INHIBITION OF CORROSION OF CARBON STEEL IN BORE WATER BY NATURAL MUNTINGIA CALABURA -Zn2+ SYSTEM

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Abstract:The corrosion inhibition of carbon steel in an aqueous medium using the leaves extract of Muntingiacalabura was studied using chemical and spectroscopic techniques. This green inhibitor was employed to prevent steel corrosion in the aqueous medium. Fourier transform infrared spectroscopy (FTIR) was used to identify the electron-rich functional groups in the plant extract, which contribute to its corrosion inhibition effect. Scanning electron microscopy (SEM) analysis of the steel surface clearly demonstrates the anticorrosion effect of Muntingiacalabura plant leaves. The leaves extract can be suitably applied as an inexpensive, non-toxic, biodegradable, and efficient green corrosion inhibitor for the protection of carbon steel in aqueous environments.

Key words: Carbon steel, plant extract, FT-IR, SEM, Bore water

1.1 INTRODUCTION

Corrosion is a process in which useful metals react with the environment and are typically lost, usually in the form of oxides. This phenomenon is observed as the formation of a green coating on bronze and copper, a greyish appearance on shining silver, and most commonly, the rusting of iron. Rust is a mixture of ferric hydroxide ($Fe(OH)3$) and ferric oxide ($Fe2O3$), produced by the action of water on iron in the presence of dissolved oxygen and sometimes carbon dioxide. Iron and steel are so widely used that combating rusting is of paramount importance. Iron can be protected from rusting by barrier protection and sacrificial protection [1].

The rate of corrosion is highest in acidic environments, and corrosion can be reduced by increasing the pH of the medium. Acidic environments are more corrosive than alkaline or neutral ones. Corrosion reactions are always surface reactions. Corrosion can be controlled by either modifying the metal or modifying the environment. The corrosion resistance of a metal can be improved by alloying it with a suitable metal. Substances that, when added in small quantities to the corrosive environment, reduce the corrosion of metals are called anodic inhibitors and cathodic inhibitors. Metal surfaces can also be protected from corrosion by applying organic or inorganic coatings [2].

Corrosion is particularly severe in the presence of chloride ions and dissolved oxygen [3]. Scanning Electron Microscopy (SEM) provides valuable information about the steel surface, especially in terms of morphology. Deposits on the surface can be either amorphous or crystalline, with X-ray diffraction (XRD) being used to identify crystalline compounds. Polarization studies and AC impedance are also commonly used to study corrosion behavior. Due to the toxicity of many corrosion inhibitors, there is increasing interest in using environmentally friendly inhibitors [4]. The rate of corrosion can also be reduced by using corrosion inhibitors, which are chemical compounds that decrease the corrosion rate of metals in actively corrosive environments [5].

II. MATERIALS AND METHODS

2.1. Weight Loss Method

The length, breadth, and thickness of the carbon steel specimens, as well as the radius of the holes, were determined using high-precision Vernier calipers. The surface area of the specimens was then calculated. All weighings of the carbon steel specimens, both before and after corrosion, were carried out using a Shimadzu balance (Model AY62).

2.2 Fourier Transform Infrared Spectra

After the 1-day immersion period in various environments, the specimens were removed from the test solution and dried. A Perkin-Elmer 1600 spectrophotometer was used to record the FTIR spectra using the KBr pellet method.

2.3 Synergism Parameters

Synergism parameters indicate the synergistic effect between two inhibitors. The synergistic effects can be calculated.

2.4 AC Impedance Measurements

A CHI electrochemical impedance analyzer (Model 660A) was used for AC impedance measurement. A time interval of 5 to 10 minutes was allowed for the system. The real part (Z') and imaginary part (Z") of the cell impedance were measured in ohms for various frequencies.

2.5 Potentiodynamic Polarization Study

Potentiodynamic polarization studies were carried out using a CHI electrochemical impedance analyzer, model 660A. A three-electrode cell assembly was used, with the working electrode being a rectangular specimen of carbon steel, with one face of the electrode exposed. A saturated calomel electrode (SCE) was used as the reference electrode. The electrodes were immersed in an aqueous medium, both in the absence and presence of the inhibitor. The saturated calomel electrode was connected to the test solution through a salt bridge.

2.6 Scanning Electron Microscopy Study

The surface morphology of the carbon steel specimens was examined using a TESCAN VEGA 3 model. All SEM micrographs of carbon steel were taken at a magnification of X=500.

