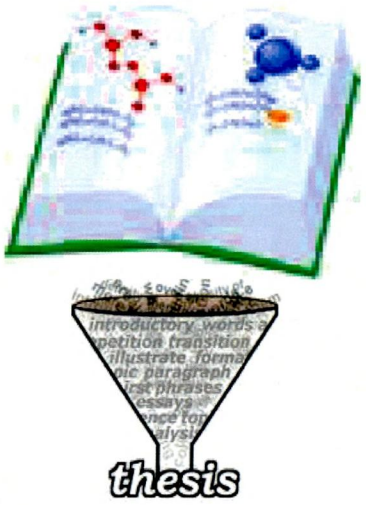

SUMMARY AND CONCLUSION

CHAPTER-V

SUMMARY AND CONCLUSION

Among numerous inhibitors that have been tested and applied industrially as corrosion inhibitors, those that are non-toxic or low-toxic are now far more strategic than in the recent past. In the twenty-first century, the research in the field of "green" or eco-friendly corrosion inhibitors has been addressed towards the goal of using cheap effective compounds at low or zero environmental impact.

In the present investigation on "Inhibitive action of *Cocos nucifera* L. (coconut palm) and *Borassus flabellifer* L. (palmyra palm) – shell, leaf stalk and peduncle extracts on the corrosion of mild steel in acidic media and their adsorption characteristics" has been undertaken and the results pertaining to the current study is discussed in detail in chapter IV.

Efforts have been taken to study the inhibitive action of shell, leaf stalk and peduncle of CN and BF on corrosion of mild steel in 0.5 M H_2SO_4 and 1 M HCl by mass loss and electrochemical techniques. Characterization of CN and BF extracts were done using FT-IR and GC-MS techniques. Studies were carried out at various concentration of aqueous extract obtained from destructive distillation at different time of immersion at room temperature by mass loss method. Effect of temperature was also studied to evaluate the kinetic and thermodynamic parameters. Various adsorption isotherms were also fit for the adsorption of CN and BF inhibitors on mild steel surface. Electrochemical techniques – linear polarization technique, Tafel intercept method and EIS method were adopted to understand the mechanism of inhibition. Efforts have also been to suggest a suitable mechanism for mild steel corrosion. Surface analytical techniques – FT-IR and SEM were carried to study the surface morphology of mild steel in the presence of studied inhibitor.

The results obtained during this investigation have been summarized as follows:

- The shell, leaf stalk and peduncle extract obtained from destructive distillation of CN and BF act as good and efficient inhibitors for corrosion of mild steel in 0.5 M H_2SO_4 and 1 M HCl.
- The investigated inhibitors could furnish the following efficiency at a maximum concentration of 4.0%v/v – 98.6% and 98.1% in 0.5 M H_2SO_4 and in 1 M HCl in the presence of CNS, 98.4% and 96.3% in 0.5 M H_2SO_4 and 1 M HCl in the presence of CNLS, 97.6% and 97.5% in 0.5 M H_2SO_4 and 1 M HCl in the

presence of CNP, 97.6% and 98.1% in 0.5 M H_2SO_4 and 1 M HCl in the presence of BFS, 98.7% and 97.0% 0.5 M H_2SO_4 and 1 M HCl in the presence of BFLS, 97.0% and 97.8% in 0.5 M H_2SO_4 and 1 M HCl in the presence of BFP, respectively.

- Immersion studies reveal that, as the time of immersion increased from ½ hr to 24 hrs the inhibition efficiency increased for all the studied inhibitors, thereby indicating the enhanced stability of the adsorbed constituents of the extract on mild steel surface, at longer periods of immersion. All the investigated inhibitors could afford a maximum IE(%) in the range of 90-98% in both acid media. It is obvious that the studied inhibitors are promising inhibitors in 0.5 M H_2SO_4 and 1 M HCl at various time of immersion.
- The effect of immersion time of all the CN and BF extracts at the optimum concentration showed maximum efficiency in 3 h immersion time at 30°C and found sufficient for pickling process.
- All the inhibitors analyzed in the current study reveal that inhibition efficiency increased to a particular temperature (313 K) and then decreased at higher temperatures. Maximum IE(%) for all investigated inhibitors was found to be around 90%. This may be due to the adsorption of the inhibitor to a particular temperature (313 K) and then desorption of the inhibitor at higher temperature.
- Values of thermodynamic parameters revealed physical adsorption at lower concentration and chemisorption at higher concentration for the inhibition action of these CN and BF extracts on mild steel acid corrosion.
- All the investigated systems obey Frumkin adsorption isotherm.
- In the present investigation E_a values were found to be greater/smaller than those calculated in the absence 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. The E_a value increased in the presence of CN/BF extract may be interpreted as physical adsorption (weakening) that occurs in the first stage and the proceeding stage of chemisorption of plant extract on mild steel at the final stage.
- All the studied inhibitors furnish a large negative value of free energy of adsorption. In the present study, the calculated values of ΔG°_{ads} obtained for CN and BF extracts in both the acid media ranges between 11 kJ/mol and 16 kJ/mol, indicating that the adsorption of CN and BF extracts on mild steel in acid solution was spontaneous.

- The entropy values were found to be negative for the CN in both acid media and positive for BF in both acid media. The negative ΔS°_{ads} values can be attributed to the adsorption process which is accompanied by an increase in the order of the system resulting from the associated complex of inhibitor and mild steel. The positive sign of ΔS°_{ads} arises from substitutional process which can be attributed to the increase in the solvent entropy and more positive water desorption entropy. This leads to an increase in disorder due to the fact that more water molecules can be desorbed from the metal surface by one inhibitor molecule.
- The values of ΔH°_{ads} were found to be negative for the following inhibitor systems – CNS and CNLS in 0.5 M H_2SO_4 medium and CNS, CNLS,BFS and BFLS in 1 M HCl, and positive for the rest of the inhibitor systems. Negative values of ΔH°_{ads} indicate that the adsorption of inhibitor molecules is an exothermic process whereas positive values indicate endothermic nature of the reaction.
- Potentiodynamic polarization studies revealed that the extracts understudy in the acidic media act through mixed mode of inhibition.
- The Nyquist diagrams obtained in impedance method concluded that charge transfer process mainly controls the corrosion of mild steel.
- Results obtained in mass loss method were quite comparable with the electrochemical methods (potentiodynamic polarization method, LPR and impedance method).
- The FT-IR spectrum showed that the inhibition is due to the formation of the film on the metal/acid solution interface through adsorption of shell, leaf stalk and peduncle of CN and BF extracts.
- The SEM morphology of the adsorbed protective film on the mild steel surface has confirmed the high performance of inhibitive effect of the CN and BF extracts.
- Quantum chemical studies results show that these investigated CN and BF extracts can adsorb on the mild steel surface through the π-electrons of the phenolic compounds.
- This current investigation justified the inhibitive potential of CN and BF extracts on mild steel acid corrosion.

Research on green inhibitors is of considerable interest in investigations into the replacement of hazardous classical molecules.