Influence of Ni^{2+} on the Corrosion Inhibition of Carbon Steel by an Ethanolic Extract of Pisonia Alba in Well Water

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Abstract— The inhibition property of Pisonia Alba Extract (PAE) on the corrosion of carbon steel in well water was investigated using weight loss technique. Weight loss study reveals that the formulation consisting of 300 ppm of Pisonia Alba (PSA) and 50ppm of Ni^{2+} offers 89% inhibition efficiency to carbon steel immersed in well water. FT-IR spectra confirms that protective film formed on the metal surface. The smoothness of the metal surface were examined by SEM analysis.

Keywords: Pisonia Alba, Inhibition Efficiency, Corrosion Rate, Protective Film

I. Introduction

Corrosion is the deterioration of metal by chemical attack or reaction with its environment. It is a constant and continuous problem, often difficult to eliminate completely [1]. The use of inhibitors is one of the best options of protecting metals against corrosion in various fields of application as acid pickling and acid descaling [2]. Corrosion inhibition of steel in hydrochloric acid solution by Rosemary oil has been studied by Chaieb [3].Naturally occurring henna (Lawsona inermis L) has anti-inflammatory, antipyretic and analgesic effect [4-5]. Henna has inhibitory action on aluminium and steel in aggressive solution [6]. Henna has been used as corrosion inhibitor for iron in hydrochloric acid [7]. The inhibitors employed are varied and some have been found to be severe to health and the environment at large. Thus efforts are now directed towards formulation of modern environmentally safe inhibitors in which plant extracts have become important as eco-friendly, economical, readily available and renewable sources of effective corrosion inhibitors. Pisonia alba (Nyctaginaceae), commonly known as Lettuce Tree, is an evergreen tree 9-12 m high found sparsely wild in the beach forests of Andaman Islands, cultivated to a small extent in India and Ceylon. The fresh leaves moistened with Eau-de-Cologne are used to subdue inflammation of a filariosis nature in the legs and other parts [8]. They are used as diuretic. The root is purgative. A survey of literature revealed that Pisonia alba is an untapped candidate for antidiabetic activity though it is extensively used in traditional healing of diabetes in Kerala (Anonymous,1969) [9]. The present study aimed at investigating the inhibitive properties of extract of Pisonia Alba plant leaves on the corrosion of carbon steel in well water.

II. Materials and Methods

A. Preparation of Specimen

Carbon steel specimen [0.0267 % S, 0.06 % P, 0.4% Mn, 0.1 % C and the rest iron] of dimensions 1.0 cm × 4.0 cm × 0.2 cm were polished to a mirror finish and degreased with trichloroethylene.

B. Preparation of Plant Extract

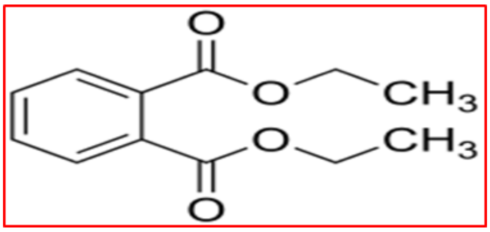

Fig. 1: Main constituents of Pisonia Alba Extract (PAE) are shown below:

The fresh leaves of Pisonia Alba were collected from Kodaikanal hills. The leaves were washed with fresh water and dried under shade of sunlight for 12 days. The dried plant leaves were coarsely powdered with the help of mechanical grinder. About 20 g of powder was soaked in 100 mL of ethanol at room temperature for 48 hours. The mixture was then filtered and concentrated extract produced using rotary evaporator at 80^0C to remove the excess solvent, resulting in the Pisonia Alba Extract powder. About 1 g of Pisonia Alba Extract powder was dissolved in 100 mL of distilled water and used as corrosion inhibitor in the present study.

C. Weight-Loss Method

Carbon steel specimens in triplicate were immersed in 100 mL of the solutions containing various concentrations of the inhibitor in the presence and absence of Ni^{2+} for one day. The weight of the specimens before and after immersion was determined using a Shimadzu balance, model AY62. The corrosion products were cleaned with Clarke's solution [10]. The inhibition efficiency (IE) was then calculated using the equation:

$$\text{IE}\ (\%) = \left[\frac{W_2 - W_1}{W_2}\right] \times 100$$

where W_2 is the weight loss value in the absence of inhibitor and W_1 is the weight loss value in the presence of inhibitor.

D. Surface Examination Study:

The carbon steel specimens were immersed in various test solutions for a period of one day. After one day, the specimens were taken out and dried. The nature of the film formed on the surface of the metal specimen was analysed by various surface analysis techniques.

