



The effect of sodium hydroxide solutions with different pH on the corrosion of iron alloy (C1010) in industrial water

Chasib Khaiber Bkhakh , * Mouayed Yousif Kadhum and ** Muayad Hasan Mohammed Albehadili

Industrial Water Section , Iraqi Drilling Company ,Northern Rumaila , Basrah , Iraq

* Department of Chemistry , College of Education for Pure Science , University of Basrah , Basrah , Iraq

** Department of Applied Marine Science, College of Marine Science , University of Basrah , Basrah , Iraq

ABSTRACT

The effect of increasing pH value in the corrosion of iron alloy type (C1010) was studied in the presence of different pH solutions of sodium hydroxide dissolved in industrial water at 35°C and it was found that the corrosion rate of iron alloy was less at pH of 9.5 . This result was proved by measuring some thermodynamic parameters such as corrosion current and covered surface area that pertain to corrosion using weight loss electrical (Tafel plot) methods . Also the effect of temperature on the rate of corrosion at (25°C , 35°C and 45°C) at different pH was studied and it was found that the rate of corrosion is increased with increasing the temperature at the same pH .

Keywords

Industrial water , pH , Tafel plot , Rate of corrosion , Drilling operation

INTRODUCTION

Corrosion is the deterioration and loss of material and its critical properties due to chemical , electrochemical and other reactions of the exposed material surface with the surrounding environment .The corrosion is from the major problems experienced most of alloys used in the industrial process such as oil industry [1,2] , particularly oil wells drilling companies . The pipes and equipments of drilling fluids systems are exposed to corrosion continuously due to the presence of fluids permanently whether drilling fluids , rainwater or acidic water outside of subsoil [3] . Therefore , they are exposed to corrosion with different rates depending on temperature , degree of acidity and quantity and quality of salts in these types of fluids . In the field of drilling and reclamation , the use of the industrial water is commonly because of the cheap and easy to get it and it is used in dissolving materials used in the operations of drilling [4] , this is influenced in the rates of corrosion of iron used in fluids systems tanks , pipelines and equipments of drilling .Industrial water is average of total salts dissolved in it (1208-1250 ppm) which includes a large proportion of chloride ion which attacks the alloys , causing the corrosion [5] .

The aim of the current study is to demonstrate the effect of sodium hydroxide solutions dissolved in industrial water on the corrosion rate of iron alloy at different pH and temperatures .

Experimental

In this study , it was used the iron alloy with the symbol C1010 , which has the chemical composition as shown below :

element	Fe	Ni	C	Si	Mn	P	S	Cr	Cu	As
%	98.33	0.3	0.13	0.37	0.3	0.04	0.05	0.1	0.3	0.08

Sample of iron alloy (C1010) was taken and cut into pieces with a surface area of 1 cm² and cleaned thoroughly with water .The surface was then softened by silicon carbide type (200 – 600) in a vertical direction and then washed with acetone and dried . Solutions of sodium hydroxide dissolved in industrial water were prepared with pH values (8.5 , 9 , 9.5 , 10 , 10.5) . The corrosion of iron alloy in the presence of these solutions and industrial water alone was measured using weight loss [4] and Tafel plot methods [5,6] .

Results and discussion

Table (1) shows the corrosion rate , the percentage of inhibition and covered surface area by sodium hydroxide at different pH . It was found that the corrosion rate was reduced with increasing the value of pH while the percentage of inhibition was increased .This is due to increase the covered surface area by hydroxide ions and that mean the chloride ion in the industrial water will be combined with the sodium ions produced by the sodium hydroxide [7,8] . At the concentration of sodium chloride increases , the chloride ions bond ratio with sodium ions increases where become a number of chloride ions few that attack the surface of the metal . But at the pH of 9.5 , the corrosion rate is the lowest possible and it represents the highest correlation between chloride ions and sodium ions , after that the corrosion rate is increased again



[7], possibly due to the hydrolysis of sodium chloride which is formed or to the release of chloride ions that bind to sodium and then the hydroxide ions attack the surface of metal which causes an increase in the corrosion rate [9].

