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A Comparative Study on Corrosion Inhibition of Mild Steel Using *Piper Nigrum* L. in Different Acid Medium

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Abstract: The inhibition of corrosion of mild steel using *Piper nigrum* L in different acid medium by weight loss method was investigated. The corrosion inhibition was studied in hydrochloric acid and sulphuric acid by weight loss method at different time interval at room temperature. The result showed that the corrosion inhibition efficiency of this compound was found to vary with different time interval and different acid concentration. Also, it was found that the corrosion inhibition behavior of *Piper nigrum* L is greater in sulphuric acid than hydrochloric acid. So, *Piper nigrum* L can be used as a good inhibitor for preventing mild steel material.

Keywords: Mild steel, Corrosion inhibitors, Weight loss method, *Piper nigrum* L.

Introduction

Concentrated mineral acids are used extensively in pickling, cleaning, descaling and oil well acidising of metallic materials cause damage of corrosion[1,2]. It has been speculated that organic inhibitors are more effective with iron and that the polar organic compounds containing sulphur and nitrogen are good corrosion inhibitors for the acidic solutions of metals[3]. Due to the aggressiveness of hydrochloric acid and sulphuric acid in the solution against structural materials, such as carbon steel, the use of corrosion inhibitor is usually required to minimize the corrosion attack[4-7]. Therefore, in this investigation, the corrosion inhibition of mild steel in 1N HCl and 1N H_2SO_4 solution was studied in the absence and presence of *Piper nigrum* L at one hour at room temperature by weight loss method.

Experimental

According to ASTM method as reported already[8], cold rolled mild steel strips were cut into pieces of 5 cm × 1 cm having the following composition (in percentage) of Fe = 99.686, Ni

= 0.013, Mo = 0.015, Cr = 0.043, S = 0.014, P = 0.009, Si = 0.007, Mn = 0.196 and C = 0.017. They were pickled in pickling solution (5% H_2SO_4) for 3 minutes and washed with distilled water followed by polished with various grades of emery papers and degreased using trichloroethylene. The weight of specimen were noted and then immersed in test solution containing various concentrations of inhibitors at room temperature. After the duration of one hour in hydrochloric acid and sulphuric acid, the specimens were removed from test solutions and pickled in pickling (5% sulphuric acid) solution, dried and finally weighed. The differences in weights were noted and the corrosion rates were calculated.

Solutions

All the solutions were prepared using NICE brand AR grade chemicals in double distilled water and bubbling purified by nitrogen gas for 30 min to carry out de-aeration of the electrolytes. 1 N Hydrochloric acid and 1 N sulphuric acid solution was prepared by double distilled water. The corrosion inhibitor solution of 1% *Piper nigrum* L solution was prepared by dissolving 0.1 g of pepper in 100 mL of test solution. And also, 0.2%, 0.4%, 0.6% and 0.8% solutions of *Piper nigrum* L were prepared.

Results and Discussion

The corrosion behaviour of mild steel in hydrochloric acid and sulphuric acid with *Piper nigrum* L was given in Figure 1, which was studied by weight loss method at one hour at room temperature From the graph, it was observed that the weight loss of mild steel in the acid decreases with increasing concentration of additives. It suggests that the additives are corrosion inhibitor for mild steel in 1N HCl and 1N H_2SO_4. From the data of weight loss method, the corrosion rate (CR) was calculated using the equation:

$$CR= (87.6 \times W) / (D \times A \times T) \quad (1)$$

Where W, D, A and T are weight lose (in mg), density of mild steel (7.86 g/cc), area of the specimen in cm square and exposure time in hours respectively. Similarly, Inhibition efficiency was calculated using the equation,

$$IE\ \% = [(W_o - W_i)/W_o] \times 100 \quad (2)$$

Where W_o and W_i are the values of the weight loss (in g) of mild steel in the absence and presence of inhibitor respectively. The values of corrosion rate and inhibition efficiency in absence and presence of difference concentration of inhibitor used in 1 N HCl and 1N H_2SO_4 solution at room temperature for one hour were given in Table 1.

