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Title of PhD Thesis:

INHIBITION OF CORROSION OF CARBON STEEL IN SEA WATER BY AMINIO ACIDS

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Abstract

The corrosion of a metal is a chemical process by which the metal is oxidized. The tendency to suffer corrosion attack in a given environment varies with the particular metal. Corrosion is the result of a chemical reaction between a metal and its surroundings during which the metal is oxidized. Corrosion is the deterioration of a material due to interaction with its environment. It is the process in which metallic atoms leave the metal or form compounds in the presence of water and gases. Metal atoms are removed from a structural element until it fails, or oxides build up inside a pipe until it is plugged. Metals can be corroded by the direct reaction of the metal to a chemical; e.g., zinc will react with dilute sulfuric acid, and magnesium will react with alcohols.

Corrosion is a pervasive problem that costs 3% or more of GDP for most developed nations. Corrosion costs nearly $4 Trillion worldwide each year. Corrosion is a global problem that has plagued buildings, monuments, equipment, and infrastructure for centuries.

The systematic analysis of amino acids as corrosion inhibitors and also use of various surface examination techniques besides the polarization studies and weight loss is necessary, so as to bring out some useful conclusion regarding the mechanistic aspects of corrosion inhibition when amino acids along with the synergists with Zn^{2+} are used in the inhibitor formulation. Electrochemical studies such as polarization, cyclic voltammatry and AC impedance spectra provide mechanistic aspects of corrosion inhibition. The surface analytical techniques likes SEM, EDAX, AFM, FTIR, and XRD also provide better understanding about the reaction takes places on the metal surface.

L- Tyr- Zn^{2+} system

The results of weight loss study show that the formulation consisting of 250 ppm of L-Tyr and 15 ppm of Zn^{2+} has 92% IE, in controlling corrosion of carbon steel in sea water. A synergistic effect exists between L-Tyr and Zn^{2+}. The polarization study reveals that the L-Tyr- Zn^{2+} system functions as anodic inhibitor controlling anodic reaction predominantly and controls cathodic reaction some extent. AC impedance spectra reveals that the formation of protective film on the metal surface. Cyclic voltammetry study reveals that the protective film is more compact and stable even in 3.5% NaCl environment. FTIR spectra reveal that the protective film consists of Fe^{2+}- L-Tyr complex and $Zn(OH)_2$. SEM and AFM studies confirm the formation of protective film on the metal surface. The effective synergistic formulation with 150 ppm of SDS has 96% corrosion inhibition efficiency and 100% biocidal efficiency.

L- Arg- Zn^{2+} system

The results of weight loss study show that the formulation consisting of 250 ppm of L-Arg and 25 ppm of Zn^{2+} has 91% IE, in controlling corrosion of carbon steel in sea water. A synergistic effect exists between L-Arg and Zn^{2+}. The polarization study reveals that the L-Arg- Zn^{2+} system functions as anodic inhibitor controlling anodic reaction predominantly and controls cathodic reaction some extent. AC impedance spectra reveals that the formation of protective film on the metal surface. Cyclic voltammetry study reveals that the protective film is more compact and stable even in 3.5% NaCl environment. FTIR spectra reveal that the protective film consists of Fe^{2+}- L-Arg complex and $Zn(OH)_2$. SEM and AFM studies confirm the formation of protective film on the metal surface. The effective synergistic formulation with 200 ppm of SDS has 95% corrosion inhibition efficiency and 100% biocidal efficiency.

L- Aln- Zn^{2+} system

The results of weight loss study show that the formulation consisting of 250 ppm of L-Aln and 25 ppm of Zn^{2+} has 87% IE, in controlling corrosion of carbon steel in sea water. A synergistic effect exists between L-Aln and Zn^{2+}. The polarization study reveals that the L-Aln- Zn^{2+} system functions as anodic inhibitor controlling anodic reaction predominantly and controls cathodic reaction some extent. AC impedance spectra reveals that the formation of protective film on the metal surface. Cyclic voltammetry study reveals that the protective film is more compact and stable even in 3.5% NaCl environment. FTIR spectra reveal that the protective film consists of Fe^{2+}-L-Aln complex and $Zn(OH)_2$. SEM and AFM studies confirm the formation of protective film on the metal surface. The effective synergistic formulation with 200 ppm of SDS has 95% corrosion inhibition efficiency and 100% biocidal efficiency.

L- GA- Zn^{2+} system

The results of weight loss study show that the formulation consisting of 200 ppm of L-GA and 25 ppm of Zn^{2+} has 87% IE, in controlling corrosion of carbon steel in sea water. A synergistic effect exists between L-GA and Zn^{2+}. The polarization study reveals that the L-GA- Zn^{2+} system functions as anodic inhibitor controlling anodic reaction predominantly and controls cathodic reaction some extent. AC impedance spectra reveals that the formation of protective film on the metal surface. Cyclic voltammetry study reveals that the protective film is more compact and stable even in 3.5% NaCl environment. FTIR spectra reveal that the protective film consists of Fe^{2+}- L-GA complex and $Zn(OH)_2$. SEM and AFM studies confirm the formation of protective film on the metal surface. The effective synergistic formulation with 150 ppm of SDS has 91% corrosion inhibition efficiency and 100% biocidal efficiency.

