Chapter - 5

Summary and conclusion

CHAPTER V

SUMMARY AND CONCLUSION

Metal corrosion processes can be controlled by different methods such as the modification of the corrosive medium or the metal and the use of protective agents. Protective agents act like corrosion inhibitors and they can be a single substance or a mixture that, when present on the surface in a specific concentration, can reduce or eliminate the corrosion process. Corrosion is the most serious and complex problem of the industries. Corrosion is the damage of material resulting from exposure and interaction with the environment. The structural materials used are invariably metals, which are easily damaged by the corrosive environment, causing heavy loss.

In recent times, the use of polymers as corrosion inhibitors has attracted considerable attention. Polymers are used as corrosion inhibitors, because through their functional groups they form complexes with metal ions and on the metal surface these complexes occupy a large surface area, thereby blanketing the surface and protecting the metals from corrosive agents present in solution. In the current investigation, efforts are made to synthesis and characterise the PVA-selected amino acids composites and to utilise the characterised PVA-selected amino acids composites as corrosion inhibitors in 1M HCl medium.

The corrosion inhibition potential of Polyvinyl Alcohol-Selected Amino Acid Composites was examined by weight loss method, electrochemical method, surface analytical methods. All these methods confirm the inhibitive potential of the investigated inhibitors.

Salient features:

The salient features pertaining to the present study entitled **"Synthesis, characterisation and utilisation of water soluble Polyvinyl alcohol- selected Amino acid composites as corrosion inhibitors for mild steel in acid medium"** are summarized below:

- Synthesis of polyvinyl alcohol-selected amino acid composites were carried out using standard procedure.
- Synthesised polymer composites were confirmed with the help of Elemental analysis, conductivity studies, FTIR, UV-Visible, TGA-DTA, DSC, XRD and SEM-EDX Analysis.
- The investigated inhibitors, performed in an effective manner to minimize the corrosion of mild steel in 1M HCl medium.

- Analysis of the results of the weight loss measurement infer that the inhibition efficiency increased with increasing concentration of the water soluble Polyvinyl alcohol- selected Amino acid composites.
- The inhibitors could furnish the following efficiency at a maximum concentration of 0.6% – 93.4% (6 h) in the presence of PVAALA, 95% (6 h) in the presence of PVAVAL, 95.5 %(6 h) in PVAGLU, 94.4% (6 h) in PVAGLN, 96.8% (12 h) in PVATYR, 94.6% (3 h) in PVATRP respectively.
- Immersion studies reveal that as the time of immersion increased from ½ hr to 6 h the inhibition efficiency increased. After 6 h, there was a slight decline in the inhibition efficiency at 12 hrs and 48 h for all the investigated polymer composites. The decrease in inhibition efficiency at longer immersion time may be due to the desorption of the protective layer formed in the presence of the water soluble Polyvinyl alcohol-selected amino acids composites on the mild steel surface. All the investigated inhibitors could furnish efficiency 90-95% at 3 hof immersion.
- All the examined inhibitors reveal that inhibition efficiency increased with increase in particular temperature and then decreased at higher temperatures. Maximum inhibition efficiency for all investigated inhibitors was found to be around 90%. This may be due to the adsorption of the inhibitor upto a particular temperature and then desorption of the inhibitor at higher temperature.
- The adsorption of the investigated inhibitors on the mild steel surface followed Langmuir adsorption isotherm and the inhibition efficiency increased with increase in concentration of the investigated inhibitors but decreased with rise in temperature. The values of ΔG^{*}_{ads} are negative which suggest that the investigated inhibitors were strongly and spontaneously adsorbed on the mild steel surface. The values obtained support the physical adsorption coupled with chemical adsorption, leading to comprehension adsorption.
- From the effect of temperature, the activation parameters of the investigated inhibitors for the corrosion process (Ea, ΔH^{o}_{a} and ΔS^{o}_{a}) were calculated. In the present investigation, Ea values were found to be greater or smaller than those calculated in the presence of the inhibitors. This can be explained by the fact that at high degree of coverage, the dissolution process is not only determined by the reaction of the metal from the bare surface but also involves the adsorbed inhibitor. In investigated inhibitors system, the positive signs of the enthalpy (ΔH_a) reflect the endothermic nature of the mild steel

dissolution process. The positive values of entropy (ΔS_a) in the presence of the inhibitors imply that the activation complex in the rate determining step represented association rather than a dissociation step, meaning that an increase in disordering takes place on going from reactants to the activation complex.

