
TABLE OF CONTENT

Chapter 1: Introduction	1-42
1.1 Definition of Corrosion	2
1.2 Economic losses	3
1.2.1 Direct losses	3
1.2.2 Indirect losses	3
1.3 General idea of Corrosion	4
1.3.1 Corrosion problems in oil/petroleum industry	5
1.3.2 Acidizing treatment in oil wells	5
1.3.3 Pickling	6
1.4 Classification of Corrosion	7
1.4.1 Chemical Corrosion or Dry Corrosion	7
1.4.2 Electrochemical Corrosion or Wet Corrosion	8
1.5 Different forms of corrosion	10
1.5.1 Uniform corrosion	11
1.5.2 Galvanic or two metal corrosion	12
1.5.3 Crevice Corrosion	12
1.5.4 Pitting Corrosion	13
1.5.5 Selective leaching or selective dissolution	14
1.5.6 Intergranular Corrosion	15
1.5.7 Stress-corrosion cracking	16
1.5.8 Erosion Corrosion	17
1.5.9 Hydrogen Damage	17
1.6 Factors Affecting Corrosion rate	18
1.6.1 Primary factors, depending on the metal	18
1.6.1.1 Nature of the metal	18
1.6.1.2 Surface state of the metal	18
1.6.1.3 Nature of the corrosion product	18
1.6.1.4 Hydrogen over voltage	19
1.6.2 Secondary factors related to the environment	19
1.6.2.1 pH of the medium	19

1.6.2.2 Temperature	19
1.6.2.3 Presence of oxidizing agents	20
1.6.2.4 Humidity	20
1.6.2.5 Presence of impurities in the atmosphere	20
1.6.2.6 Conductance of the medium	20
1.6.2.7 Area effect	21
1.6.2.8 Polarization at anodic and cathodic area	21
1.6.3 Electrochemical Theory of Corrosion	21
1.7 Thermodynamic Principles of Corrosion	24
1.7.1 Kinetics of Corrosion	25
1.7.2 Activation controlled corrosion	25
1.7.3 Diffusion controlled reaction	28
1.7.4 Diagrams associated to Kinetic parameters	29
1.7.4.1 Evans Diagram	29
1.7.5 Mixed Potential Theory	31
1.7.6 Tafel Extrapolation Method	33
1.7.7 Linear Polarization Resistance	34
1.7.8 Electrochemical Impedance Spectroscopy	35
1.7.9 Methods of Corrosion Control	38
1.7.9.1 Surface modification of metal and their alloys	38
1.7.9.2 Cathodic protection	39
1.7.9.3 Anodic protection	40
1.7.10 Other measures	41
1.7.10.1 Design	41
1.7.10.2 Electroplating	41
1.7.10.3 Metallic coatings	41
1.7.10.4 Organic coatings	41

Chapter 2: Literature review

2.1 Corrosion Inhibitors	43
2.1.1 Definition of Inhibition	43

2.1.2 Definition of Inhibitor	43
2.1.3 Classification based on the effect on partial electrochemical reactions	44
2.1.3.1 Anodic inhibitors	45
2.1.3.2 Cathodic inhibitors	45
2.1.3.3 Mixed inhibitors	46
2.1.3.3.1 Inorganic inhibitors	47
2.1.3.3.2 Organic inhibitors	48
2.1.4 Classification based on reaction mechanism	48
2.1.4.1 Inhibition by adsorption	49
2.1.4.2 Inhibition by passivation	49
2.1.4.3 Inhibition by film formation	50
2.1.5 Interface inhibitors (Vapour phase)	50
2.2.1 Quantum chemical calculations in corrosion inhibition studies	51
2.3 Hetero-Cyclic Compounds as Corrosion Inhibitors	52
2.3.1 Triazine -based inhibitors	58
2.3.2 Naphthyridne based inhibitors	62
2.3.3 Quinolines based derivatives	64
2.3.4 Imidazole based inhibitors	66
2.4 The scope and importance of corrosion inhibitor technology	69
2.5 Objective of present study	69
Chapter 3: Materials and Methods	71-97
3.1 Materials	71
3.1.1 Chemicals used	71
3.1.2 Composition of Testing Material	71
3.1.3 Test specimen for electrochemical study	72
3.1.4 Test solutions	72
3.1.5 Inhibitors used	72
3.1.5.1. Synthesis of Substituted Triazines	75
3.1.5.2. Synthesis of Chromeno naphthyridines	79
3.1.5.3. Synthesis of Hydroxyquinoline derivatives	83
3.1.5.4 Synthesis of substituted benzimidazole	85

