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Corrosion Control by Green Solution - An Overview

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Abstract: *Plant extracts have become important as an environmentally acceptable, readily available renewable source for wide range of inhibitors. They are the rich sources of ingredients which have very high inhibition efficiency. Several researchers are trying to make use of natural products as corrosion inhibitors. Plant scientists have already established the active principles present in most of the plant materials. The active principles form protective film on the metal surface by coordinating with metal ion through O, S or N atoms of the functional groups present in the active principles. The formation of the protective film have been analysed by many surface analysis techniques such as AFM, FTIR, UV, fluorescence spectra and SEM. This article briefly discusses some of the interesting features of the green inhibitors*

Keywords: *Green inhibitors, Plant extracts, Metal, AFM, SEM, UV, FTIR.*

1. INTRODUCTION

Corrosion is the deterioration of metal by chemical attack or reaction with its environment. It is a constant and continuous problem, often difficult to eliminate completely. Prevention would be more practical and achievable than complete elimination. Inhibitors are substance which when added in small quantity to a corrosive environment, lower the corrosion rate. They reduces the corrosion by either acting as a barrier, by forming an adsorbed layer or retarding the cathodic and / or anodic process.

Before the 1960s inorganic inhibitors such as zinc, chromate, polyphosphate and nitrite were used as inhibitors. They provided good corrosion protections. However, discharge of such materials has become unacceptable, due to environmental hazards. Between 1960 and 1980, zinc, polyphosphate, phosphonates, polymer and phosphono carboxylic acids were used as corrosion inhibitors. After 1980 molybdate, phosphonates, phosphono carboxylic acids and polymers were used as inhibitors, along with metal ions such as Zn^{2+}. Recent trend is the search for environmental friendly inhibitors, by the researchers. Most of the natural products are non-toxic, biodegradable and readily available in plenty. Various parts of the plants-seeds, fruits, leaves, flowers etc have been used as corrosion inhibitors. Several studies have been published on the use of natural products as corrosion inhibitors [1-50].

1.1 Metals

Plant extracts are used as inhibitors for metals such as mild steel[1-4,6,8,9,13,14,17,19,21,22,25,26,30,32-37,41-43,48-50],Aluminium [11,27,29,40],Duplex brass [23], C38Steel [28,46], Nickel [18], Copper [18], Steel[47,24,31], Carbon Steel[5,7,10,12,16,20,38,44,45], Medium carbon low alloy steel{15}, Iron[18,39].

1.2 Medium

The plant extracts of various inhibition efficiency in different medium have been investigated such as acidic medium [1-4,8,9,13-17,19-26,31-38,40,41-43,45-50],Alkaline medium [11.27] and neutral medium[5-7,10,12,18,29,30,39,42]

1.3 Additives

During the application of plant extracts as inhibitor, additives are added along with it. Some of the additives used are NaCl and Na_2SO_4[1], KI and EtOH [4],CTAB[5,32], Zn^{2+}[5,7,10,44], Malic acid[10],aluminiumsulphate [12], chloride [12,44].

2. METHODS

There are several methods used for finding the inhibition efficiency of various plant extracts used, weight loss method[23,26,27,29,30,32-38,41-45,48-50],Electrochemical studies (polarization and AC impedance) [1-3,5-27,28,41,42,44-49,50],Gravimetric technique[22,24,25,39,40],Gasometric method [22,45].

3. ADSORPTION ISOTHERMS

The thin film of extract of plant get deposited over the surface of the metal, which is studied using various adsorption isotherms such as, Langmuir adsorption isotherm[3,4,11-16,21-22,25,27,30,31,33-35,39,40,46,48-50],Freundlichadsorption isotherm[13,36], Tempkin adsorption isotherm[17,22,33].

And various thermodynamic parameters such free energy, enthalpy and entropy are also evaluated to prove various adsorption isotherms used.

4. SURFACE ANALYSIS

Surface analysis is carried out to study the film present over the metal surface and its monitored through various techniques such as SEM[1-3,9,10,17,25,30,35,37,41,45,50], AFM[7,35,41,44],EDX [37],FTIR [2,5,7,10,37,41,44,50],UV fluorescence[5,44},Raman spectra[46].

