Research Article

Comparative Corrosion Inhibition Effect of Imidazole Compounds and of *Trichodesma indicum* (Linn) R. Br. on C38 Steel in 1 M HCl Medium

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Corrosion inhibition effect of alkaloid extract part of the plant *Trichodesma indicum* (Linn) R. Br. of Boraginaceae family was studied and compared with that of imidazole compounds (imidazole, benzimidazole) on C38 steel in 1 M HCl solution by weight loss method at various temperatures. The study showed that the alkaloid part of the plant extract acts as a better inhibitor in comparison to the selected organic inhibitors. The maximum inhibition efficiency of the extract of *Trichodesma indicum* R. Br. was found to be 94.5% at a concentration of 75 mg/L at 30°C.

1. Introduction

The study of corrosion of steel and iron in acid media remains a global scientific problem which affects all kinds of industries [1, 2]. The economic cost of corrosion is enormous and has been estimated to be in the range of 2–4% of an industrialized country's gross national product. In the field of combating corrosion, both economic and scientific considerations are involved. Acids are widely used in industrial processes such as pickling, cleaning, decaling, and oil well acidizing. Because of the aggressivity of acid, solutions inhibitors are used to reduce the rate of dissolution of metals [1].

In general, an inhibitor retards corrosion reactions by

- (i) adsorption of ions/molecules on metal surface,
- (ii) altering the anodic and/or cathodic reaction, and
- (iii) decreasing the diffusion rate of reactants to the metal surface [3].

Corrosion inhibition is reversible and a minimum concentration of the inhibiting compound is required to maintain the inhibiting surface film. The effectiveness of inhibitor depends on solution corrosivity, concentration, and temperature. It is well known that the organic inhibitors having heteroatom –O, N, S are the best corrosion inhibitors in

acid solution as they have higher basicity [4–9]. These hetero atoms act as active centre for adsorption on metal surface [10]. However most of these organic inhibitors are toxic to the environment. This has prompted to the search of green inhibitors.

Green inhibitors are biodegradable and nontoxic compounds. They are cost effective and renewable source materials. Several reports are available on various natural products used as green inhibitors [3, 4]. Low-grade gram flour, natural honey, onion, gelatin, plant roots, leaves, and seeds had been reported as good inhibitors. Plant extracts are viewed as a rich source of natural corrosion inhibitors, which can be extracted at low cost [2]. Many plants are known to produce various types of alkaloids [5, 6]. The selected plant *Trichodesma indicum* (Linn) R. Br. is an annual herb, available as weed in greater part of India. It belongs to Boraginaceae family, and pyrrolizidine alkaloids are found to be present in this family [11]. The present study focused on the application of extract of *Trichodesma indicum* (Linn) R. Br. as green inhibitor for corrosion control, and it was compared with that of the organic inhibitors.

This investigation was related to studies on corrosion behavior of C38 steel in 1 HCl medium at various temperatures by weight loss method using thermostat. Besides,

the influence of temperature on inhibition of mild steel corrosion had also been studied. The inhibitor efficiency and the surface coverage have also been found out.

2. Materials and Methods

2.1. Preparation of Steel Specimen and Solution. All the test specimens of C38 steel were cut into an overall apparent size of 5 cm × 1 cm. Steel strips containing 0.36 wt% of C, 0.66 wt% of Mn, 0.27 wt% of Si, 0.02 wt% of S, 0.015 wt% of P, 0.021 wt% of Cr, 0.02 wt% of Mo, 0.22 wt% of Cu, and remaining iron. They were pickled in 1-2% H₂SO₄ for 3 minutes and washed with bidistilled water. They were then subsequently polished with different grades of emery papers then degreased with trichloroethylene, dried, and weighed.

The 1 M hydrochloric acid solution was prepared by dilution of concentrated hydrochloric acid (Merck, A.R grade) with bidistilled water. Imidazole and benzimidazole solutions of 2%, 4%, and 6% were prepared by dissolving 2 gms, 4 gms, and 6 gms of imidazole and benzimidazole (Merck, A.R grade), respectively, in 1 M HCl acid solution.

