, f) in 0.5 M citric acid with 8 ml inhibitor, g) in 0.5 M citric acid with 10 ml inhibitor, h) in 0.5 M H_2SO_4 with no inhibitor, i) in 0.5 M H_2SO_4 with 2 ml inhibitor, j) in 0.5 M H_2SO_4 with 4 ml inhibitor, k) in 0.5 M H_2SO_4 with 6 ml inhibitor, l) in 0.5 M H_2SO_4 with 8 ml inhibitor, m) in 0.5 M H_2SO_4 with 10 ml inhibitor, n) in 3.5wt% NaCl with no inhibitor, o) in 3.5wt% NaCl with 2 ml inhibitor, p) in 3.5wt% NaCl with 4 ml inhibitor, q) in 3.5wt% NaCl with 6 ml inhibitor, r) in 3.5wt% NaCl with 8 ml inhibitor, s) in 3.5wt% NaCl with 10 ml inhibitor.

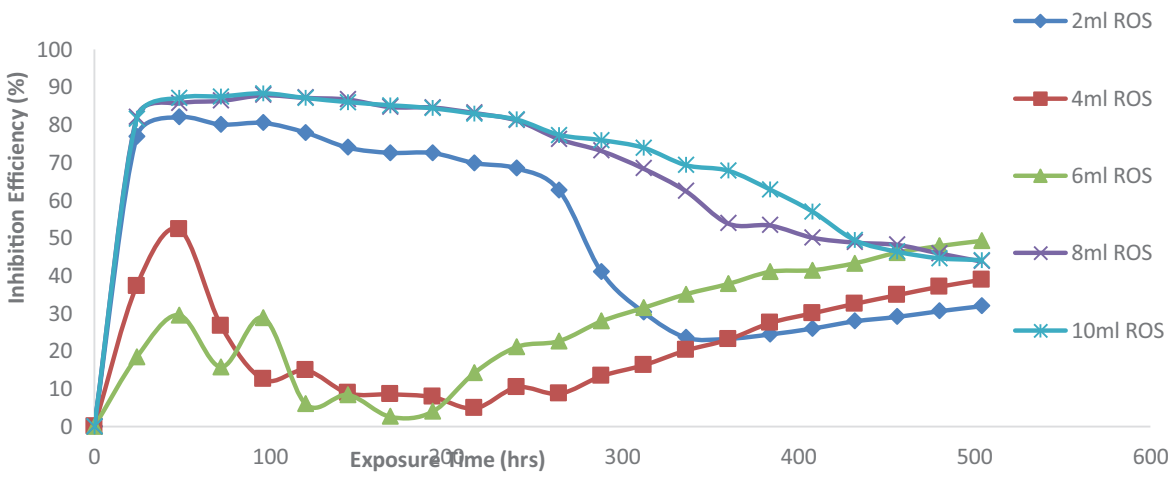

Fig. 4. IE% for Citric acid solution and RO within 504 h.

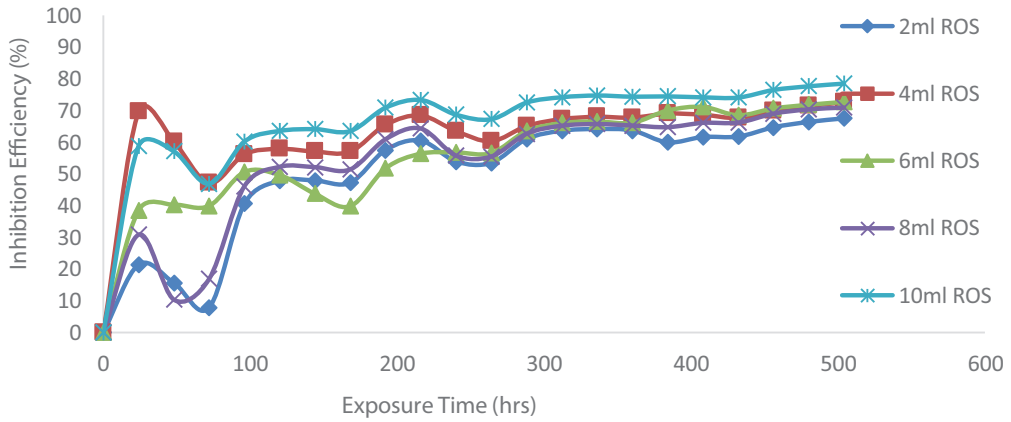

Fig. 5. IE% for Sulphuric acid solution and RO within 504 h.