1) Fourier Transform InfraRed (FTIR) spectra:

FTIR spectra were recorded in a Perkin-Elmer-1600 spectrophotometer using KBr pellet. The FTIR spectrum of the protective film was recorded by carefully removing the film, mixing it with KBr and making the pellet.

2) Scanning electron microscopy

The surface morphology of the formed layers on the carbon steel surface after its immersion in control solutions containing well water in the absence and in the presence of the inhibitor were carried out. The SEM photographs of the surfaces of the specimens were investigated using a VEGA3-TESCAN model scanning electron microscope.

III. Results and Discussion

A. *Analysis of Results of Weight Loss Study: (Ni^{2+}-PAE)*

The calculated Inhibition efficiencies (IE) and corresponding corrosion rates (CR) of an Pisonnia Alba Extract (PAE) on the corrosion of carbon steel immersed in well water in the presence and absence of has been evaluated by weight loss method. The results are given in Table: 1.

PAE (00 ppm)	Ni^{2+} (0 ppm)		Ni^{2+} (25 ppm)		Ni^{2+} (50 ppm)	
	IE %	CR (mdd)	IE %	CR (mdd)	IE %	CR (mdd)
0	-	50.63	15	43.03	21	39.97
100	45	27.82	52	24.29	57	21.76
200	55	22.75	62	19.22	75	12.64
300	63	18.73	73	14.26	89	5.53
400	56	22.73	66	17.19	82	9.09
500	51	24.76	56	22.52	70	15.15

Inhibitor system: Ni^{2+}- PAE Immersion period: one day

Table 1: Corrosion rates (CR) of carbon steel immersed in well water containing in the presence and absence of inhibitor system at various concentrations of inhibitors and the inhibition efficiencies (IE) obtained by weight loss method:

It is observed that when the carbon steel is immersed in well water contains 300 ppm of PAE only shows 63 % inhibition efficiency (IE) (in the absence of Ni^{2+}). This inhibition efficiency is found to be enhanced in the presence of Ni^{2+} ions. When Ni^{2+} is added IE also increases and gives maximum 89 % IE at 300 ppm of PAE and 50 ppm of Ni^{2+} this shows that synergistic effect exists between Ni^{2+} and the active principles present in PAE. For example, 50 ppm of Ni^{2+} has only 21 % of IE; 300 ppm of PAE has 63 percent IE. Interestingly their combination has high IE, namely, 89%. Therefore the mixture of inhibitors shows better IE than individual inhibitors.

When the concentration of PAE - Ni^{2+} increases from 25 ppm to 50 ppm the IE slightly increases. This may be due to the fact that, when the concentration of Ni^{2+} increases, the Ni^{2+}- PAE complex formed in the bulk of the solution. After increasing concentration of PAE the IE decreases. This may be due to the fact that, when the concentration of PAE increases, the Ni^{2+}- PAE complex formed is precipitated in the bulk of solution [11-19].

B. *Influence of immersion period on the inhibition efficiency of Pisonia Alba Extract (PAE):*

The influence of duration of immersion on the IE of PAE (300 ppm) – Ni^{2+} (50 ppm) system is given in Table: 2. When the immersion period increases the inhibition efficiency decreases and the corrosion rate increases this shows that the protective film formed on the metal surface, was broken by the corrosive environment and the film was dissolved. Similar observations were shown in Phyllanthus amaranthus extract [20], Banana Peel Extract [21].

Immersion Period (days)	Corrosion Rate (CR) in the absence of the inhibitor (mdd)	Corrosion Rate (CR) in the presence of the inhibitor PAE (300 ppm) + Ni^{2+} (50 ppm) (mdd)	Inhibition Efficiency (IE%)
1	50.63	5.53	89
3	61.31	12.21	80
5	72.42	26.71	63
7	96.46	57.80	40

Table 2: Influence of duration of immersion on the inhibition efficiency of PAE - Ni^{2+} system.

C. *Analysis of FTIR spectra*

FTIR spectra have been used to analyze the protective film formed on the metal surface. A few drops of an aqueous extract of Pisonia Alba was dried on a glass plate. A solid mass was obtained and their corresponding FTIR spectra shown in Fig.2a. The C=O stretching frequency appears at 1641 cm^{-1}. The -OH stretching frequency appears at 3431 cm^{-1}. Fig.2b. shows that the C=O stretching frequency shifts from 1641 cm^{-1} to 1635 cm^{-1} and -OH stretching frequency shifts from 3431 cm^{-1} to 3428 cm^{-1}. This suggested that PAE is coordinated with Fe^{2+} on the anodic sites of the metal surface also resulting in the formation of Fe^{2+}-PAE complex. The peak appears at 621 cm^{-1} could be attributed to the Ni-O stretching frequency. The FTIR results indicate the formation of a protective film on the metal surface [22,23].