- The negative value of ΔG^{o}_{ads} indicate that the investigated inhibitors are spontaneously adsorbed onto the metal surface. In the present study, the calculated values of ΔG^{o}_{ads} obtained for the investigated system were between around 20 KJ/mol indicating that the adsorption of the inhibitors on the surface of the mild steel is not merely physical but also chemical adsorption. The negative/positive signs of ΔH^{o}_{ads} indicated that the adsorption of water soluble Polyvinyl alcohol- selected Amino acid composites on the mild steel surface is exothermic/endothermic in nature. The values of entropy of adsorption are also negative. Inspection of water soluble Polyvinyl alcohol- selected Amino acid composites revealed that decrease in enthalpy and entropy are the driving force for the adsorption on the mild steel surface.
- The values of free energy adsorption, activation energy suggest strongly that investigated inhibitors are absorbed on mild steel surface by physical adsorption mechanism.
- Thermodynamic data for both inhibitor adsorption isotherm and mild steel corrosion led to suggest the occurrence of (i) comprehensive adsorption (physical and chemical adsorption) for the inhibitor species on mild steel from HCl solution.
- The E_{corr} for all the examined investigated inhibitors systems in 1M HCl acid medium do not change appreciably with the addition of the inhibitors and thus affect the anodic dissolution as well as cathodic hydrogen evolution reactions and act as mixed type inhibitors.
- I_{corr} values decreased significantly in the presence of inhibitors showing that all the inhibitors are effective in controlling corrosion.
- The anodic and cathodic tafel slopes b_a and b_c were shifted to a higher potential region in the presence of the inhibitors. Appreciable shift of cathodic and anodic polarization curves is an indication of mixed type behaviour of the inhibitors.
- R_p values increased with increase in inhibitor concentration indicating a better corrosion protective ability of the inhibitors under study.

- The Nyquist plots contain depressed semi-circles with the centre under the real axis, whose size increased with the increase in water soluble Polyvinyl alcohol- selected Amino acid composites concentration, indicating that a charge transfer process mainly controls the corrosion of mild steel. The impedance parameter R_{ct} for the corrosion of mild steel in acid medium with the addition of various concentrations of water soluble Polyvinyl alcohol-selected Amino acid composites increased with increasing concentration of the inhibitors. Adsorption of investigated inhibitors on the mild steel was indicated by decrease in the double layer capacitance. The inhibition was due to the adsorption of the investigated inhibitors on the mild steel surface and a resultant blocking of active sites.
- The inhibition efficiencies of the investigated inhibitors obtained from weight loss, potentiodynamic polarisation and Electrochemical impedance methods were in good agreement.
- From the IR spectral data, it has been found that the peaks for -OH, -NH2, -COOH and aliphatic and aromatic C-H stretching disappeared, thereby proving that the adsorption takes place through oxygen, nitrogen and aromatic ring atoms. IR studies confirmed the involvement of NH_3^+, COO^- and –CO-NH- groups in the adsorption process. UV spectra confirmed the possibility of the formation of water soluble Polyvinyl alcohol- selected Amino acid composites-Fe complex.
- The morphology of the specimen surface using SEM revealed a corroded rough and coarse uneven surface in the absence of the inhibitor. However in the presence of the inhibitors, smooth surface of the specimen was observed due to the suppression of the corrosion rate. SEM images of the mild steel specimens confirm the formation of passive layer on the metal surface.
- The SEM photographs revealed the formation of non-porous film on the metal surface.
- The mechanism of inhibition of mild steel corrosion by PVA – selected Amino acid composites is physical adsorption according to the classical adsorption isotherm of Langmuir. The investigated inhibitors molecules can also be adsorbed on the metal surface in the form of negative charged species which can interact electrostatically with positively charged metal surface. The inhibitive action of these PVA – selected Amino acid composites takes place through the adsorption of their molecules via the O and N atoms on the mild steel surface.

- Experiments performed with PVA, Amino acids individually for 3h immersion studies revealed an efficiency of 80 % and 55 % whereas the PVA – selected Amino acid composites could furnish an efficiency of 90 %.
- This study justifies the utilisation of the PVA – selected Amino acid composites as corrosion inhibitors.

The current investigation on **"Synthesis, characterisation and utilisation of water soluble Polyvinyl alcohol- selected Amino acid composites as corrosion inhibitors for mild steel in acid medium"** highlighted the adsorption behaviour of Polyvinyl alcohol- selected Amino acid composites on mild steel surface and the effectiveness of Polyvinyl alcohol- selected Amino acid composites as corrosion inhibitor in investigated acid medium. Research on non-toxic inhibitors is of considerable interest in investigations into the replacement of hazardous classical molecules.