3. Data, value and validation

The above data in Tables 3–8 show the values of corrosion rate and inhibitor efficiencies of high carbon steel in 0.5 M Citric acid ($C_6H_8O_7$), 0.5 M Sulphuric acid (H_2SO_4) and Sodium Chloride (NaCl) solutions with 2–10 ml RO concentrations. The results of Tables 3–5 show that optimum corrosion rate of HCS occurred at 0 ml RO samples in Citric acid ($C_6H_8O_7$), Sulphuric acid (H_2SO_4) and Sodium Chloride (NaCl) as compared with other samples of each corrosive environments. This suggest severe corrosion attack of redox reaction on HCS 0 ml RO samples of each corrosive environment due to the absence of RO inhibitor. The corrosion rate value increases for each of the corrosive environment as the immersion time increases and at a time its retarded and later increases again until it became stable toward the end of 504 h. The inhibited samples of 2–10 ml OR samples show significant decrease in corrosion rate in the three (3) corrosive environments with the lowest corrosion rate values occurring in NaCl solution, follow by $C_6H_8O_7$ and then H_2SO_4 solution, which show the highest corrosion rate value. This suggest that Sulphuric acid solution initiated strong severe adsorption effect on HCS than the two (2) corrosive environments due to the presence of active site of SO_4^{-2} anion. Furthermore, the inhibitor efficiency values of each of the corrosive environment as shown in Tables 6–8, corresponds to the reduction in corrosion rate of NaCl solution with optimum inhibitor efficiency values compared with the other corrosive solutions and also responsible for the lowest corrosion rate of HCS in NaCl solution for all the HCS samples of 2–10 ml OR organic inhibitor at 504 h. Table 8 reveals the highest performance value of OR organic inhibitor with inhibition performance of 70% above with HCS samples in NaCl solution within 504 h of immersion time. Also, Tables 6 and 7 shows that HCS samples performed with excellent adsorption on the surface of the samples in Citric ($C_6H_8O_7$) and Sulphuric (H_2SO_4) solution within the range of 40–78% inhibitor efficiency.

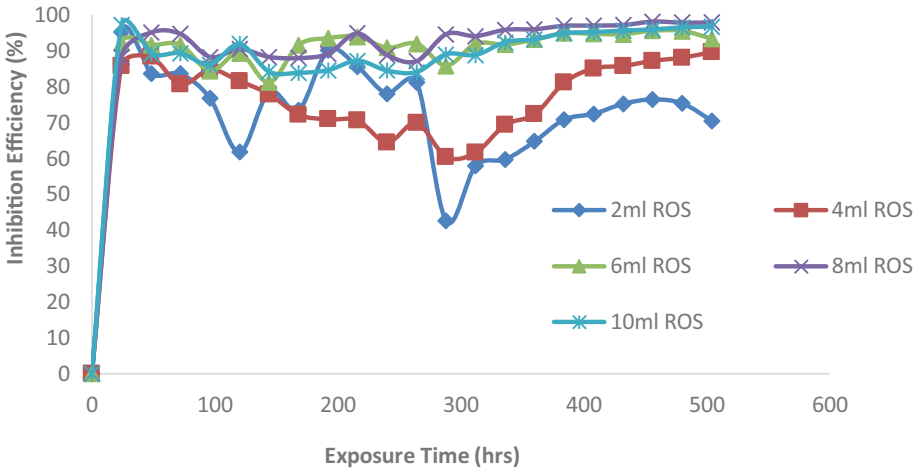

Fig. 6. IE% for Sodium chloride solution and RO within 504 h.