2.2. Preparation of Plant Extract. The plant *Trichodesma indicum* (Linn) R. Br. of Boraginaceae was collected in western ghats region of south India and was authenticated by botanical survey of India, Coimbatore. The voucher specimen was stored in pest proof container in Chemistry Department of Karpagam University, Coimbatore, under the number 11CH231. The aerial parts of the plant were collected, washed with running water, and shade dried. It was then powdered using a mechanical grinder and passed through 40 mesh sieve to obtain uniformity. It was treated with alkaline solution of NH₄OH (5%) and extracted with dichloromethane (3 × 200 mL) and it is filtered, and the combined fractions were washed with water. Then the organic layer was extracted with dilute hydrochloric acid. The combined aqueous fractions were washed with dichloromethane (3 × 80 mL), and the PH of the aqueous solution was adjusted to 9 by using NH₄OH (25%). This aqueous layer was extracted with dichloromethane (3 × 100 mL). All the combined organic layers were washed with bidistilled water (2 × 100 mL) dried over anhydrous sodium sulphate and collected by filtration. The solvent was removed under reduced pressure, and the alkaloid residue was obtained [12]. Various alkaloid qualitative tests (Mayer's reagent, Wagener's reagent, etc.) were done with the residual part in order to confirm the presence of alkaloid compounds in it [11].

2.3. Weight Loss Measurement. The specimens were weighed and immersed in 1 M HCl acid and placed in thermostat maintained at various temperatures –30°C, 40°C, 50°C, and 60°C. After five hours, the specimens were removed from thermostat, dried and, finally weighed. The corrosion rates were calculated from difference in weight.

The inhibitor efficiency of benzimidazole was found out by immersing three specimens in each beaker containing 2%, 4%, and 6% of benzimidazole as inhibitor. The same

FIGURE 1: Inhibition efficiency of Imidazole at various temperatures.

procedure was repeated for another inhibitor (imidazole). They were kept for five hours in the same temperature range.

The inhibitor efficiency of the alkaloid extract of the plant was found out by following the same procedure with different concentrations –25, 50, 75, and 100 mg/L of plant extract in acid medium.

The corrosion rates were calculated in mmpy (miles per year) using the following relation:

$$\text{Corrosion} = \frac{[87.6 \times W]}{A \times T \times D \text{ mmpy}}, \quad (1)$$

where W —weight loss in grams, A —area of specimen in sq-cm, D —density of the specimen in g/cm³, and T —Time for which the specimens were exposed to the corroding medium (in hours).

Weight losses in the presence and in the absence of inhibitors were determined. The inhibitors efficiencies were obtained from the following relationship:

$$\text{I.E} = \left(W_o - \frac{W_i}{W_o} \right) \times 100\%, \quad (2)$$

where W_o and W_i are weight losses without and with inhibitors, respectively, in grams.

Surface coverage was calculated from the rate of corrosion by using the following relation:

$$\text{Surface coverage } (\theta) = W_o - \frac{W}{W_o}, \quad (3)$$

where W_o and W are corrosion rates without and with inhibitor, respectively.

3. Results and Discussion

The average corrosion rate for each concentration studied was determined and the inhibition efficiency (IE) was evaluated by using (2). The results were presented in Tables 1 and 2 and Figures 1, 2, and 3. The inhibitor efficiency increased with increase in concentration. At certain concentration, IE reached a plateau of maximum protection. It could be assumed that the difference in the IE of the tested organic

FIGURE 2: Inhibition efficiency of Benimidazole at various temperatures.

FIGURE 3: Inhibition efficiency of alkaloid extract of *Trichodesma indicum* at various temperatures.

inhibitors might be due to their different molecular structures. The lone pair of electrons present above the N³ atom of five-membered ring in both the organic inhibitors would be transformed to a cationic form in presence of an acid [8, 9]. Since the present work was carried out in the acidic medium (1 M HCl), formation of protonated form could be expected.

The alkaloid part of the plant *Trichodesma indicum* (Linn). R. Br. showed better inhibition efficiency on C38 steel in 1 M HCl medium than that of the other two organic inhibitors. It established the inhibition via adsorption of its molecules on the metal surface forming a protective barrier. However a synergistic or antagonistic effect of the alkaloid compounds might play an important role on the inhibition efficiency. Alkaloid compounds had been shown to possess significant anticorrosion activity which was based on their structural characteristics (nitrogen atoms, other groups, conjugated systems) [13]. The maximum inhibition efficiency of the extract was found to be 94.5% at 30°C at a concentration of 75 mg/L. The adsorption of alkaloids compounds in the extract on the metal surface might be responsible for the corrosion inhibition.

4. Conclusion

The selected organic inhibitors showed good inhibition efficiencies in the control of C38 steel corrosion in HCl acid medium up to a concentration of 4%. The rise in concentration of both the inhibitors above 4% decreased

the inhibition effect due to desorption. On comparison, alkaloid part of the selected plant showed better efficiency in inhibiting the corrosion than these organic inhibitors and the maximum inhibition efficiency of the alkaloid part of the extract of *Trichodesma indicum* (Linn) R. Br. was found to be 94.5% at a concentration of 75 mg/L at 30°C. Therefore, it is concluded that the alkaloid content of the selected medicinal plant acts as a good green inhibitor.

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