L- Tryp- Zn^{2+} system

The results of weight loss study show that the formulation consisting of 250 ppm of L-Tryp and 20 ppm of Zn^{2+} has 79% IE, in controlling corrosion of carbon steel in sea water. A synergistic effect exists between L-Tryp and Zn^{2+}. The polarization study reveals that the L-Tryp- Zn^{2+} system functions as anodic inhibitor controlling anodic reaction predominantly and controls cathodic reaction some extent. AC impedance spectra reveals that the formation of protective film on the metal surface. Cyclic voltammetry study reveals that the protective film is more compact and stable even in 3.5% NaCl environment. FTIR spectra reveal that the protective film consists of Fe^{2+}- L-Tryp complex and $Zn(OH)_2$. SEM and AFM studies confirm the formation of protective film on the metal surface. The effective synergistic formulation with 200 ppm of SDS has 85% corrosion inhibition efficiency and 100% biocidal efficiency.

The present study leads to the following conclusions:

- All the five inhibitors exhibit synergism with Zn^{2+} ions in the corrosion inhibition of carbon steel in sea water.
- The corrosion IE of the Amino acids used is in the order-

  L- Tyr > L- Arg > L- Aln > L- GA > L- Tryp

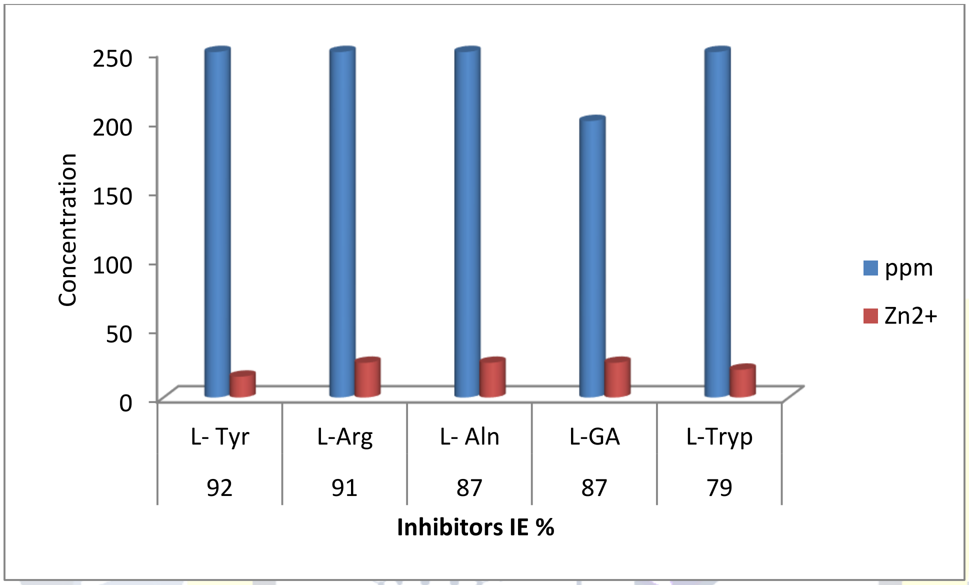

Fig. 6.1 Graph of IE of various inhibitors

The IE value is minimum for the L- Tryp and maximum for the L- Try. The difference in the IE can be explained based on the amino group, hydroxyl group and carboxyl group present in the amino acids.

- All the inhibitor formulations are effective in neutral aqueous medium and also in basic medium.
- All the inhibitor formulations are effective in acidic, neutral and basic environment, the IE decreasing with increasing pH.
- The stability of the film formed on the surface of the carbon steel immersed in sea water in the presence of the inhibitors decreases with in immersion period.
- SEM, EDAX, CV and AFM studies confirm the presence of the protective film on the surface of the metal.
- BE and corrosion IE of the biocides SDS in all the effective synergistic inhibitor-Zn^{2+} system has been studied. The corrosion IE of SDS with various inhibitors in the presence of Zn^{2+} is in the order of

  L- Tyr = L- Arg = L- Aln = L- GA > L- Tryp
- Based on the weight loss method, electrochemical method and spectroscopic techniques, a suitable mechanism has been proposed for all synergistic inhibitor and Zn^{2+} systems.

Scope of the further study

- The study of corrosion inhibition of carbon steel at different temperature and dynamic conditions can be carried out.
- The maximum duration of the stability of the protective film formed on the surface of the metal by inhibitor complex may be found.
- An investigation in elucidation of the coordination of the inhibitor compound with Fe^{2+} metal ion may be done.
- The protective film formed on the metal surface may be analysed by EPR spectroscopy.
- IE of the selected inhibitors may be evaluated in combinations with other synergistic metal as Co^{2+}, Al^{2+}, Ni^{2+}, Mn^{2+}, Mg^{2+} etc .
- In AFM analysis, specific roughness properties can be investigated in details through spectral roughness analysis i.e., determining power spectral density (PSD) provides valuable information not only on the height deviation of the roughness profile, but also on its lateral distribution, and hence it gives more general description than rms roughness alone.
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- How to cite this work?

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