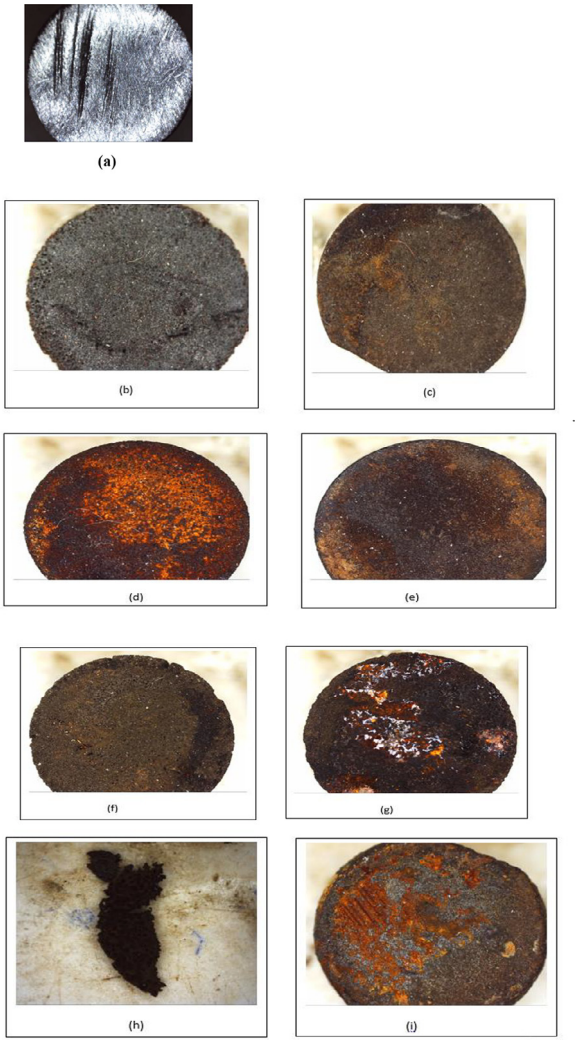

Fig. 7. (a)
(b-g) The following images were obtained for steel samples immersed in citric acid medium for different inhibitor concentrations:
(h-m) The following images were obtained for steel samples immersed in sulphuric acid medium for different inhibitor concentrations.
(n-s) The following images were obtained for steel samples immersed in sodium chloride medium for different inhibitor concentrations.

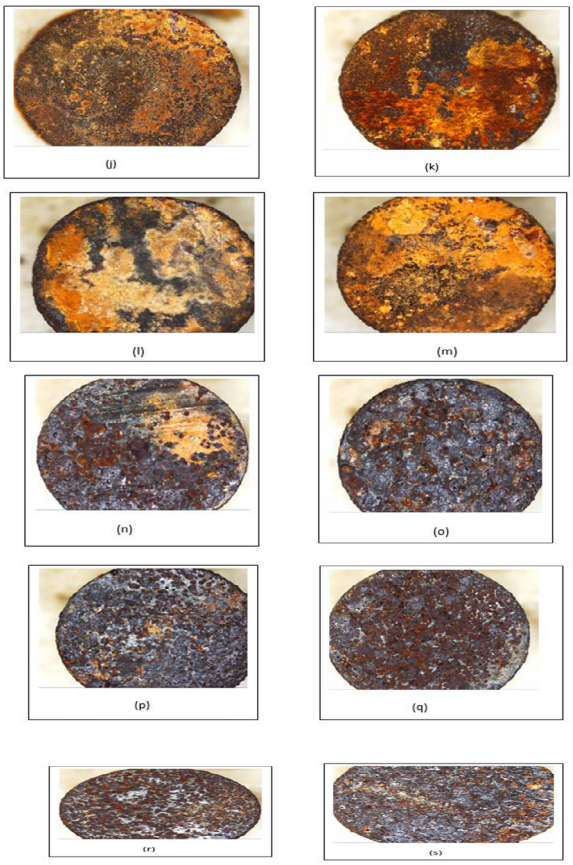

Fig. 7. Continued

Declaration of Competing Interest

None.

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Supplementary materials

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