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Corrosion Inhibition of Mild Steel in Citric Acid by Aqueous Extract of *Piper Nigrum* L.

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Abstract: The inhibition efficiency (IE) of an aqueous extract of *Piper Nigrum* L. in controlling corrosion of mild steel at pH 12 has been evaluated by weight loss method in the absence and presence of inhibitor in citric acid medium at different concentration. The result showed that the corrosion inhibition efficiency of these compounds was found to vary with the different concentration at two hour time interval at room temperature. Also, it was found that the corrosion inhibition behaviour of *Piper Nigrum* L. is greater in 2 N Citric acid than 1 N Citric acid medium. So *Piper Nigrum* L. can be used has a good inhibitor for preventing mild steel material which is used in many construction purpose.

Keywords: Mild steel, Corrosion inhibitors, Weight loss method, *Piper Nigrum* L., Environment friendly inhibitor

Introduction

Mild steel finds application in many industries due to its easy availability, easy of fabrication, low cost and good tensile strength besides various other desirable properties. It suffers from severe corrosion when it comes in contact with acid solutions during acid cleaning, transportation of acid, construction of ship and other chemical processes. The heavy loss of metal as a result of its contact with acids can be minimized to a great extent by the use of corrosion inhibitors. Inorganic compounds like chromate, phosphates, molybdates *etc* and a variety of organic compounds containing heteroatom like nitrogen, sulphur and oxygen are being investigated as corrosion inhibitors[1-5].

Pure synthetic chemicals are costly, some of them are not easily biodegradable and their disposal creates pollution problem. Plant extracts are environment friendly, biodegradable, non-toxic, easily available and of potentially low cost. Most of the naturally occurring substances are safe and can be extracted by simple procedure. Recent literature is full of researches which test different extracts for corrosion inhibition applications. The examples are numerous such as fenugreek[6], olive[7], henna[8,9], black pepper[10], jojaba[11], occimum viridis[12], onion, garlic[13] *etc*. Many of these naturally occurring substances proved their ability to act as corrosion inhibitors for the corrosion of different metals and alloys in different aggressive media.

The aim of the present study is to investigate the corrosion inhibition effect of *Piper Nigrum* L. (a pepper family) as cheap and environment friendly corrosion inhibitor for mild steel in 1 N citric acid and 2 N citric acid at different concentration of inhibitor at two hour time interval by weight loss method.

Experimental

According to ASTM method as reported already[14], cold rolled mild steel strips were cut into pieces of 5 cm×1 cm having the following composition (in percentage) of Fe = 99.437, Ni = 0.019, Mo = 0.016, Cr = 0.050, S = 0.025, P = 0.041, Si = 0.029, Mn = 0.335 and C = 0.048. 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 two hours in citric acid, the specimens were removed from test solutions and dried and finally weighed in an electronic balance for an accurate weight. The differences in weights were noted and the corrosion rates were calculated.

Inhibitor material

5% Stock solution of the inhibitor material (*Piper Nigrum* L. extract) was prepared by refluxing 10 g of dry *Piper Nigrum* L. seed powder with 200 mL ethanol for two hours. The refluxed solution is allowed to stand over night and then filter through an ordinary filter paper. The filtrate was made upto 200 mL using distilled water. From this solution, different concentrations of inhibitor solution ranging from 0.02 to 1% were diluted. All the solutions were prepared using NICE brand AR grade chemicals in double distilled water and bubbling purified by nitrogen gas for 30 minutes to carry out de-aeration of the electrolytes. Citric acid solution (Concentration 1 N and 2 N) was prepared by double distilled water.

Results and Discussion

The corrosion behaviour of mild steel in citric acid with *Piper Nigrum* L. was given in Figure 1, which was studied by weight loss method at different concentration 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, which suggesting that the additives are corrosion inhibitor for mild steel in 1 N citric acid and 2 N citric acid. From the data of weight lost method, the corrosion rate (CR) was calculated using the equation:

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

Where W, D, A and T are weight loss (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,

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

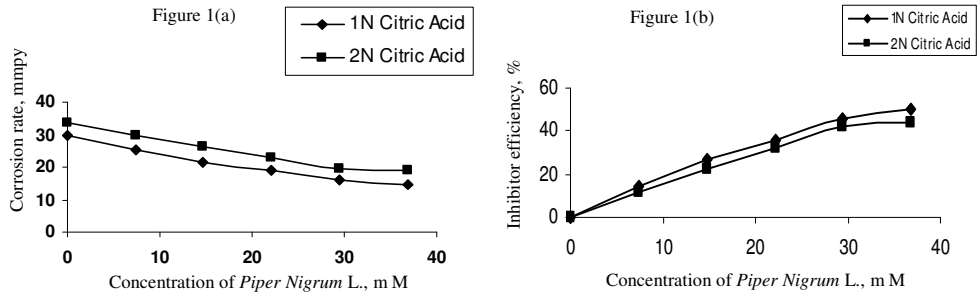

Figure 1 (a). Comparison of corrosion rate (CR) with concentration of *Piper Nigrum* L. (in %) in 1 N citric acid and 2 N citric acid solution at one hour at room temperature, (b) Comparison of inhibition efficiency (IE) with concentration of *Piper Nigrum* L. (in %) in 1 N citric acid and 2 N citric acid solution at one hour at room temperature

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 inhibitor in difference concentration say 1 N citric acid and 2 N citric acid are used for two hours were given in Table 1.

Table 1. Corrosion inhibition behaviour of mild steel in 1 N citric acid and 2 N citric acid solution in absence and presence of *Piper Nigrum* L. by weight loss measurement at two hour

Corrosion Inhibitors	Conc. of inhibitor, mM	Corrosion Rate (mm/y)		Inhibitor Efficiency	
		1 N Citric acid	2 N Citric acid	1 N Citric acid	2 N Citric acid
Piper Nigrum L.	Blank	29.5343	33.7694	-	-
	7.37	25.2992	29.8687	14.33	11.55
	14.74	21.5099	26.3022	27.16	22.11
	22.11	18.8351	22.7358	36.22	32.67
	29.48	16.0488	19.5038	45.66	41.66
	36.85	14.8229	19.0580	49.81	43.56

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 49.81% at 1 N Citric acid and 43.56% in 2 N Citric acid at 36.85 mM (milli molar) solution at two hour respectively. And also, it was concluded that *Piper Nigrum* L. was best inhibitor in preventing mild steel material in many construction purpose. So that *Piper Nigrum* L. acts as a good inhibitor in citric acid medium.

Comparison of corrosion inhibitory behaviour of Piper Nigrum 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 1 N citric acid and 2 N citric acid shows goods inhibitory character. So, inhibition behaviour of *Piper Nigrum* L. increases in 1 N citric acid when compared to 2 N citric acid at two hour at room temperature.

Conclusion

The *Piper Nigrum* L. showed good performance as corrosion inhibitor in citric acid solution. The inhibition efficiency increased with increase in concentration of inhibitors for 7.00 mM to 35.04 mM at two hour at room temperature. The maximum corrosion inhibition efficiency of *Piper Nigrum* L. was 54.89% at 1 N citric acid and 50.36% in 2 N citric acid at 35.04 mM solution at two hour respectively. And also, it was concluded that *Piper Nigrum* L. was best inhibitor in preventing mild steel material in many construction purpose. From the comparative studies, it was concluded that the inhibitor efficiency is better in 1 N citric acid than 2 N citric acid due to acid aggressiveness at two hour time interval.

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