Data Article

Data on the corrosion inhibition effect of 2-meracaptobenzothiazole on 316 austenitic stainless steel, low carbon steel and 1060 aluminium in dilute acid media

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ABSTRACT

2-Mercaptobenzothiazole was evaluated for its corrosion inhibition effect on 316 stainless steel, low carbon steel and 1060 aluminium alloy in 3 M HCl, 1 M HCl and 2 M H_2SO_4 solution by coupon measurement. Results showed the organic compound performed effectively at all concentrations studied on 316 steel and 1060 aluminium with highest inhibition values of 94.07% and 79.7%. Generally, the inhibition performance of 2-mercaptobenzothiazole was above 90% at all concentrations for 316 steel and 70% for 1060 aluminium. The inhibition performance was observed to be independent of inhibitor concentration, though performance was significantly time dependant on 1060 aluminium. 2-mercaptobenzothiazole performed very poorly on low carbon steel at inhibitor concentrations above 1.25% and inhibition efficiency values below 0%. At concentrations below 1.25%, the inhibition performance was marginal at average value of 57%. 2-mercaptobenzothiazole inhibition performance on low carbon steel was observed to be time and concentration dependant.

Specifications table

Subject area	Chemistry
Specific subject area	Material Science, Corrosion
Type of data	Tables
How data was acquired	Ohaus analytical balance was used to determine the weight loss from which corrosion rate and inhibition efficiency was calculated.
data format	Analysed
Experimental factors	Metal samples were mechanically cut and grounded with silicon carbide abrasive paper, rinsed with distilled water and acetone and dried in a desiccator for coupon measurement
Experimental features	Corrosion rate and inhibition efficiency data were obtained every 48 h after immersion of the 316 austenitic stainless steel in 3 M HCl solution, low carbon steel in 1 M HCl solution and 1060 aluminium in 2 M H_2SO_4 solution at specific 2-mercaptobenzothiazole concentration for a total of 384 h
Data source location	Ota, Ogun State, Nigeria
Data accessibility	The data is with this article

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1. Rationale

Corrosion cost worldwide is estimated to be between €1.3 and €1.4 trillion which is equivalent to 3.5% of developed nations GDP annually [1]. Corrosion is the deterioration of metallic alloys by chemical interaction with their environments [2]. The metals are extracted from their ores at the expense of huge energy resources, thus they are thermodynamically unstable in the refined state and tend to gradually lose their energy by reverting to their original energy states [3]. Metallic alloys are used in the fabrication of machinery and devices, buildings and structures due to their excellent physical and mechanical properties [4]. Stainless steels are extensively used metallic alloys due to its exceptional properties compared to other alloys, durability and corrosion resistance. 316 austenitic stainless steel is extensively applied in heat exchangers, food production, pharmaceuticals, marine structures and vessels, petrochemicals and chemical processing industries [5]. The steel is second to 304 in importance within the austenitic grade of stainless steels. Mb enhances the corrosion resistance of 316 steel especially against pitting and crevice corrosion in Cl^- and SO_4^{2-} anion containing environments [6–8]. However, the steel is prone to localized corrosion within the environment earlier mentioned at certain conditions. Even in seawater the steel is not fully resistant to corrosion. Carbon steel is the most widely used ferrous alloy worldwide due to its low cost, recyclability and ease of fabrication in petrochemical operations, chemical processing units, energy generating plants, pipelines, automobiles etc. [9–11]. The steel has weak resistance to corrosion due to its inability to passivate in the presence of corrosive anions. Aluminium is an important structural engineering alloy whose application is only behind ferrous alloys as a result of their light weight, relatively high strength and excellent corrosion resistance properties. Aluminium alloys are highly reactive metals and vulnerable to corrosion due to its amphoteric nature wherewith it can sometimes undergo accelerated degradation in the presence of threshold concentrations of salts, acids or bases. Conventional corrosion prevention and control methods such as electroplating, galvanizing, use of sacrificial anodes, proper material selections etc. have their disadvantages in terms of cost, versatility and application. The most appropriate method of corrosion control of metallic alloys in Cl- anion containing environments is through the use of chemical compounds known as corrosion inhibitors [12–15]. Corrosion inhibitors play an important role in oil extraction and processing industries, heavy industrial manufacturing, water treatment facility, cooling systems, refinery units, pipelines, oil and gas production units, boilers and water processing, paints, pigments, lubricants etc. to minimize localized corrosion and unexpected failures [16–18]. Inhibitors reduce the rate of metal wastage and can function as anodic, cathodic, passivating or mixed type inhibitors depending on performance. This article discusses the effect of 2-mercaptobenzothiazole on the corrosion inhibition of 316-stainless steel, low carbon steel and 1060 aluminium alloy in dilute HCl and H_2SO_4 media simulating industrial operating conditions. Mixed type inhibitors are more preferable for inhibition performance on stainless steels due to the vulnerability to and prevailing occurrence of localized corrosion deterioration.