3.2 Equipment and Techniques Used	86
3.2.1. Characterization of the synthesized compounds	86
3.2.1.1 Determination of melting point	86
3.2.1.2 Determination of Corrosion Rate and Other related parameters	87
3.2.2 Electrochemical studies	88
3.2.2.1 Electrochemical impedance spectroscopy	89
3.2.2.2 Potentiodynamic Polarization Technique	90
3.2.3 Determination of Thermodynamics of Parameters	92
3.2.3.1 (i) Determination of Activation Energy	92
3.2.3.2 (ii) Determination of Enthalpy and Entropy of activation	93
3.2.3.3 (iii) Determination of Free Energy of Adsorption	93
3.2.3.4 (iv) Determination of Enthalpy and Entropy of Adsorption	94
3.2.4 Surface study	94
3.2.4.1 Scanning Electron Microscopy (SEM) study	94
3.2.4.2 Energy dispersive X-ray Spectroscopy (EDX) study	94
3.2.5 Theoretical study	95
3.2.5.1 Quantum chemical calculations	95
3.2.5.2 Molecular dynamics simulation	96
Chapter 4: Results and Discussion	98-202
4.1 Heterocyclic substituted Triazine as corrosion steel for carbon(N-80) steel	98
4.1.1 Wt loss measurements	99
4.1.1.1 Effect of inhibitor concentration	99
4.1.1.2 Adsorption isotherm	100
4.1.2 Electrochemical studies	103
4.1.2.1 Electrochemical Impedance Spectroscopy	103
4.1.2.2 Potentiodynamic polarization study	108
4.1.3 Surface study	111
4.1.3.1 UV-visible spectroscopy	111
4.1.3.2 FTIR spectral analysis	113
4.1.3.3 Atomic force microscopy (AFM) characterization	114
4.1.4 Mechanism of inhibition	116

4.1.5 Conclusions	117
4.2 Chromeno naphthyridines based heterocyclic compounds as novel acidizing corrosion inhibitors	118
4.2.1 Weight loss measurements	120
4.2.1.1 Effect of concentration	120
4.2.1.2 Adsorption studies	121
4.2.2 Electrochemical studies	122
4.2.2.1 Electrochemical impedance spectroscopy	122
4.2.2.2 Potentiodynamic polarization	128
4.2.3 Surface studies	131
4.2.3.1 Atomic force microscopy (AFM)	131
4.2.3.2 Fourier-transform infrared spectroscopy (FTIR)	133
4.2.3.3 Ultraviolet-visible spectroscopy (UV-vis)	133
4.2.4 Theoretical studies	135
4.2.4.1 Molecular modeling	135
4.2.4.2 Molecular dynamic simulation (MDS)	140
4.2.5 Mechanism of corrosion and inhibition	142
4.2.6 Conclusion	143
4.3 Quinoline Carbonitriles as Novel Inhibitors for N80 Steel Corrosion in Oil-Well Acidizing	145
4.3.1 Gravimetric Studies	147
4.3.1.1 Influence of inhibitor concentration	147
4.3.1.2 Temperature effects on the adsorption behavior of inhibitors	148
4.3.1.3 Adsorption isotherm	149
4.3.2 Electrochemical studies	150
4.3.2.1 Electrochemical impedance spectroscopy	150
4.3.2.2 Potentiodynamic polarization studies	154
4.3.3 Surface Analytical Measurements	157
4.3.3.1 Scanning electron microscopy (SEM)	157
4.3.3.2 FTIR measurements	158
4.3.4 Theoretical study	159
4.3.4.1 Computational Studies	159

4.3.5 Inhibition Mechanism	166
4.3.6 Conclusions	168
4.4 (<i>E</i>-2-styryl-1H-benzo[d]imidazole as novel green corrosion inhibitor for carbon steel	170
4.4.1 Weight loss measurements	172
4.4.1.1 Influence of STBim concentration	172
4.4.1.2 Influence of temperature	173
4.4.1.3 Adsorption considerations	174
4.4.2 Electrochemical investigations	176
4.4.2.1 Impedance analyses	176
4.4.2.2 Frequency modulations	182
4.4.2.3 Polarization studies	185
4.4.3 Surface studies	187
4.4.3.1 Atomic force microscopy	187
4.4.3.2 FTIR studies	188
4.4.4 Theoretical studies	189
4.4.4.1 DFT simulations	189
4.4.5 Mechanism of corrosion inhibition	199
4.4.6 Conclusions	201
Chapter 5: Summary and Conclusions	
5.1 Summary	203
5.1.1 Substituted Triazines (TZs) as Corrosion Inhibitors	205
5.1.2 Chromeno Naphthyridines (CMs) as Corrosion Inhibitors	206
5.1.3 Quinolines (QDs) as Corrosion Inhibitors	207
5.1.4 Benzimidazole based corrosion inhibitors	208
5.2 Conclusions	209
5.3 Scope for future work	210
References.	211-230
List of publications.	231-232