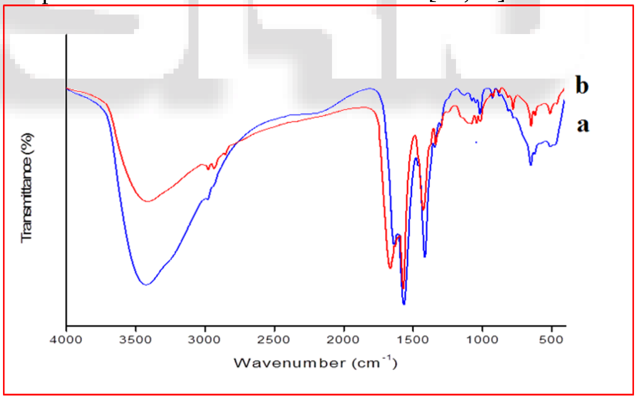

Fig. 2 FT-IR spectra of a) Pure Pisonia Alba Extract (PAE) b) protective film formed on the surface of the metal immersed in well water containing 300 ppm of Pisonia Alba Extract (PAE) and 50 ppm of Ni^{2+}.

D. *Scanning Electron Microscopy:*

The scanning electron micrographs of carbon steel are shown in Fig 3. The SEM micrograph of polished carbon steel surface is shown in Fig 3a. This shows the smoothness of the metal surface. This implies the absence of any corrosion product formed on the metal surface. The SEM micrograph of carbon steel immersed in well water is shown in Fig 3b. This shows the roughness of the metal surface by the corrosive environment and the porous layer of corrosion product is present. Pits are observed on the metal surface. Fig 3c shows that the presence of 300 ppm of PAE and 50 ppm of Ni^{2+} in well water gives the formation of thick films on the carbon steel surface. This may be interpreted as due to the adsorption of the inhibitor on the metal surface incorporating into the passive film in order to block the active site present on the carbon steel surface [24, 25].

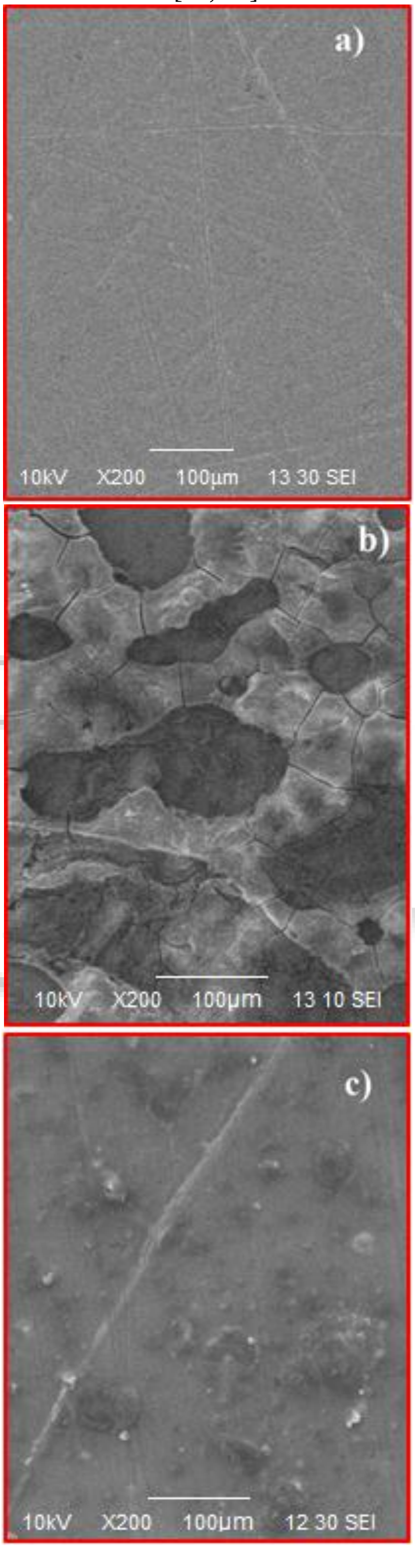

Fig. 3: SEM images of a) polished Carbon steel b) carbon steel immersed in well water c) carbon steel immersed in 300 ppm of PAE + 50 ppm of Ni^{2+} + well water

IV. Conclusion

1) The formulation consisting of 300 ppm of Pisonia Alba Extract (PAE) and 50 ppm of Ni^{2+} offers maximum 89 % Inhibition Efficiency.
2) Immersion period increases corrosion rate increases.
3) FT-IR spectra reveals that protective film consisting of Fe^{2+}- PAE complex and $Ni(OH)_2$.
4) SEM analysis confirms that the surface of the metal was smoother due to the formation of protective on the metal surface.

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