III. RESULT AND DISCUSSION :

3.1 Weight Loss Method

Figure 1: Graph of Weight loss method

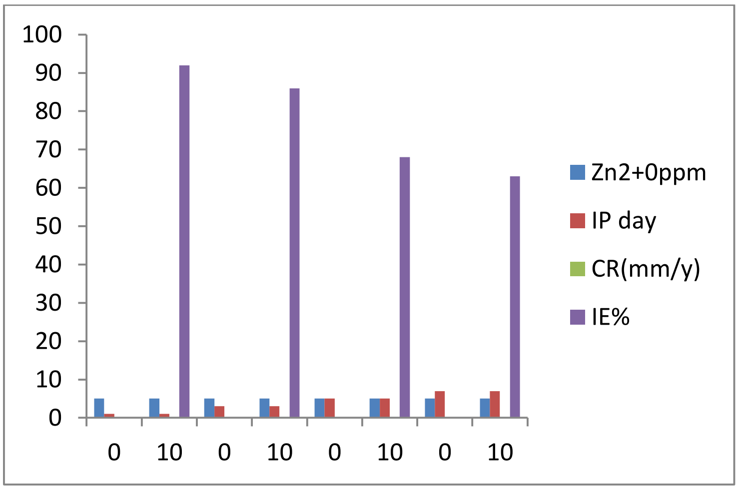

Table I: Weight loss method

The 10ml of MCLE and 50 ppm of Zn2+offers 92% inhibition

MCLE	Zn^{2+} 0ppm	Immersion period day	Corrosion rate(mm/y)	IE%
0	5	1	0.1447	-
10	5	1	0.0158	92
0	5	3	0.0668	-
10	5	3	0.0093	86
0	5	5	0.0489	-
10	5	5	0.0156	68
0	5	7	0.0381	-
10	5	7	0.0143	63

The inhibition efficiency (IE) of the 10 ml MCLE + 50 ppm Zn^{2+} system was found to decrease as the immersion period increased. The protective film formed on the metal surface is unable to withstand the continuous attack of corrosive ions, such as chloride ions present in bore water.

3.2 Synergism Parameters

Synergism parameters have been calculated to evaluate the synergistic effect between the two inhibitors. If the value of the synergism parameter is greater than one, a synergistic effect exists.

Table II: Synergism parameters of MCLE – Zn2+ (50ppm)

MCLE(ml)	Zn^{2+}		Si
	0ppm	50ppm	
0	-	41	-
2	45	69	1.0467
4	55	77	1.1543
6	59	82	1.3438
8	63	85	1.4550
10	68	92	2.36

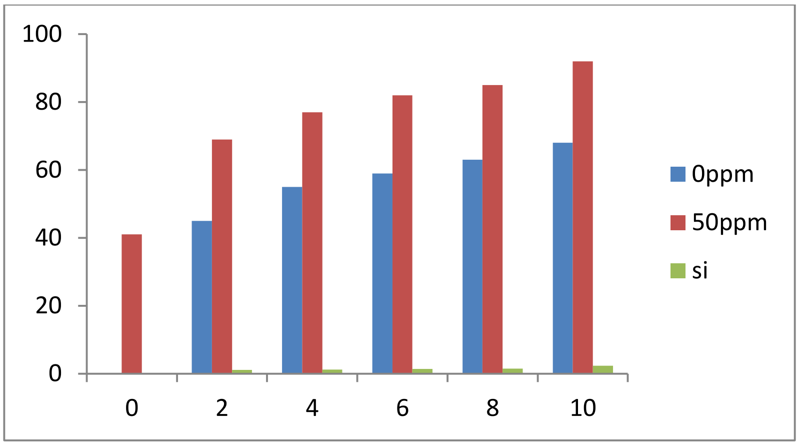

Figure:2 Synergism parameters for 50ppm of Zn^{2+} in bore water

3.3 SEM Analysis

SEM provides a visual representation of the surface. It helps in analyzing the nature of the surface film in both the absence and presence of inhibitors, as well as assessing the extent of corrosion on carbon steel. The SEM micrographs of the surface are examined for this purpose [6].