2. Experimental design, materials and methods

316 austenitic stainless steel (316ST), low carbon steel (LCS) and 1060 aluminium (AL1060) rods were cut and prepared into 7 experimental samples. The surface ends of the samples were grinded with emery papers of 80, 120, 220, 800 and 1000 grits for weight loss measurement. 2-mercaptobenzothiazole (MBT) was prepared in volumetric concentrations of 0%, 0.19%, 0.25%, 0.31%, 0.38%, 0.44% and 0.50% per 200 ml of 3 M of HCl acid solution for 316ST. The compound was prepared in volumetric concentrations of 0%, 0.75%, 1%, 1.25%, 1.5%, 1.75% and 2% per 1 M HCl for LCS while for AL1060; the compound was prepared in volumetric concentrations of 0%, 0.19%, 0.25%, 0.31%, 0.38%, 0.44% and 0.50% per 2 M H_2SO_4. Weight measured 316ST, LCS and AL1060 samples were separately immersed in 200 ml of the acid electrolytes for 384 h. The samples were weighed every 48 h with Ohaus analytical weighing balance. The weighing balance instrument was checked for possible causes of systematic errors. The uncertainty of single measurement is limited by the precision and accuracy of the measuring instrument. As a result calibration of the instrument and hardware test was performed. Pre-experimental test confirmed the reproducibility of results and the experiment was performed once. Tabulated results of metal sample corrosion rates and inhibition efficiencies of MBT on them in the electrolyte at specific MBT concentrations are shown from Tables 1–6. The weight loss is the difference between the initial weight of the metal sample (kept constant for 384 h) and

Table 1
Data on the corrosion rate of 316ST in 3 M HCl solution at 0% −1%MBT concentration ($n = 1$).

MBT Conc. (%) Exp. Time (h)	0	0.38	0.5	0.63	0.75	0.88	1
48	2.36E-03	5.00E-04	4.10E-04	3.30E-04	4.30E-04	3.10E-04	2.30E-04
96	2.19E-03	3.90E-04	3.20E-04	2.80E-04	3.80E-04	3.00E-04	2.30E-04
144	5.87E-04	1.70E-05	1.50E-05	1.10E-05	1.50E-05	1.00E-05	7.90E-06
192	4.28E-04	1.30E-05	1.00E-05	8.40E-06	1.00E-05	8.90E-06	6.50E-06
240	3.57E-04	1.20E-04	9.50E-05	7.80E-05	1.00E-04	7.80E-05	5.50E-05
288	1.17E-04	6.70E-05	5.40E-05	4.50E-05	5.80E-05	4.40E-05	3.10E-05
336	8.93E-05	6.40E-06	5.20E-06	4.30E-06	5.70E-06	4.70E-06	3.30E-06
384	6.92E-05	4.70E-06	3.80E-06	3.10E-06	3.90E-06	3.00E-06	2.10E-06

Table 2
Data on the corrosion rate of LCS in 1 M HCl solution at 0% −2% MBT concentrations ($n = 1$).

MBT Conc. (%) Exp. Time (h)	0	0.75	1	1.25	1.5	1.75	1.75
48	24.303	29.243	23.179	26.423	58.777	59.862	66.390
96	24.343	24.812	23.179	26.994	59.054	59.862	66.390
144	30.864	26.373	26.463	27.934	58.009	60.784	68.264
192	33.439	26.816	27.531	27.607	56.515	59.984	63.452
240	59.189	26.344	26.644	26.556	61.211	69.223	73.193
288	49.846	22.165	22.263	22.265	51.232	61.374	61.562
336	43.236	19.147	19.212	19.217	43.970	52.606	52.948
384	39.834	16.833	16.896	16.830	38.610	46.030	46.506

Table 3
Data on the corrosion rate of AL1060 in 2 M H_2SO_4 solution at 0% - 0.5% MBT concentration ($n = 1$).

MBT Conc. (%) Exp. Time (h)	0	0.19	0.25	0.31	0.38	0.44	0.50
48	2.163	1.276	1.742	1.748	1.820	2.184	1.703
96	1.506	0.869	2.015	1.406	1.240	1.235	1.156
144	1.229	1.079	1.844	1.149	0.990	1.069	0.946
192	2.269	0.979	1.553	1.035	0.885	0.997	0.862
240	2.911	0.955	1.415	0.954	0.932	0.972	0.899
288	3.382	0.869	1.253	0.874	0.911	0.943	0.882
336	3.929	0.893	1.166	0.825	0.937	0.966	0.883
384	3.756	0.835	1.080	0.735	0.850	0.901	0.830

Table 4
Data on the inhibition efficiency of MBT compound on 316ST in 3 M HCl solution at 0% −1% MBT concentration ($n = 1$).