Also from the table (1), when the pH value increases, the corrosion rate decreases as little as possible at pH of 9.5 and increase by increasing pH. This indicates that sodium hydroxide initially protects the metal from the arrival of chloride ions dissolved in industrial water and formation sodium chloride. At pH of 9.5, the ratio of chloride ions is as low as possible in industrial water and then the corrosion rate is increased [10]. This may be due to the hydrolysis of sodium chloride in water where the water becomes supersaturated then chloride ion attack the iron alloy and increase the corrosion rate.

In addition, the sodium hydroxide itself, when it does not find chloride ions that combine with it, is attacked by an iron alloy composed of $\text{Fe}(\text{OH})_3$ which then turns to Fe_2O_3 or FeO , which is rust causing an increase in the corrosion rate [11,12].

Table (2) represents the rate and the corrosion current measured by electrical method and the figures (1-6) represent Tafel plots of iron alloy (C1010) in industrial water with different pH values at 35 °C and 8 hrs, while the table (3) shows the corrosion rate of the iron alloy at different temperatures (25°C, 35°C, 45°C) and same pH. It was observed that the corrosion rate is increased with increasing the temperature [11]. This is due to increasing the kinetic energy of the particles with increasing the temperature which increase amount of corrosive material that attack the surface of the alloy [4,13].

Table (1) : Some parameters of corrosion for iron alloy in different pH at 35 °C and 8 hrs measured by weight loss method

pH of NaOH solutions	Corrosion rate(mpy)	Percentage %	Covered surface area θ
Industrial water	2.4001	-----	-----
8.5	1.9102	20.41	0.2041
9	1.2335	48.60	0.4860
9.5	0.1103	95.40	0.9540
10	1.1128	53.63	0.5363
10.5	1.6793	30.03	0.3003

Table (2) : Some parameters of corrosion for iron alloy in different pH at 35 °C and 8 hrs measured by Tafel plot method

pH of NaOH solutions	Corrosion rate(mpy)	Percentage %	Covered surface area θ	Corrosion current A
Industrial water	2.5040	-----	-----	0.0002160
8.5	1.8820	24.48	0.2448	0.0001624
9	1.1850	52.67	0.5267	0.0001022
9.5	0.0299	98.80	0.9880	0.0000025
10	1.1070	55.79	0.5579	0.0000955
10.5	1.7020	32.02	0.3202	0.0001468



Table (3) : Corrosion rate of iron alloy at different temperatures and 8 hrs

pH of NaOH solutions	Corrosion rate (mpy) at 25 °C	Corrosion rate (mpy) at 35 °C	Corrosion rate (mpy) at 45 °C
Industrial water	2.2099	2.4001	2.7133
8.5	1.6618	1.9102	2.0098
9	1.1953	1.2335	1.5722
9.5	0.1007	0.1103	0.3051
10	1.0933	1.1128	1.4398
10.5	1.4879	1.6793	1.995