5. PLANT MATERIAL

Various plant parts are used and extracts are made out of it and are used as corrosion inhibitors like leaves[2,7,14,17,19,20,35,36,38,40,41,45,46], Bract[3], Flower[13,15,42,44], Fruit[30,31,34,37], Root[5,8,10,18], Stem[32], Peel[43,33].

6. EXTRACTS

Various solvents are used to prepare extracts out of plant materials , such as ethanol[4,19,29,49], water[5-7,12,18,29,30,39,44], Acid[10,39].

7. CONCLUSION

Corrosion control of metals is an important activity of technical, economical, environmental, and aesthetical importance. The use of inhibitors is one of the best options of protecting metals and alloys against corrosion. Generally green inhibitors are excellent inhibitors under a variety of corrosive environments for most of the metals. The non-toxicity, biodegradability, relatively less expensive and do not contain heavy metals are the major advantages for these inhibitors. The main disadvantage of using plant material as corrosion inhibitors is their instability; they are biodegradable. However, this disadvantage can be minimised or avoided by adding some biocides such as such as sodium dodecyl sulphate and N-Cetyl –N,N,N-trimethyl ammonium bromide. If plant materials are used as corrosion inhibitors, to prevent the corrosion of metals, the plant Kingdom will slowly diminish; Metals will be protected at the cost of destruction of plant Kingdom. Although a number of publications are witnessing the green inhibitors as a potential candidate against corrosion at different environments, further research efforts are needed to employ the green inhibitors widely at an industrial level.

8. SOME OF THE PLANTS USED AS CORROSION INHIBITORS ARE GIVEN BELOW

S. No	Metal	Medium	Inhibitor	Additive	Methods	Findings	Reference
1.	Mild steel	2M H_3PO_4	Thymol(1PMP)	Nacl, Na_2SO_4	a)Electochemical impedence studies. b)Potentiodynamic polarization. c)SEM	a) Corrsion increases with temperature and causes evolution of hydrogen	1
2.	Mild steel	HCl H_2SO_4	Dodonaiaviscosa leaf extract	-	a)EIS b)UV,FTIR,&SEM c)Potentiodynamics Polarization	a)Inhibition is by adsorption of inhibition on metal surface	2
3.	Mild steel	1N HCl	Bract extract of musaacuminata	-	a)EIS b)Potentiodynamic polarization c)SEM	a)Inhibitor has efficiency of 94.93% at 2%v/v inhibitor concentration	3
4.	Mild steel	H_2SO_4	Tannin extract of chamaeropshumilis	KI EtOH	a)Thermodynamics calculation	a)Obeys Langmuir adsorption isotherm	4
5.	Carbon steel	Well water	Betavulgaris extract	CTAB Zn^{2+}	a)EIS b)UV,FTIR spectra c)Potentiodynamic polarization	a)98% of inhibition efficiency by zinc b) controls cathodic reaction.	5
6.	Mild steel	Drinking water	Gum exudate from Acacia seyal	-	a)EIS b)Potentiodynamic polarization.	a)95%of inhibition efficiency at 400ppm b)It's an anodic inhibitor	6
7.	Carbon steel	Sea water	Eclipta Alba leaves extract	Zn^{2+}	a)AFM,FTIR b)EIS c)Polarization	a)It's a mixed type inhibitor b) 92% IE	7
8.	Mild steel	H_2SO_4	Alpine galinga	-	a)Potentiodynamic polarization b)EIS	a)Adsorption happens on metal surface	8
9.	Mild steel	1M HCl	EclobiumViride	-	a)EIS b)Tafel polarization	a) Obeys Langmuir adsorption isotherm	9

