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Schiff Bases as Corrosion Inhibitors for Carbon Steel in HCl Solution

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***Abstract*— Six well known Schiff bases as inhibitors for the corrosion of carbon steel in HCl solution have been investigated. A detailed behavior of the Schiff bases as corrosion inhibitors were tabulated. It was shown that the efficiency of the Schiff bases is strongly correlated with their resistance towards hydrolysis in acidic medium. The effect of variables on corrosion rates and inhibition efficiencies were studied. In all cases, the optimum conditions for satisfactory inhibition of corrosion have been recorded in 6N HCl solution.**

***Index Terms*— Schiff Bases, corrosion, inhibition**

I. INTRODUCTION

Various carbonyl compounds, amines and some Schiff bases derived out of some of them have been investigated as corrosion inhibitors [1-5]. But little work concerning the latter compounds has been published so far [1].

In all studied cases the efficiency of Schiff bases was much greater than that of the corresponding amines [1]. In the present work some well known Schiff bases derived from Mesitylaldehyde; 2,4-Dimethoxybenzaldehyde and aniline, 2-Nitroaniline, 2-Hydroxyaniline have been tested as corrosion inhibitor on standard compounds of carbon steel in HCl solution using weight loss technique.

II. EXPERIMENTAL:

In this work weight loss method has been followed. The preparation of specimens and corrosion tests were carried out as described below.

Carbon steel, low grade having the following composition was used for the study. Mn, 0.33%; C, 0.15%; S 0.02%; P,0.005%; Cr, 0.017%; Ni, 0.025%; the reminder is iron.

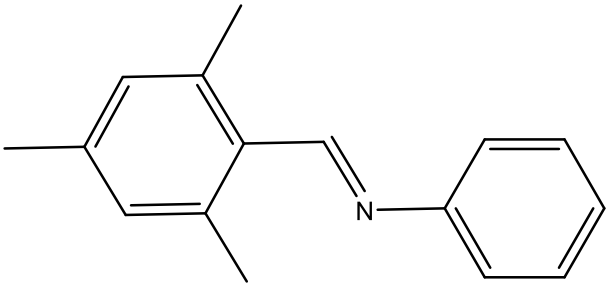
Rectangular specimens of area 7.2 x 1 cm (thickness 1 mm) with a small hole of about 5 mm diameter just near the one end (0.5 cm side end) of the specimen for suspension have been used. Specimens were prepared for corrosion rates as described in earlier publications [2,3]. The volume of corrosive liquid in experiments was 80 mL. The Schiff bases in the tests were prepared according to procedure published elsewhere [6]. The efficiency of corrosion inhibition is calculated by the equation below:

$$\text{Efficiency (eff.)} = \frac{\text{the weight loss of the blank} - \text{the weight loss of the specimen}}{\text{the weight loss of the blank}} \times 100$$

III. RESULTS AND DISCUSSION:

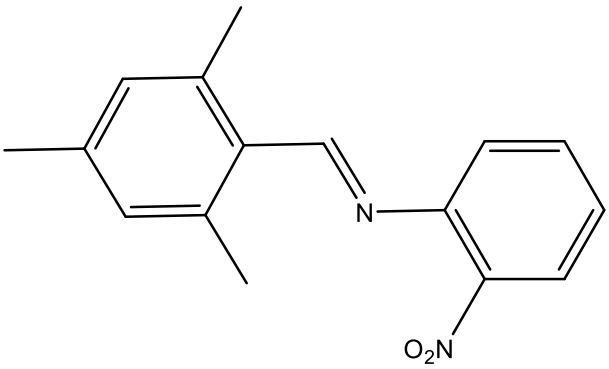
Previous studies showed that the corrosion of carbon steel in HCl solution increases with time as well as HCl concentration [1]. However polarization measurements in 1.0-6.0 N HCl indicates that the corrosion process is cathodically controlled [1, 2]. Table (1) shows the results of the research and the influence of time, temperature of 6N HCl on the efficiency of the tested Schiff bases as aqueos acidic solutions at the range of concentrations ($5x10^{-4}$ M, $8x10^{-4}$ M, $1x10^{-3}$M, 3.5 $x10^{-3}$ M, $8x10^{-3}$ M, 2.5 $x10^{-2}$ M, $3.1x10^{-2}$ M, 3.5 $x10^{-2}$ M, $5x10^{-2}$ M, $8x10^{-2}$M) to inhibit corrosion as follows:

Compound S_1 (2, 4, 6-trimethylbenzylidineaniline)



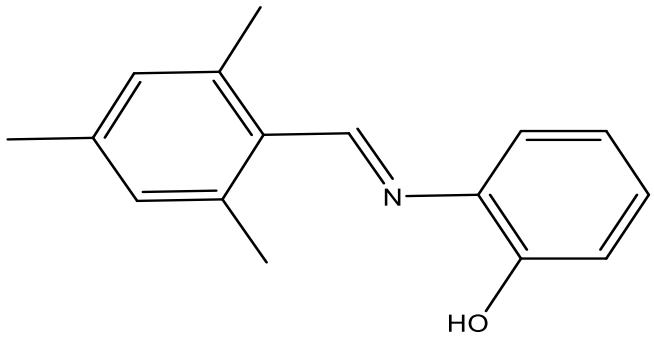
This compound which was derived from mesitylaldehyde and aniline was shown to be totally inactive as inhibitor at range of concentrations($5x10^{-4}$ M – $3.5x10^{--3}$ M). But its protective action started to be improved at $8x10^{-3}$M till it reached the optimum value at $3.5x10^{-2}$ M. However its efficiency, in contradict with previous works, deteriorated with the passage of time, and it was more pronounced during 18 hrs. Table (1)

Compound S_2 (2, 4, 6-trimethylbenzylidine-2- nitro aniline)



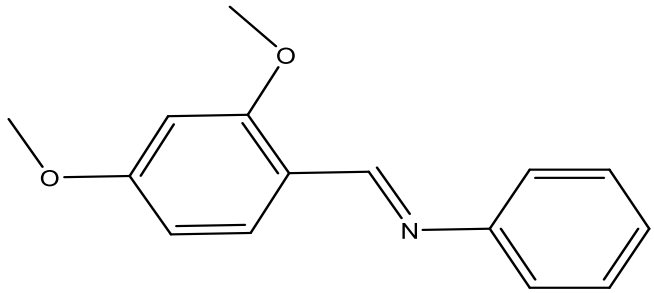
This compound was derived from mesitaldehyde and 2-nitro aniline. Exposing the standard coupons to this compound in 6N HCl solutions for different temperatures and times showed very poor results, even if, it compared with that recorded for compound S1. In these experiments the optimum concentration were shifted even to the more concentrated solution $8.0x10^{-3}$ when the same range of concentration there of were investigated.

Compound S_3 (2, 4, 6-trimethylbenzylidine- 2-hydroxyaniline)



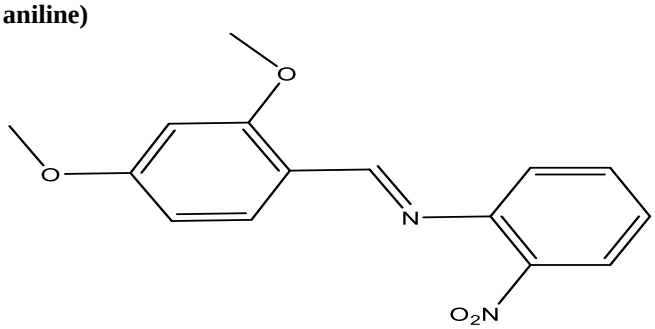
This compound is derived from mesityaldehyde and 2-hydroxyaniline. And its effective range was noticed at $8x10^{-3}$ to $5x10^{-2}$ where in this range it gave 35-55% protection in the 6 N HCl solution considered. The optimum concentration was shown to be $2.5x10^{-2}$. The efficiency of this compound remained constant with time throughout the tests.