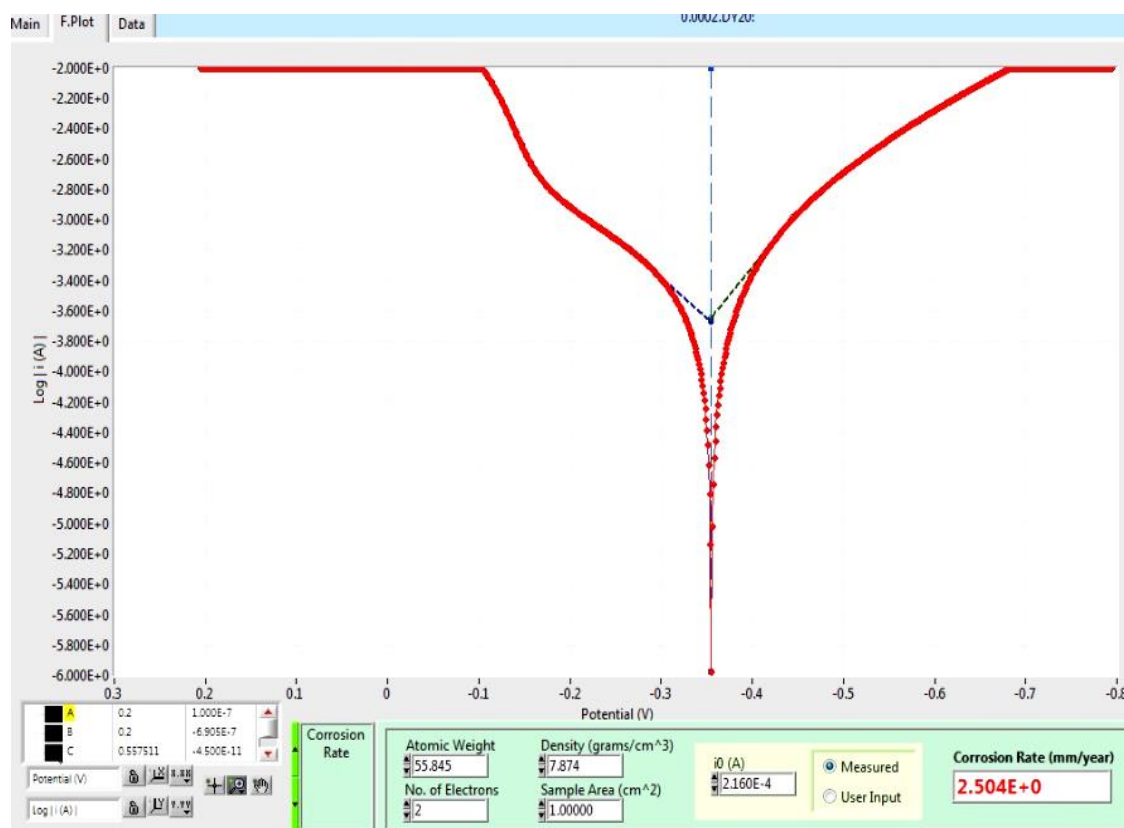


Figure (1) : Tafel plot of iron alloy in the presence of industrial water alone at 35 °C and 8 hrs

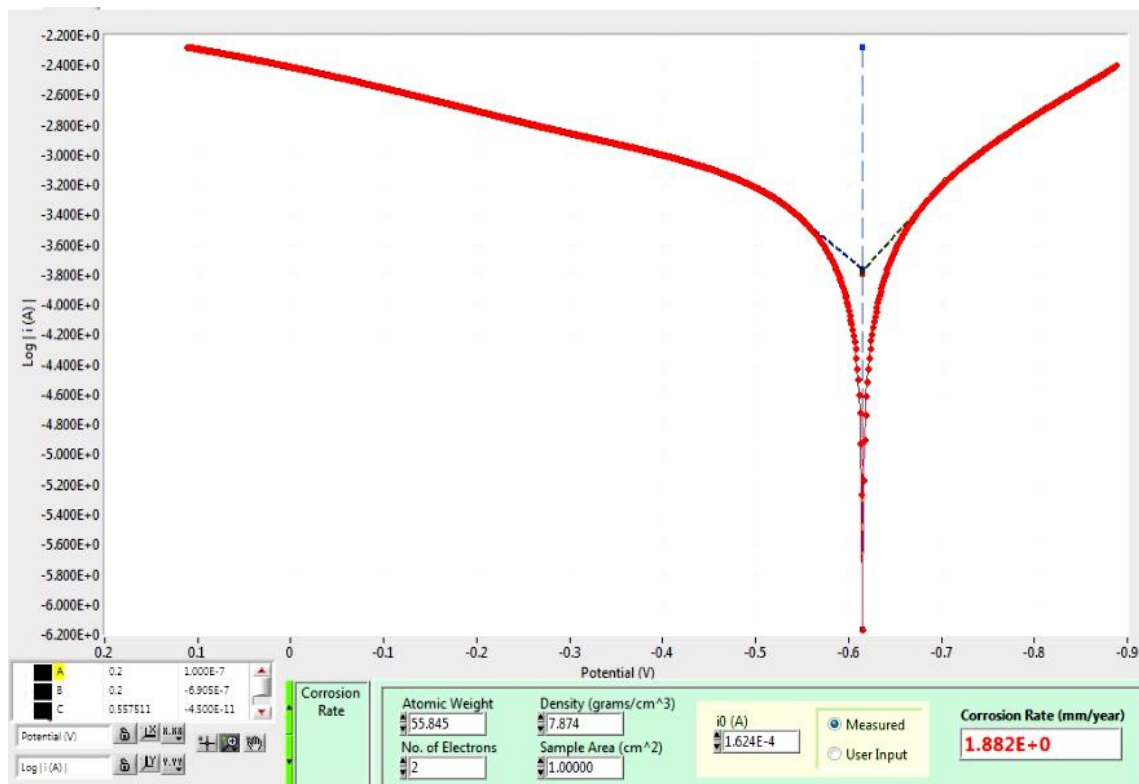


Figure (2) : Tafel plot of iron alloy in the presence of sodium hydroxide solution dissolved in industrial water at pH of 8.5 , 35 °C and 8 hrs