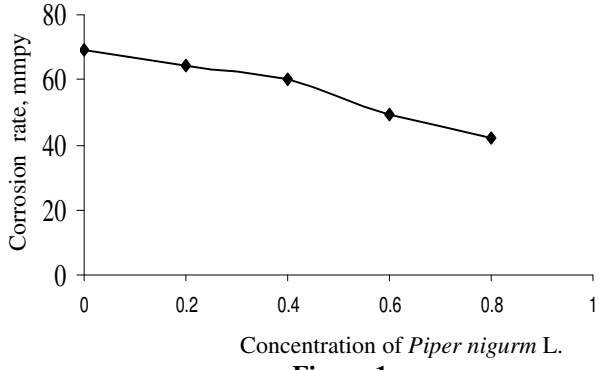

Figure 1a.

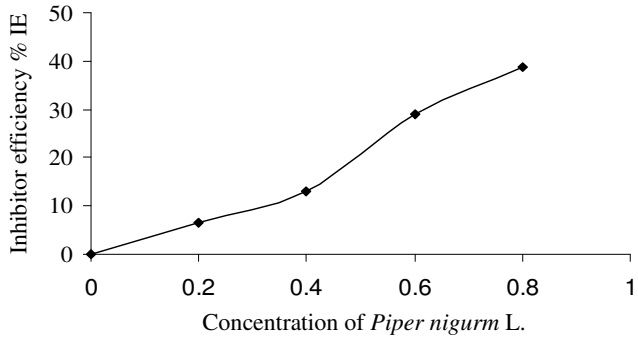

Figure 1b.

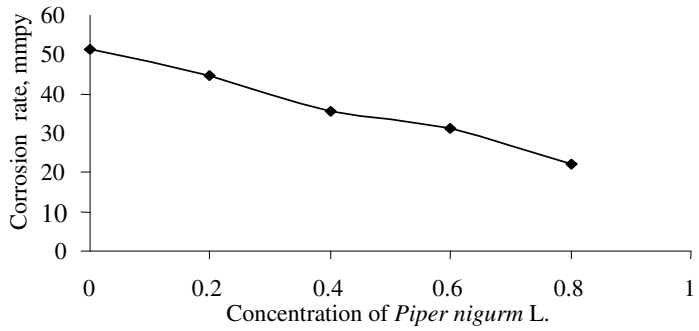

Figure 1c.

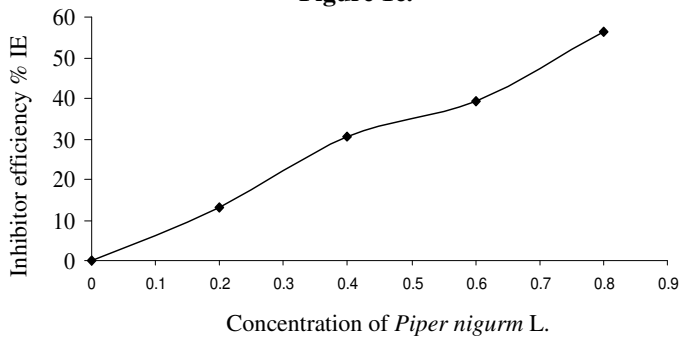

Figure 1d.

Figure 1(a). Variation of corrosion rate (CR) with concentration of *Piper nigrum* L (in %) in HCl solution, **(b)** Variation of inhibition efficiency (IE) with concentration of *Piper nigrum* L (in %) in HCl solution, **(c)** Variation of corrosion rate (CR) with concentration of *Piper nigrum* L (in %) in H_2SO_4 solution, **(d)** Variation of inhibition efficiency (IE) with concentration of *Piper nigrum* L (in %) in H_2SO_4 solution.

From Table 1, it was clear that the corrosion rate was decreased with increasing concentration of inhibitor and inhibition efficiency increased with increasing the concentration of the inhibitor. In addition, the maximum corrosion inhibition efficiency of *Piper nigrum* L was 38.70% at 1 N HCl and 56.52% at 1 N H_2SO_4 respectively at 0.8% solution of inhibitor in one hour at room temperature. And also, it was concluded that the inhibitor was best inhibitor in mild steel corrosion in HCl and H_2SO_4. But when comparing with acids the inhibitor efficiency was best in sulphuric acid than hydrochloric acid.