Compound S_4 (2, 4, -dimethoxybenzylidine aniline)



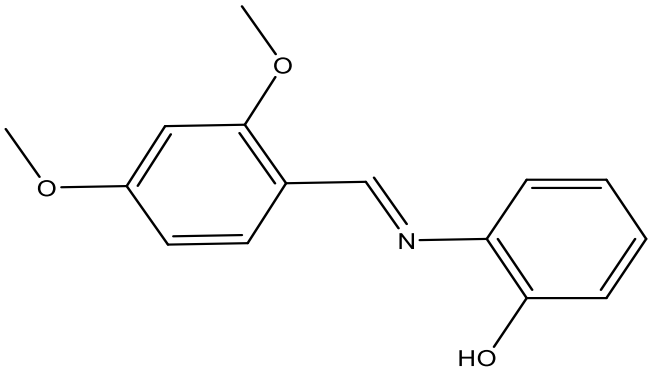
This compound was derived from 2,4- dimethoxy benzaldehyde and aniline. On comparing the behavior of this compound to that of S1, it was found that its efficiency moderately improved even at longer time of tests. Moreover lower concentration of this compound was needed to reach most the same efficiencies, Table (1).

Compound S_5 (2, 4, -dimethoxybenzylidine- 2-nitro aniline)



This compound was prepared from 2,4-dimethoxybenzaldehyde and 2- nitroaniline. In spite of the prevailing deterioration profile of this compound comparing with S4 throughout the tests, however it remained more efficient than its comparator (S2). Where the nitro group substituted on the aniline ring was the chromopher. The optimum concentration did not changed significantly by increasing the temperature, Table (1)

Compound S_6 (2, 4 -dimethoxybenzylidine- 2-hydroxyl aniline)



This compound was derived from 2,4-dimethoxybenzaldehyde and 2-hydroxyl aniline. Extraordinary improvement in its efficiencies wasrecorded for this compound, and the optimum range were extremely lowered to 5.0×10^{-3} M. While the efficiency of this compound with time at least for 55 °C (71-80%) was improved.

One of the main aims of the present work was to compare the protective behaviors of the investigated substances toward carbon steel (used in boilers). Earlier works [1, 2] had shown for aluminum alloys, mild steels in HCl Schiff bases gave maximum protection at an optimum concentration unfortunately similar observations did not recorded during this work, at least for carbon steel case using weight loss technique. In contradict to what was previously shown by others [1]. In the present work the performance of our Schiff bases (efficiencies) were shown to be strongly correlated with the structure of the prepared compounds especially the aniline part thereof. In general, it is believed that the deterioration of the efficiencies of our Schiff bases is due to their ease toward hydrolysis in strongly concentrated acidic medium. These results are quite matched with similar work, in which the same Schiff bases were used as organic photosensitizers in slightly acidic medium [6].

Accordingly the deviations of compound S6 from the remaining five compounds S1-S5 are quite reasonable according to the mechanism of their hydrolysis [6-12]. Where the role of 2,4 –dimethoxy moiety as donating group is enhanced with positive mesomeric effect of the hydroxyl group substituted on the aniline ring which creates finally a strong intact compound resisting hydrolysis process. As well as improving the nitrogen atom attachment on the bare surface of the cleaned metal by enhancing the availability of the lone pair of electrons of Schiff base nitrogen [7-9]. The presence of the – OH group on the aniline ring as a functional group may serve also as a good protective hydrochloric acid solvent [5]

Table (1) Corrosion inhibition efficiencies of Schiff bases (S1-6) in 6 N HCl solutions

Cpd No	Optimum concentration of Schiff bases to inhibit corrosion	Optimum eff % in 6N HCl soln. at 25 °C			Optimum eff % in 6N HCl soln. at 35 °C			Optimum eff % in 6N HCl soln. at 45 °C			Optimum eff % in 6N HCl soln.at55 °C			Optimum eff % in 6N HCl soln.at 65°C		
		6 hr.	12 hr.	18 hr.	6 hr.	12 hr	18 hr.	6 hr.	12 hr	18 hr.	6 hr.	12 hr	18 hr.	6 hr.	12 hr	18 hr.
S1	3.5×10^{-3} M	30	28	23	29	27	22	27	25	23	25	25	21	23	20	18
S2	8.0×10^{-3}M	29	27	24	29	26	23	28	25	24	27	26	22	26	23	20
S3	2.5×10^{-2} M	50	47	46	49	46	43	47	44	42	45	43	39	44	39	35
S4	3.1×10^{-2} M	36	34	34	35	32	29	33	32	31	30	28	27	29	28	26
S5	3.5×10^{-2} M	40	38	36	40	39	34	38	35	33	37	34	31	33	31	29
S6	5.0×10^{-2} M	80	72	72	78	76	72	76	73	72	75	73	70	75	73	71

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