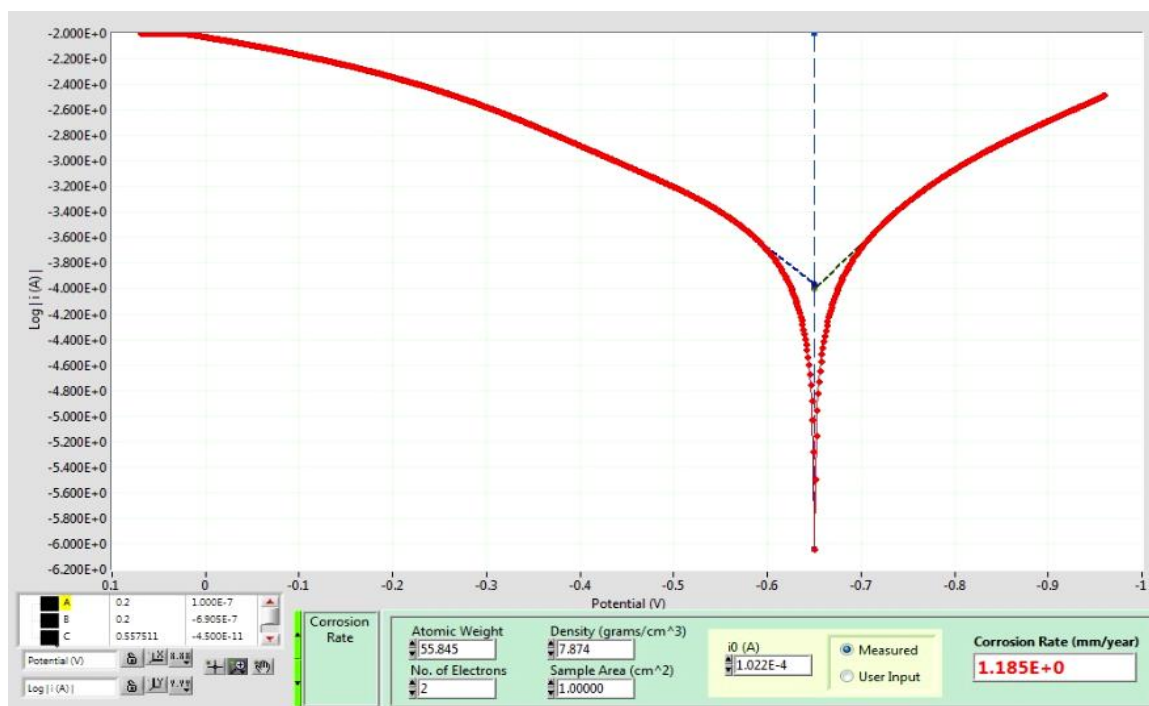


Figure (3) : Tafel plot of iron alloy in the presence of sodium hydroxide solution dissolved in industrial water at pH of 9 , 35 °C and 8 hrs

