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E: ISSN NO.: 2349-980X **Shrinkhla Ek Shodhparak Vaicharik Patrika**

Corrosion Inhibition of Aluminium by Newly Schiff Base in 0.5 M HCl

Abstract

The Schiff base N,N'-bis[(3,4-dihydroxy-5-nitrophenyl)methylidene]thiourea (BDHNPMTU) synthesized by condensation of 3,4-dihydroxcy-5-nitro-benzaldehyde and thiourea. The structure of Schiff base was fully characterized by elemental analysis, FT-IR and UV–Vis methods. The corrosion inhibition effect of BDHNPMTU on the corrosion of aluminium in 0.5 M HCl acid have been studied using weight loss measurements and scanning electron microscope (SEM). Results showed that BDHNPMTU is an effective inhibitor for aluminium corrosion in 0.5 M HCl solution. The inhibition efficiency also increased with concentration of inhibitor increased. Maximum inhibition efficiency (95.1%, 4 hr) is shown at highest concentration of inhibitor 5% ($5X10^{-5}M$). The adsorption process of BDHNPMTU on aluminium surface obeys Langmuir isotherm. SEM method also supports the corrosion inhibition of alumnium in 0.5 M HCl by BDHNPMTU.

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Introduction

Corrosion is a natural process that converts a pure metal into a more chemically stable form such as oxide, hydroxide, or sulfide. Corrosion is one of the major causes of material failure and hence leads to a huge coast to our society [1-7]. The global cost of corrosion is estimated to be US $ 2.5 trillion, which is equivalent to 3.4% of the global gross domestic product (GDP) (2013). By using available corrosion control practices, it is estimated that saving of between 15 and 35% of the cost of corrosion could be realized; i.e., between U S $ 375 and $ 875 billion annually on a global basis, an astronomical savings [8].

Aluminium and its alloys are used in many applications in industries (aerospace, household industries, electronic devices, food industry, etc.) due to their low price, high electrical capacity, and their high energy density. Aluminum and its alloys, however, are reactive materials and are prone to corrosion [9-11]. Though aluminium has the ability to form a stable thin oxide film that protects it from the corrosion phenomenon, it undergoes corrosion when being in contact with aggressive media such as hydrochloric acid[12-14]. Hydrochloric acid solutions are used for acid cleaning, acid de-scaling, chemical and electrochemical etching in many chemical process industries where in aluminium alloys are used. It is very important to add corrosion inhibitors to prevent metal dissolution and minimize acid consumption [15]. The use of inhibitor is one of the most practical methods for protection against corrosion to protect metal dissolution and acid consumption [16]. Organic compounds containing a heteroatom (N, O and S) in their structure act as good corrosion inhibitors. The corrosion inhibitor efficiency of organic inhibitor are depends on the chemical structure and physiochemical properties of the compound like functional groups, electron density at the donor atom, *p*-orbital character, and the electronic structure of the molecule [17-19]. Recently the use of synthetic inhibitors has created environmental problems due to its toxicity properties.Thus it is important and necessary to develop low cost and environmentally safe corrosion inhibitors [20]. In recent years, the efficiency of Schiff bases as organic corrosion inhibitors for aluminium corrosion in acidic medium has been studied in a wide range [21-28]. The Schiff base BDHNPMTU is nontoxic, soluble in aqueous media, relatively cheap and easy to produce with high purity. These properties would justify the use of Schiff base BDHNPMTU as corrosion inhibitor.

Aim of the Study

The aim of the present paper is to study the anticorrosive properties of Schiff base BDHNPMTU on aluminium corrosion in a strong acidic media.

Synthesis and Characterization of BDHNPMTU

Synthesis of BDHNPMTU:

All the reagents used in this study were of analytical grade. 3,4-dihydroxcy-5-nitro-benzaldehyde, thiourea and glacial acetic acid were of obtained from (SLR, India). The BDHNPMTU was synthesized and characterized on the basis of past various research studies done so far [29-34].

