GREEN CORROSION INHIBITORS FOR MILD STEEL IN ACIDIC MEDIUM

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Abstract - Corrosion control of metals and their alloys is significant and an environmentally imperative matter. Extracts of plant material serve as the superior alternative to replace the environmentally hazardous organic and inorganic corrosion inhibitors. Literature review shows that corrosion of mild steel in acidic and other adverse environmental conditions can be inhibited by extracts of plant parts. Several organic compounds with heteroatom such as N, O, S and P present in the plant extracts are adsorbed directly onto the metals surface through polar atoms and thereby forming the protective layer. Their adsorption follows various adsorption isotherms. This paper discusses the different types of eco-friendly inhibitors for corrosion control of mild steel in acidic media.

Keywords - Corrosion inhibitors; Eco-friendly; non-toxic; plant materials; adsorption isotherms

I. INTRODUCTION

Mild steel is also called as the carbon steel which is a low carbon (0.3%) steel with superior strength. It is used when large amount of steel is needed and can be twisted and welded into an infinite range of shapes for uses in vehicles, construction material and vessels fabrication etc. In many industries, mild steel (MS) is the material of choice in the fabrication of reaction vessels, storage tanks etc. which get corroded easily in the presence of acids [1].

Hydrochloric acid solutions are widely used in several industrial processes, some of the important fields of application being acid pickling of steel, chemical cleaning and processing, ore production and oil well acidification. Because of the general aggression of acid solutions, inhibitors are commonly used to reduce the corrosive attack on metallic materials [2].

Acid solutions are commonly used in the chemical industry to remove mill scales from metallic surfaces. The inhibitors are adsorbed and depend on the structure and surface of metal atom. Among the methods of corrosion control, use of inhibitors is very popular due to the ease of application. Plant extracts contains several organic compounds with heteroatom such as N, O, S and P. They are adsorbed directly onto the metals surface through polar atoms and thereby forming the protective layer. Plant extracts have become important due to environmentally acceptable, non-toxic, readily available and are also renewable.

This paper reviews and discusses the use of different types of eco-friendly inhibitors for corrosion control of mild steel in acidic media reported in corrosion literature.

II. ECO-FRIENDLY INHIBITORS FOR CORROSION CONTROL OF MILD STEEL (MS)

In recent years several researchers have indicated the use of eco-friendly corrosion inhibitors for mild steel in different media. They forms complexes with metal ion onto the metal surface and thus forming a protective coating on the metal surface and protecting them from corrosive agents in different media.

Inhibition efficiency of these inhibitors in different media have been evaluated by employing different investigational techniques like weight loss method, electrochemical studies, Raman spectroscopy, gasometric techniques, potentiodynamic polarization, electrochemical impedance, polarization method, SEM, FTIR etc. are being used.
Various plant extracts that have been used as a corrosion inhibitor for mild steel in acidic medium is tabulated in Table 1.

Table 1: Various plant extracts that have been used as a corrosion inhibitor for mild steel in acidic medium