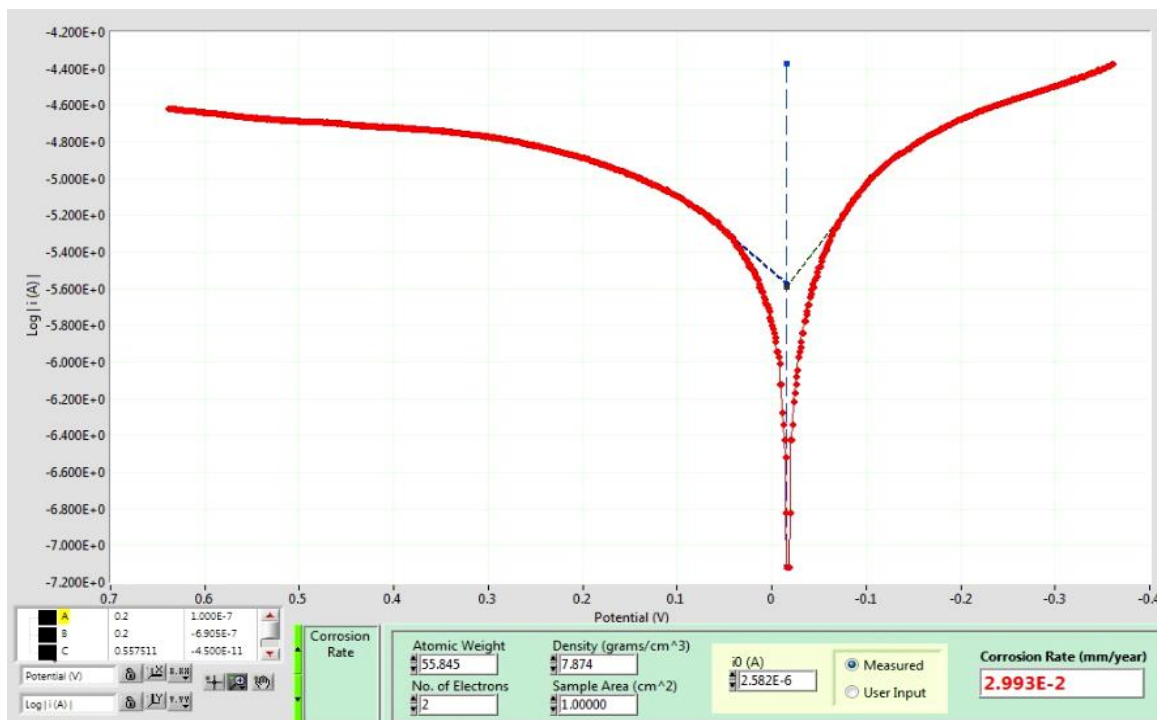


Figure (4) : Tafel plot of iron alloy in the presence of sodium hydroxide solution dissolved in industrial water at pH of 9.5 , 35 °C and 8 hrs