					c)SEM	b)Anionic inhibitor	
10.	Carbon steel	Well water	Albiumsativum	Zn^{2+},Malic acid	a)SEM,FTIR b)Polarization	a)Controls anodic reaction b) inhibition efficiency of 65%.	10
11.	Aluminium	NaOH	Trachyspermumcoplium seed extract	-	a)Tafel polarization	a) Obeys Langmuir adsorption isotherm. b)IE is 94% at 500ppm c)It's a mixed type inhibitor	11
12.	Carbon steel	Water	Propolis extract	Aluminiumsulphate,Chloride solution	a)Potentiodynamic polarization	a) Obeys Langmuir adsorption isotherm. b)IE is upto 92% c)It's a mixed type inhibitor	12
13.	Mild steel	1M HCl	Cassia auriculata	-	a)Potentiodynamic polarization	a) Follows Langmuir,Tempkin,Frendlich adsorption isotherm b)IE is upto74.4% c)It's a mixed type inhibitor.	13.
14.	Mild steel	1M HCl	Jatrophacureas	-	a)Kinetic and thermodynamic parameters	a)Langmuir adsorption isotherm b)IE is upto 93.69%.	14
15.	Medium Carbon low alloy steel	H_2SO_4	Lignin Extract of TithoniaDinersifolia	-	a)Activation energy and negative free energy of adsorption.	a) Obeys Langmuir adsorption isotherm	15
16.	Carbon Steel	1M HCl	Sesbaniasesban extract	-	a)Potentio dynamic polarization	a)obeys langmuir adsorption isotherm b)Inhibition efficiency is 91.08% c)Mixed type inhibitor	16
17.	Mild steel	H_2SO_4, 1M HCl	SolanumTuberosum	-	a)Electrochemical impedence	a)Mixed type inhibitor	17

					studies b)SEM	b)Obeys tempkin adsorption isotherm	
18.	Iron, Nickel, Copper	Industrial chill water	Alliumcipa	-	a)Weight loss method	a)Inhibition efficiency is about 92%for iron,88%nickel, 46%for copper	18
19.	Mild steel	HCl	Andrographis paniculata	-	a)Quantum chemical studies b)GC-MS studies	a)physical adsorption happens b)anticorrosive agent	19
20.	Carbon steel	H_2SO_4	LaunaeaResedifolia	-	a)Electrochemical impedence studies	a)Mixed type inhibitor	20
21.	Mild steel	HCl	Fig leaves	-	a)Electrochemical impedence studies	a)obey langmuir adsorption isotherm b)Inhibition efficiency is about 87%	21
22.	Mild steel	H_2SO_4	Carica papaya	-	a)Gravimetric method b)Gasometric method	a)obeys langmuir and tempkin adsorption isotherm.	22
23.	Duplex brass	1N HNO_3	Carica papaya extracts and camellia sinenris leaves	-	a)Weight loss method b)Potentiodynamic polarization	a)exhibits corrosion reaction synergism	23
24.	Steel	H_3PO_4	Rosemary oil	-	a)gravimetric method b)Electrochemical impedance studies	a)oil is rich in 1,8-cineole b)inhibition efficiency decreases with temperature	24
25.	Mild steel	H_2SO_4	Centellaasiatica	-	a)Gravimetric method b)electrochemical impedance studies c)SEM	a)obeys langmuir adsorption isotherm b)Mixed type inhibitor c)inhibition efficiency is upto95.08%	25
26.	Mild steel	1N H_2SO_4	NyctanthesArbortristis	-	a)Weight loss method b)polarization studies	a)Mixed type inhibitor b)Inhibition efficiency is upto90%	26

27.	Alum inium	1M NaOH	Vitexnegundo	-	a)Weight loss method b)electrochemi cal impedence studies.	a)Mixed type inhibitor b)obeys langmuir adsorption isotherm	27
28.	C_{38}	1MHCl	Aspidosperm a album	-	a)Potentiodyna mic polarisation b)Electrochemi cal impedance studies	a)Obeys langmuir adsorption isotherm b)Mixed type inhibitor	28
29.	Alum inium	Sea water	Marine micro algae	Ethanol, Dichloro ethane	a)Potentiodyna mic polarisation b)Electrochemi cal impedance studies c)Weight loss	a)Decreased corrosion rate	29
30.	Mild steel	Water	Green capsicum annum	-	a) Electrochemica l impedance studies b) Weight loss c)SEM	a)85%of inhibition efficiency b)Obeys langmuir adsorption isotherm	30
31.	Steel	HCl	Prunuscerasu s	-	a) Electrochemica l impedance studies b) Potentiodynami c polarisation	a) Obeys langmuir adsorption isotherm	31
32.	Mild steel	H_2SO_4	Aspararacem osus stem	CTAB	a) Electrochemica l impedance studies b) Potentiodynami c polarisation c) Weight loss	a)Inhibition efficiency is upto 51.11% and 91.66%	32
33.	Mild steel	1M H_3PO_4	Sidarhombifo lia	-	a) Electrochemica l impedance studies b) Potentiodynami c polarisation c) Weight loss	a)Inhibition efficiency is upto97.8% b) Obeys langmuir and tempkin adsorption isotherms	33
34.	Mild steel	2M HCl	Egg plant peel	-	a) Weight loss b) Electrochemica	a) Obeys langmuir adsorption isotherm	34