The N,N'-bis[(3,4-dihydroxy-5-nitrophenyl)methylidene]thiourea (BDHNPMTU) was synthesized from 3,4-dihydroxcy-5-nitro-benzaldehyde and thiourea in equal molar ratio in ethanol (20ml) in presence of glacial acetic acid(2ml). The content was refluxed for about 4-5 hours at 70^{o}C with water condenser. On cooling the contents the dark brown coloured solid (M.P.110^{o}C) separated out. The same was filtered, washed with 50% ethanol, recrystallised in ethanol. The method of synthesis is summarized in Figure (1).

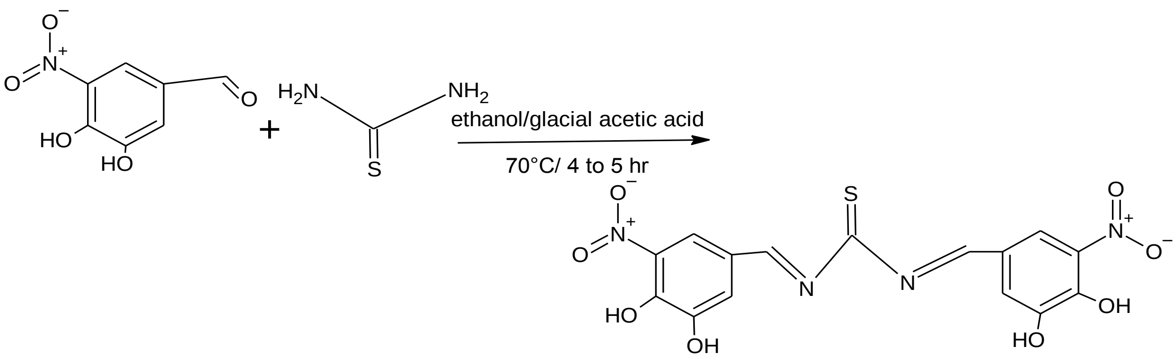

Figure 1: Reaction Scheme

Characterization of BDHNPMTU

The structure of compound was characterized by elemental analysis, IR and electronic studies. The elemental study shows the presence of C (44.34%), H (2.48%), N (13.79%), O (31.50%) and S (7.89%) in the compound. Absence of a υ(C=O) band of aldehyde and presence of υ(C=N) band occurred at 1690-1640 cm^{-1} in the IR spectra of BDHNPMTU indicating the condensation between aldehyde group of 3,4-dihydroxcy-5-nitro-benzaldehyde and amino group of thiourea. In the electronic spectrum of BDHNPMTU n-$\pi*$absorption peak of azomethine group were observed at 310.5, 320.5, 341.5, 354, 370 nm and π- $\pi*$peak of benzene ring observed at 249.5nm.

Experimental

Weight Loss Measurements

The weight loss measurement method widely used by various researchers in previous years [35-40]. For the mass loss study rectangular aluminium specimens of size 3.0cm x 3.0cm x 0.1 cm was employed with a small hole of about 0.02 cm. diameter near the upper edge were employed. All the chemicals employed were of analytical grade and the corresponding solutions were prepared in double distilled water. .01M inhibitor solution was used for corrosion study. Firstly the each specimen was immersed by capillary glass tube for sufficient time in 50 ml acidic test solution (0.5M HCl). After exposure of sufficient time specimens were taken out, cleaned and dried in oven. After drying each specimens weighted. For weight loss measurement time interval taking followed 4 to 72 hours as shown in table 1.

The percentage corrosion inhibition efficiency (η %) was calculated as

$$\eta \% = 100 (\Delta M_b – \Delta M_{wi})/ \Delta M_b$$

Where, ΔM_b = Mass loss of metal in acid solution.
ΔM_{wi} = Mass loss of metal in presence of inhibitor.