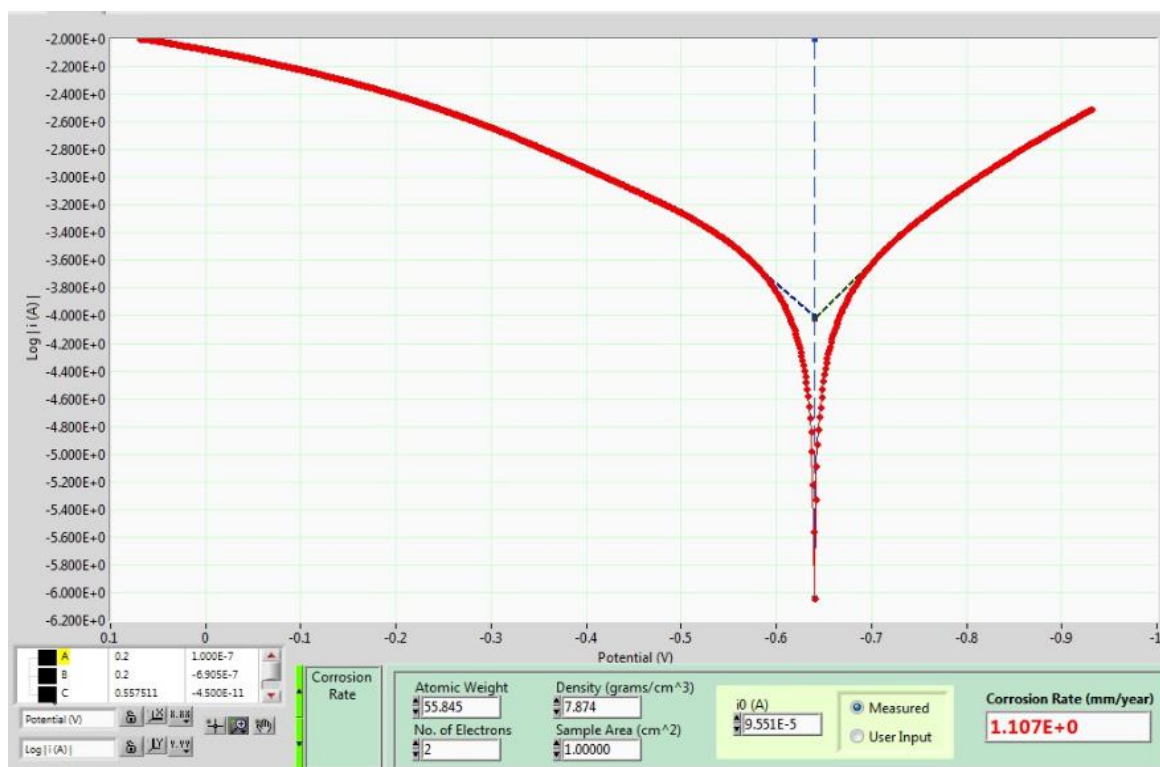


Figure (5) : Tafel plot of iron alloy in the presence of sodium hydroxide solution dissolved in industrial water at pH of 10 , 35 °C and 8 hrs

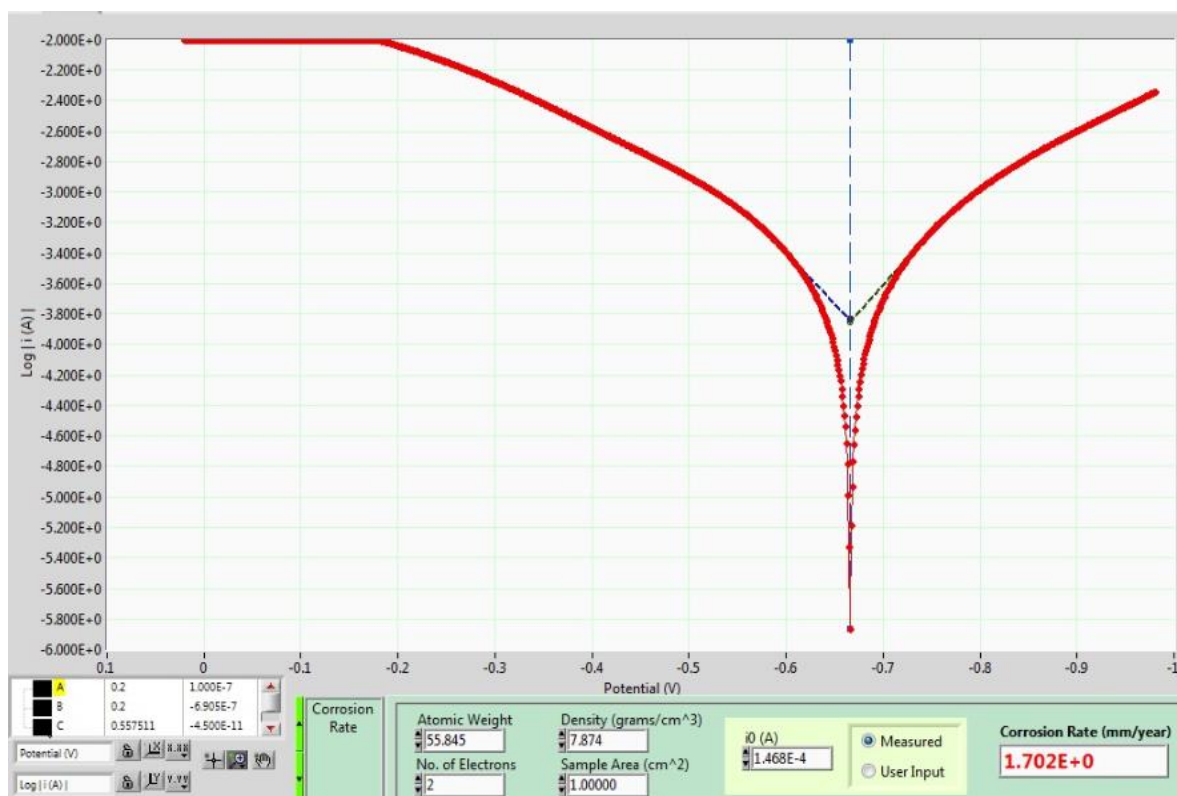


Figure (6) :Tafel plot of iron alloy in the presence of sodium hydroxide solution dissolved in industrial water at pH of 10.5 , 35 °C and 8 hrs

Conclusion

The corrosion rate of iron alloy (C1010) in the presence of sodium hydroxide solutions dissolved in industrial water with different pH was measured by two methods (electrical and weight loss methods) and it was found agreement between them where the corrosion rate is the lowest at pH of 9.5 . Also the corrosion rate is generally decreased with increasing pH while it is increased with increasing temperature .

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