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paper
UDC:

Green corrosion inhibitors-An Overview

To replace the environmentally hazardous chromates, several non –chromates have been used as corrosion inhibitors. Extracts of plant materials top the list. The plant extracts are environmentally friendly, non- toxic and readily available. These extracts contain many ingredients. They contain several organic compounds which have polar atoms such as O, N, P and S. They are adsorbed onto the metal surface through these polar atoms; protective films are formed. Adsorptions of these ingredients obey various adsorption isotherms. The films have been analyzed by many surface analysis techniques such as AFM, FTIR, UV, Fluorescence spectra and SEM.

Key words: *green inhibitors, environmentally friendly corrosion inhibitors, natural product, plant materials.*

Use of some inhibitors, such as chromates, has been banned because of toxicity and the environmental hazards they create. Hence there is a strive to make use of environmental friendly, non toxic /less toxic, extracts of naturally occurring plant materials as corrosion inhibitors[1-111].

Extracts of plant materials contain a wide variety of organic compounds. Most of them contain heteroatoms such as P, N, S, O. These atoms coordinate with the corroding metal atom (their ions), through their electrons. Hence protective films are formed on the metal surface and hence corrosion is prevented.

Metals: Extracts of plant materials have been used to control the corrosion of various metals such as mild steel [2, 5-10, 13-18, 20, 23, 24, 26, 28-45, 47, 48, 50, 52-55, 59, 60, 62-65, 67-72, 74-76, 81, 83-85, 88-98, 100-105, 107, 108, 111], Zinc [1, 76], various types of steel [3, 4, 19, 21, 51, 78, 80], Aluminium and its alloys [11, 12, 22, 25, 27, 46, 49, 56-58, 61, 73, 77, 79,82, 86, 87, 106, 109, 110], Copper [49, 66], nickel [76], and tin [99].

Medium: The inhibition efficiency of plant extracts, in controlling corrosion of metals in various environments has been investigated. Acidic medium, [1, 2, 5-9, 16-34, 36-44, 47-56, 60, 62-65, 67-69, 71,77-85, 88-91, 94-105,108-111], alkaline medium [3, 11, 12, 45, 46, 61, 73, 86, 106], and neutral medium [10, 57, 59, 66, 74, 75, 87], have been used for this purpose.

Additives: Plants extracts have been used as corrosion inhibitors, alone or in combination with other inhibitors such as Zn^{2+} [46, 72, 73], HEDP [13], KI [56, 27], KSCN [27], KCl, KBr[36].

Temperature: The inhibition efficiency of plant extracts have been evaluated at room temperature [1, 3-11, 13-16, 23-26, 28, 29, 31, 33, 36-39, 42-46, 49-52, 54-57, 59, 60, 66-68, 70-77, 80-82, 84, 86, 90, 92, 95-101, 103-105, 111], and also at high temperatures [2, 12, 17, 19, 20, 22, 27, 30, 32, 35, 41, 47, 48, 53, 58, 61-65, 69, 78, 79, 81, 94, 102, 107-110].

Methods: Various methods have been used to evaluate the inhibition efficiency of plant extracts, usually , weight loss method [3, 5-7, 13, 15-18, 27-35, 71-75, 81-86, 88-92, 94-98, 102-106, 109-111], electrochemical studies (polarization and AC impedance) [6, 7, 13, 21, 26, 29, 38, 56-60, 87, 100-107], and gasometric studies have been employed.[2, 8, 17, 22, 28, 47, 52, 55].

Adsorption isotherms: The adsorption behavior of the ingredients present in the plant extract onto the metal surface has been investigated, the type of adsorption isotherm has been proposed. Langmuir adsorption isotherm [1, 12, 18, 19, 21, 22, 25, 27, 29, 33, 34, 44, 49, 52, 61-64, 67, 82, 92, 100, 103-105], Freundlich adsorption isotherm [28, 29, 44, 79, 87, 92, 95, 109], Temkin adsorption isotherm [23, 29, 32, 44, 55, 58, 60, 79, 86, 110], Frumkin adsorption isotherm [41, 44, 69, 78,108], and Flory-Huggins adsorption isotherm [29, 35, 44, 68, 69], have been proposed, various thermodynamic parameters such as changes in free energy, enthalpy and entropy have been calculated inorder to support the proposed adsorption isotherms. The ingredients are adsorbed onto the metal surface, through the polar atoms such as O, N, P, S present in the active ingredients of the extract.