					l impedance studies		
35.	Mild steel	0.5M H_2SO_4	Musa Paradisiaca	-	a) Electrochemical impedence studies b) Potentiodynamic polarisation c) Weight loss d)SEM,AFM	a) Obeys langmuir adsorption isotherm b)Mixed type inhibitor	35
36.	Mild steel	HCl	Pterocarpusso yauxi	Ethanol	a)Weight loss	a)Fits to tempkin and freundlich adsorption	36
37.	Mild steel	HCl	Piper longum fruit	-	a) Electrochemical impedance studies b) Potentiodynamic polarisation c) Weight loss d)FTIR e)EDX,SEM	a)Mixed type inhibitor	37
38.	Carbon steel	0.5M H_2SO_4	Buddleia perfoliata	-	a) Electrochemical impedance studies b) Potentiodynamic polarisation c) Weight loss	a)Inhibition efficiency increases with concentration and decreases with temperature	38
39.	Iron	Water	Fenugreek seed	Citric acid	a)gravimetric method	a)Obeys langmuir adsorption isotherm	39
40.	Aluminium	HCl & H_2SO_4	Newbouldia	-	a) gravimetric method	a) Obeys langmuir adsorption isotherm	40
41.	Mild steel	H_2SO_4	Coromandelica	-	a) Electrochemical impedance studies b) Potentiodynamic polarisation c) Weight loss d)FTIR,XRD	a)Mixed type inhibitor	41

					e)SEM,AFM		
42.	Mild steel	0.5M H_2SO_4	Magnolia champaca	-	a) Electrochemical impedance studies b) Weight loss	a)Inhibition efficiency increases with concentration	42
43.	Mild steel	2M H_2SO_4	Musa sapientum peel	-	a) Weight loss	a)Inhibition efficiency is upto 71% b)Its non-toxic in nature	43
44.	Carbon steel	Water	Hibiscus Rosa sinensis Linn	Zn^{2+},Cl	a) Electrochemical impedance studies b) Potentiodynamic polarisation c) Weight loss d)FTIR e)AFM f)UV spectra	a)Mixed type inhibitor	44
45.	Carbon steel	1NHCl	Murrayakoenigii	-	a) Electrochemical impedance studies b) Potentiodynamic polarisation c) Weight loss d)gasometric studies e)SEM	a)Good inhibitor	45
46.	C_{38} steel	1MHCl	Oxandraasbeckii	-	a) Electrochemical impedance studies b) Potentiodynamic polarization c)Raman spectra	a) Obeys langmuir adsorption isotherm b)Mixed type inhibitor	46
47.	Steel	1M H_2SO_4 &2M HCl	Lupine	-	a) Electrochemical impedance studies b) Potentiodynami	a)Mixed type inhibitor	47

					c polarization		
48.	Mild steel	H_2SO_4	Musa Acuminata	-	a) Electrochemical impedance studies b) Weight loss	a) Obeys Langmuir and temkin adsorption isotherm b)Mixed type inhibitor c)Inhibition efficiency is upto96%	48
49.	Mild steel	H_2SO_4	Terminaliacatappa	Ethanol	a) Weight loss b)hydrogen evolution c)Infrared methods	a) Obeys langmuir adsorption isotherm	49
50.	Mild steel	1M HCl	Clematis gouriana	-	a) Electrochemical impedance studies b) Potentiodynamic polarisation c) Weight loss d)FTIR e)SEM	a)Anticorrosive in nature b)Inhibition is upto 57% c)Obeys Langmuir adsorption isotherm	50.

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