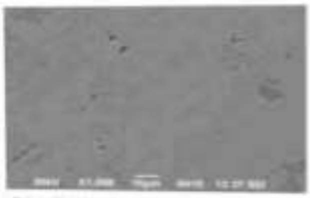

figure 3: Polished carbon steel

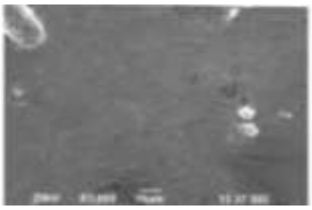

figure:4 Carbon steel immersed in bore water +50ppm of Zn2+

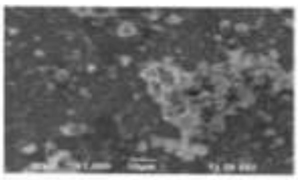

figure 5: Carbon steel immersed in bore water +50ppm of Zn2++10 ml of MCLE

3.4 Analysis Of FTIR Spectra

FTIR spectra have been used to analyze the protective film formed on the metal surface [7]. The FTIR spectrometer is a powerful tool for determining the type of bonding of organic inhibitors adsorbed on the metal surface. The FT-IR was employed to evaluate the nature of the film formed on the surface of the metal. The FT-IR spectrum of the alcoholic O-H stretching frequency shifted from 3379.29 cm^{-1} to 3334.92 cm^{-1}. Additionally, the C=C vibration band shifted from 1618.28 cm^{-1} to 1620.21 cm^{-1}.

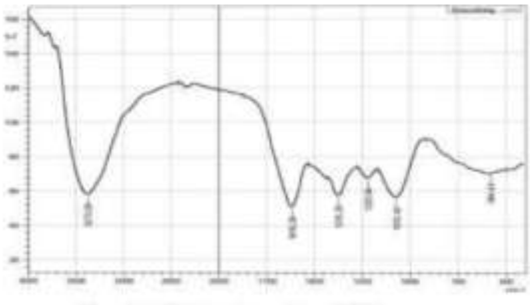

Figure 6: FTIR spectrum of pure MCLE

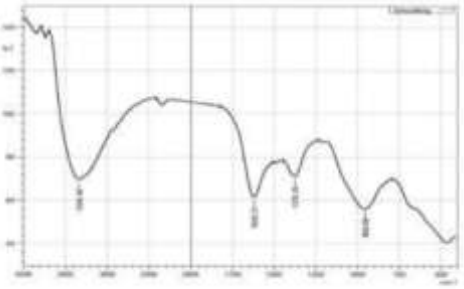

figure7:10ml of MCLE and 50 ppm of zn2+.

3.5 Analysis of Polarization Curves

A polarization study has been used to detect the formation of a protective film on the metal surface [8]. The corrosion inhibitor system behaves as a cathodic inhibitor, and this formulation predominantly controls the cathodic reaction. The addition of MCLE suppresses the cathodic reaction, and the inhibitor extends its efficiency by inhibiting the cathodic reduction reaction.

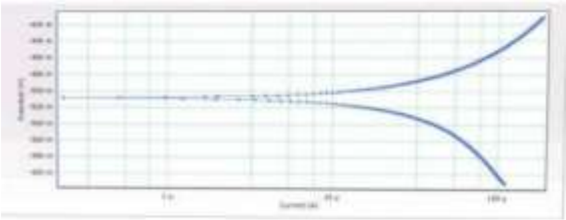

Figure 8: Bore water + 50 ppm of Zn2+

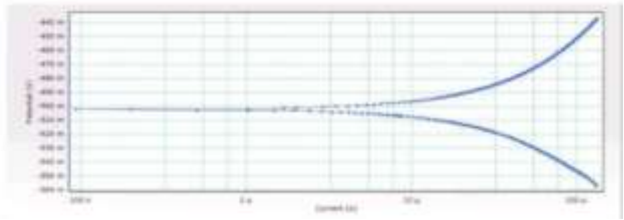

Figure 9: Bore water +10 ml of MCLE +50 ppm of Zn2

IV. CONCLUSION

The inhibition efficiency of the Muntingiacalabura dye-Zn^{2+} system in controlling the corrosion of carbon steel in an aqueous solution containing 188 ppm of chloride ions has been evaluated using the weight loss method.

. ❖The weight loss study reveals that the formulation consisting of 10 ml of Muntingiacalabura leaf extract (MCLE) and 50 ppm of Zn^{2+} exhibits 92% inhibition efficiency in controlling the corrosion of carbon steel immersed in an aqueous solution containing 188 ppm of chloride ions.

❖The synergistic parameter suggests that a synergistic effect exists between MCLE and Zn^{2+}.

❖FTIR spectra reveal that a protective film is formed on the metal surface.

❖SEM studies indicate the presence of a protective film on the metal surface.

❖ Polarization studies reveal that this system functions as a cathodic inhibitor, predominantly controlling the cathodic reaction.

❖ AC impedance spectra confirm that a protective film is formed on the metal surface

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