The Surface coverage (Θ) of metal surface by inhibitor was calculated as:

$$\Theta = (\Delta M_{wi} - \Delta M_{inh})/ \Delta M_{wi}$$

The corrosion rates (mm/yr) without presence or in presence of inhibitor were calculated as

Corrosion rate (mm/yr) = (Mass loss x 87.6)/ DAT

Where, D = density of aluminium
A = surface area of metal specimen
T = time exposure

Surface Morphological Study

The surface morphology of the formed layers on the aluminium surface after its immersion in the solutions of 0.5 M HCl in the absence and in the presence of Schiff's base BDHNPMTU (at various concentrations) were carried out by scanning electron microscope (SEM) **[Fig.4].**

Result and Discussion

The inhibition of corrosion is a complex phenomenon and the efficiency of inhibitor depends on various factors. In this paper we discuss effect of two factors namely immersion time and inhibitor concentration. Immersion time can play a decisive role in the prevention of corrosion ability. Firstly inhibition efficiency decreased by rising exposer time but after some time inhibition efficiency remain constant at higher concentration of inhibitor BDHNPMTU. Corrosion rate values decrease as the concentration of inhibitor increases. Consequently, inhibition efficiency values increase with the increase the concentration of inhibitor and maximum Inhibition efficiency 95.1 % shown at 5% (5 X 10^{-4}M) inhibitor concentration (4 hr). This is due to the adsorption of inhibitor on the aluminium surface. Adsorption of inhibitor on aluminium surface obey Langmuir isotherm. SEM image of aluminium in absence of inhibitor or in presence of inhibitor also support the inhibitory action of inhibitor BDHNPMTU.

Table 1: Concentration of inhibitor (COI), mass loss, inhibition efficiency, surface coverage and corrosion rate for aluminium metal in presence of BDHNPMTU at different time interval

COI(%)	4 hours				24 hours				48 hours				72 hours			
	ΔM (mg)	η (%)	ϴ	CR (mm/yr)	ΔM (mg)	η (%)	ϴ	CR (mm/yr)	ΔM (mg)	η (%)	ϴ	CR (mm/yr)	ΔM (mg)	η (%)	ϴ	CR (mm/yr)
blank	.82	….	….	7.3	2.0	…	…	3.0	2.2	…	…	1.6	2.7	…	…	1.3
1	.12	85.3	.853	1.0	.53	73.4	.73	.78	.98	55.8	.55	.73	.85	68.7	.68	.42
2	.08	90.2	.902	.72	.17	91	91	.26	.27	87.4	.87	.20	.42	84.3	.84	.21
3	.06	92.6	.926	.54	.17	91.2	.91	.26	.26	88	.88	.19	.24	90.9	.90	.12
5	.04	95.1	.951	.36	.15	92.4	.92	.22	.19	91.3	.91	.14	.22	91.9	.91	.11

Conclusion

The effciency of synthesized Schiff base BDHNPMTU as corrosion inhibition for aluminium in acidic media have been studies. Results obtained from weight loss technique indicate that Schiff base act as efficient inhibitor for aluminium corrosion in acidic media. The graph between inhibition efficiency and concentration shows that the inhibition efficiency increases with concentration of inhibitor.

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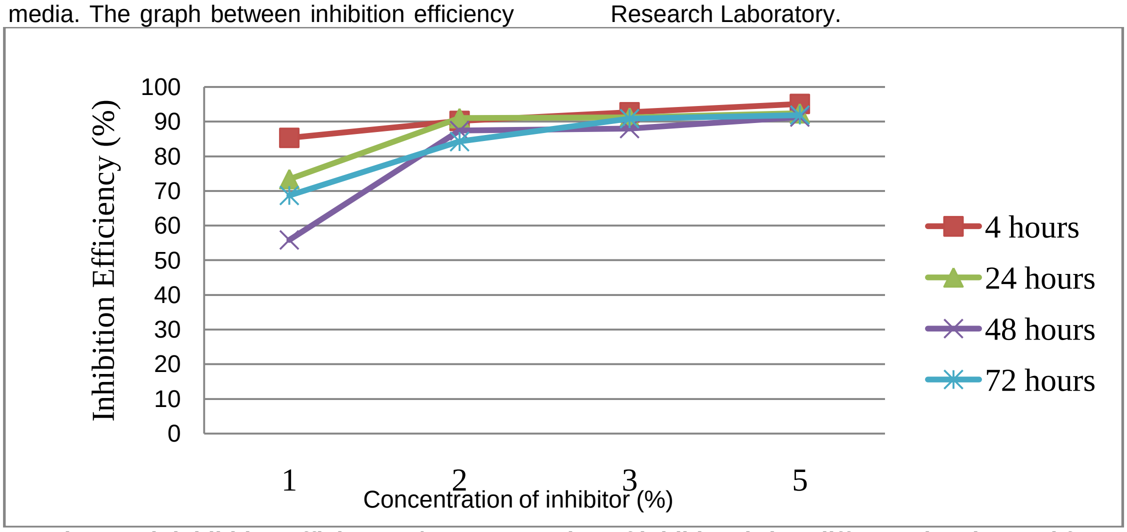