MBT Conc. (%) Exp. Time (h)	0.38	0.5	0.63	0.75	0.88	1
48	75.9	78.37	80.8	83.28	86.24	87.86
96	79.87	81.35	82.79	84.27	85.74	87.14
144	96.77	96.89	97.55	97.69	98.24	98.35
192	96.68	96.93	97.34	97.76	97.84	98.14
240	62.8	66.5	70.24	73.93	77.57	81.26
288	35.48	41.9	48.39	54.68	61.01	67.46
336	91.82	92.73	93.5	94.18	94.55	95.45
384	92.31	93.18	93.85	94.82	95.54	96.31

Table 5
Data on the inhibition efficiency of MBT compound on LCS in 1 M HCl solution at 0% - 2% MBT concentration.

MBT Conc. (%) Exp. Time (h)	0.75	1	1.25	1.5	1.75	2
48	−20.32	4.63	−8.72	−141.85	−146.31	−173.17
96	−1.93	4.78	−10.89	−142.59	−145.91	−172.73
144	14.55	14.26	9.49	−87.95	−96.94	−121.18
192	19.81	17.67	17.44	−69.01	−79.38	−89.76
240	55.49	54.98	55.13	−3.42	−16.95	−23.66
288	55.53	55.34	55.33	−2.78	−23.13	−23.50
336	55.71	55.56	55.55	−1.70	−21.67	−22.46
384	57.74	57.58	57.75	3.07	−15.56	−16.75

the final weight taken every 48 h. Table 3 shows the data of inhibition efficiency (*IE*) calculated from the equation below;

$$IE = \left[\frac{M_1 - M_2}{M_1} \right] * 100 \tag{1}$$

M_1 and M_2 are the weight-loss of the control and inhibited metal sample in the acid media with respect to exposure time.

Table 6

Data on the inhibition efficiency of MBT compound on AL1060 in 2 M H_2SO_4 solution at 0% - 0.5% MBT concentration.

MBT Conc. (%) Exp. Time (h)	0.19	0.25	0.31	0.38	0.44	0.50
48	41.35	19.74	18.80	15.79	−0.56	21.05
96	42.57	−33.11	6.22	17.57	18.24	22.97
144	12.71	−49.17	6.08	19.34	13.26	22.76
192	56.85	31.54	53.91	60.69	55.94	61.64
240	67.02	51.13	66.68	67.58	66.34	68.66
288	73.99	62.52	73.56	72.56	71.72	73.38
336	76.83	69.75	78.36	75.54	74.90	76.88
384	77.29	70.60	79.77	76.72	75.44	77.22

3. Data, value and validation

Tables 1–3 show the corrosion rate values of ST316, LCS and AL1060 in 3 M HCl, 1 M HCl and 2 M H_2SO_4 solution at specific MBT concentrations. The corrosion rate value of the control (0% MBT) 316ST and AL1060 samples significantly differs from the inhibited samples as shown in Tables 1 and 3 due to the inhibiting action of MBT. The control 316ST corroded at significantly higher corrosion rate values at the onset of the exposure hours after which it progressively decreased due to weakening of the acid solution while the control AL1060 corrosion rate values varies with exposure time alternating between high and low values before attaining stability at 288 h. The corrosion rate of inhibited 316ST and AL1060 varies with respect to MBT concentration. It is observed that the inhibiting action of MBT on 316ST depends to a slight degree on its concentration. The higher the concentration of MBT in the acid solution, the lower the corrosion rate of 316ST while MBT performance on AL1060 is completely independent of its concentration and time of exposure. The corrosion rate of control LCS (Table 2) was generally higher than the values obtained for the inhibited alloy at 0.75% and 1% MBT concentration. Beyond 0.75% MBT till 1.75% MBT, the corrosion rate values of LCS increased significantly beyond the value obtained at 0% MBT. Table 4–6 shows the data on MBT inhibition performance on ST316, LCS and AL1060. Observation has shown that MBT inhibition performance on ST316 (Table 4) is concentration dependence. The performance is also observed to be time dependant. The inhibition performance of MBT on ST316 improves with respect to exposure time. This is due to the slow rate of adsorption of MBT cations on 316ST surface stifling the electrochemical processes responsible for surface degradation. The inhibition performance of MBT on AL1060 as shown in Table 6 is strongly dependant on time progressively increasing with respect to exposure time and attaining inhibition performance values above 70% at all concentrations. MBT performed extremely poorly on LCS at higher concentrations above 0.75% MBT while at lower MBT concentrations the inhibition performance was marginal at average value of 57%. MBT performed the best on ST316 with inhibition efficiency values above 90% at all concentrations.

Declaration of Competing Interest

None.

Acknowledgements

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.cdc.2020.100349.

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