| S. No | Medium        | Inhibitor                      | Technique                                                                 | Findings                           | Ref |
|-------|---------------|--------------------------------|---------------------------------------------------------------------------|------------------------------------|-----|
| 1     | 2M H2SO4      | Medicago Sativa (alcoholic Extract) | Electrochemical Measurements, SEM, EIS, Weight loss method | Mixed-type inhibitor, Langmuir adsorption isotherm | 3   |
| 2     | 1M HCl and 1M H2SO4 | Spirulina platensis | SEM, spectroscopy measurements, potentiodynamic polarization | Temkin isotherm                   | 4   |
| 3     | 1M HCl        | Henna, L. inermis             | Weight loss technique                                                      | Chemiabsorption                    | 5   |
| 4     | 5% HCl        | Z. alatum (plant extract)     | Weight loss technique, Kinetic and thermodynamic techniques. Temp. 30-60 °C, KI and KSCN | Chemiabsorption                    | 6   |
| 5     | 4 N HCl       | Methanolic extract of A. pallens | Weight loss method, AC impedance and FTIR methods | Chemisorption                      | 7   |
| 6     | 0.2M HCl      | Mangifera Indica (extracts of leaf and bark of mango) | Weight loss method | IE                                  | 8   |
| 7     | 0.5 N HCl     | Bryophyllum Pinnatum Leaves    | Surface Analysis (SEM) & Weight Loss method                               | Langmuir Isotherm                  | 9   |
| 8     | HCl           | Acid extract of Andrographis Paniculata | Mass loss method, Tafel polarization method                               | Freundlich and Temkin adsorption isotherms | 10  |
| 9     | H2SO4         | Amaranthus                   | Weight loss method                                                        | Freundlich adsorption Chemisorption | 11  |
| No. | Acid | Plant/Extract | Method/Techniques/Equation | IE/Notes |
|-----|------|---------------|-----------------------------|----------|
| 10  | 5% HCl | Ethanolic and aqueous extract of seven aloe plant | Weight loss methods | IE dependent upon the concentrations of the inhibitor and the acid. |
| 11  | 1M HCl | Mollugo cerviana | Potentiodynamic Polarization, Weight loss method, Surface Analysis | Mixed Type Inhibitor, Obeys Langmuir Adsorption Isotherm |
| 12  | 1M HCl | Seed extract of Cyamopsis tetragonoloba | Weight loss and potentiodynamic polarization techniques | Langmuir and Temkin adsorption isotherms |
| 13  | H₂SO₄ | Combretum bracteosum | Gravimetric and hydrogen evolution measurement. | Freundlich adsorption isotherm, |
| 14  | HCl | Ginger | Weight loss techniques | IE increases with temperature. Activation energy of adsorption are determined. |
| 15  | 1M HCl | Mango, orange and cashew peels | Electrochemical impedance spectroscopy, potentiodynamic polarization curve, weight loss method. | Langmuir adsorption isotherm. IE increases with increase in extract concentration and decrease with temperature |
| 16  | 1M HCl | Phaseolus aureus seed | Weight loss, potentiodynamic polarization technique | Mixed type inhibitor, IE 93% |
| 17  | 1M HCl and H₂SO₄ | Acidic extract of Solanum tuberosum | Electrochemical impedance spectroscopy, potentiodynamic polarization curve, weight loss method, SEM. Temp 303, 313 and 323K | Mixed type inhibitor, Temkin adsorption isotherms |
| 18  | 2M HCl and 1M H₂SO₄ | Calyx extract of Hibiscus sabdariffa | Gasometric technique | Langmuir Isotherm and mixed inhibition |
| 19  | NaCl | Thymus vulgar L. plant | potentiodynamic polarization curve, weight loss method | Temkin adsorption isotherms |
| 20  | H₂SO₄ | Arica papaya (leaves, seeds, heart wood and bark) | Gravimetric and Gasometric technique | Langmuir and Temkin adsorption Isotherm |
| 21  | 2M HCl and 1M | Baphia nitida plant | Hydrogen evolution | Cationic inhibition |
III. RESULTS AND CONCLUSIONS

The summarized and discussed concluded that the naturally occurring plant extracts are readily available, cheap and renewable and are both eco-friendly and ecologically acceptable. It is required to minimize and control metal corrosion which is a major industrial problem. Green Corrosion Inhibitors are found to be effective and can play major role over toxic corrosion inhibitors. The efficiency of corrosion inhibitor depends not only on the kind of the environment in which they act, the nature of the metal surface, and electrochemical potential at the interface, but also on the structure of the inhibitor itself, which includes the number of adsorption active centres in the molecule, their charge density, the molecular size, the mode of adsorption, the formation of metallic complexes, and the projected area of the inhibitor on the metallic surface. From the experimental studies it can thus be concluded that the main mechanism of corrosion inhibition follows the different adsorption isotherms and their adsorption further depends on the physical and chemical properties of the metal surface. Studies also revealed that the corrosion inhibition of mild steel in acidic medium is concentration dependent and the inhibition efficiency was found to increase with increase in the concentration of inhibitors [12].

Further the corrosion inhibition of mild steel occurs via adsorption of inhibitors molecules onto the corroding metal surface. The inhibition efficiency depends on the mechanical, structural and chemical characteristics of the adsorption layer formed under particular conditions. These adsorption studies follow Langmuir, Freundlich, Temkin adsorption isotherm or thermodynamic kinetic model. Corrosion Inhibition also depends on the structure of the inhibitor and number of adsorption active
centres in the inhibitor molecule, the charge density, the molecular size, the mode of adsorption and formation of metallic complexes [28, 29].

The non-toxic and eco-friendly inhibitors can therefore be considered as the most essential and advantageous for both men and environment. Thus it may be concluded that the eco-friendly or green inhibitor obtained from plant extracts have a broad span and they can be used as a replacement of hazardous and toxic inorganic and organic chemicals.

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