Table 1. The values of corrosion rate and inhibition efficiency of mild steel in 1 N HCl and 1N H_2SO_4 solution in absence and presence of *Piper nigrum* L .

Corrosion Inhibitors	Conc. of inhibitor, %	Corrosion Rate mm/y		Inhibitor Efficiency	
		1 N HCl	1N H_2SO_4	1 N HCl	1 N H_2SO_4
	Blank	69.099	51.26	--	--
	0.2	64.641	44.58	6.45	13.04
Piper nigrum L	0.4	60.183	35.66	12.90	30.43
	0.6	49.038	31.20	29.03	39.13
	0.8	42.351	22.29	38.70	56.52

Comparison of corrosion inhibitory behaviour of Piper nigurm L.

Since *Piper nigrum*.L is a natural product but it has been used a best inhibitor in the field of corrosion. Hence, *Piper nigrum* L in both HCl and H_2SO_4 shows goods inhibitory character. So, inhibition behaviour of *Piper nigrum* L increases tremendously in H_2SO_4 when compared to HCl at one hour at room temperature (Figures 2a & 2b).

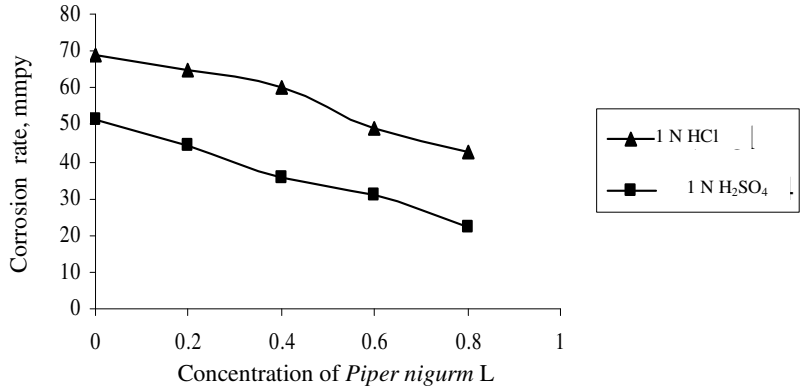

Figure 2a.

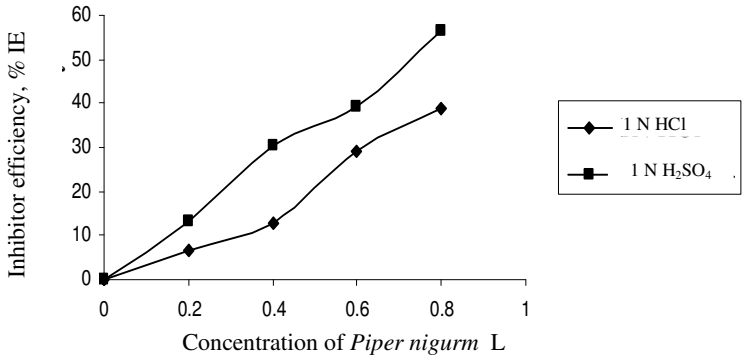

Figure 2b.

Figure 2(a). Comparison of corrosion rate (CR) with concentration of *Piper nigrum* L (in %) in HCl and H_2SO_4 solution, **(b)** Comparison of inhibition efficiency (IE) with concentration of *Piper nigrum* L (in %) in HCl and H_2SO_4 solution.

Conclusions

The *Piper nigrum* L showed good performance as corrosion inhibitor in HCl and H_2SO_4 solution medium. The inhibition efficiency increased with increase in concentration of inhibitors for 0.2% to 0.8% at one hour at room temperature. The maximum inhibition efficiency of *Piper nigrum* L was 38.70% in 1 N HCl and 56.52% in 1 N H_2SO_4 respectively in room temperature for 1 hour of immersion time. From the comparative studies, it was concluded that the inhibitor efficiency is better in H_2SO_4 than HCl, because sulphuric acid is a dibasic acid, so it stimulated the corrosion rate of mild steel.

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