Figure 2: The graph inhibition efficiency v/s concentration of inhibitor (%) at different time interval for copper in 1 M HCl

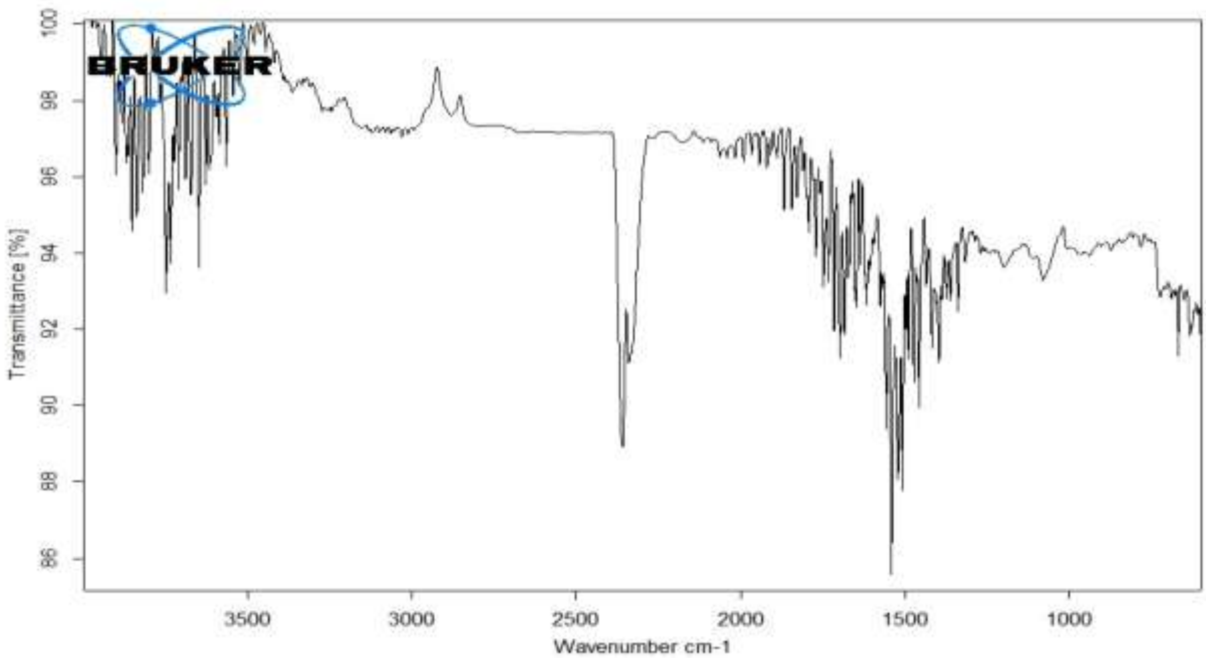

Figure 3: IR spectrum of BDHNPMTU

(a) **(b)**

Figure 4: Image of aluminium (a) immersion of aluminium in 0.5 m HCl without inhibitor (b) immersion of aluminium in 0.5 HCl with 5% inhibitor(BDHNPMTU)

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