Surface analysis: The protective films formed on metal surface, during the process of corrosion protection of metals by plant extracts, have been analyzed by various surface analysis techniques such as AFM [6, 34], ESCA [6, 34], Raman spectroscopy [7], SEM [17, 18, 26, 30, 32, 33, 48, 50, 60, 64, 101],

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FTIR [23, 26, 30, 32, 64, 65, 72, 102], UV spectra [50, 72], XPS [64, 65, 102], EDX [66]. In general, it has been observed that the protective film consists of the metal- active principle complex. In some cases, $Zn(OH)_2$ is deposited on the cathodic sites of the metal surface, if Zn^{2+} is used along with the plant extracts.

Plant materials: Extracts of various parts of the plant have been used as corrosion inhibitors. Leaves [11, 15, 16, 20, 28, 29, 40, 41, 44, 45, 55, 62, 74-76, 89, 100, 103], fruits [3, 9, 46], flowers [15], seeds [8, 28, 54, 55, 63, 104], barks [20, 63, 88, 89], root [28, 109], have been used as corrosion inhibitors.

Extracts: Solvents such as alcohol [18, 20, 23, 25, 30, 32, 47, 78, 98], acid [29, 31, 40, 48, 81, 87, 90], water [72, 73], have been used to extract the ingredients present in plant materials.

Advantages and limitations: Extracts of natural plants are environmentally friendly, non toxic and relatively less expensive. They are easily biodegradable also. However, this biodegradability limits the storage and long-term usage of plant extracts. However, it is proposed that the decomposition by plant extracts by microorganisms can be prevented by addition of biocides such as sodium dodecyl sulphate and N-Cetyl –N,N,N-trimethyl ammonium bromide.

Warning from plant Scientists: 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.

A list of various plant materials that have been used as corrosion inhibitors is given in Table 1.

Table 1 - Plant materials used as corrosion inhibitors

S. No	Metal	Medium	Inhibitor	Additive	Method	Findings	Ref
1	Zinc	2M HCl	Aloe vera	-	Langmuir adsorption isotherm.	A first-order kinetics relationship	1
2	Mild steel	H_2SO_4	Aloe vera		infra red spectrophotometer. Thermodynamic adsorption theories and Gasometric (Hydrogen evolution) methods The study was conducted at 303 and 333 K	chemical adsorption isotherm	2
3	concrete steel surface	10 or 23 per cent sodium hydroxide	Banana plant juice, taken from paradica and maghraby banana pseudostem,		weight loss method.	anti-corrosive materials	3
4	concrete steel surface		magrabe banana stem,		galvanostatic polarization technique.	mechanical and physico-chemical properties.	4
5	Mild steel	1M HCl	Pennyroyal Mint (*Mentha pulegium*, PM)		weight loss measurements, electrochemical polarisation and EIS methods.	cathodic inhibitor, adsorption isotherm	5
6	Mild steel	1M HCl	*Justicia gendarussa* extract (JGPE)		weight loss electro-chemical techniques. AFM and ESCA	mixed-type inhibitor. obeys the Langmuir adsorption isotherm.	6
7	Mild steel	0.1 M H_2SO_4	caffeic acid		weight loss, potentio-dynamic polarization, electrochemical impedance and Raman spectroscopy.	Controls the anodic reaction.	7
8	Mild steel	1M HCl and H_2SO_4	combination of leaves and seeds (LVSD) extracts of*Phyllanthus amarus*		weight loss and gasometric techniques.	Temkin isotherm	8

9	carbon steel	1 M HCl	aqueous extracts of mango, orange, passion fruit and cashew peels		electrochemical impedance spectroscopy, potentiodynamic polarization curves, weight loss measurements and surface analysis.	Langmuir adsorption isotherm	9
10	Carbon steel	Ethanol	caffeine (1,3,7-trimethylxanthine)		voltammograms, Tafel plots and EIS	The standard free energy of adsorption confirms a spontaneous chemical adsorption step.	10
11	Al	0.5 M NaOH	Hibiscus sabdariffa leaves (AEHSL)		Electrochemical measurements	mixed-type inhibitor Langmuir and Dubinin-Radushkevich isotherm	11
12	chill cast Al-Zn-Mg alloy	0.5 M NaOH	Hibiscus Teterifa		weight loss Langmuir adsorption isotherm. And Thermodynamic studies, temperatures of 30, 50 and 70°C respectively	the adsorbed molecules of the inhibitor lies on the surface of the alloy blocking the active corrosion sites on the alloy hence, lowering the corrosion rate.	12
13	mild steel		agaricus, azadirachta indica, cordia latifolia, curcumin, eucalyptus, hibiscus, jasminum auriculatum, momordica charantia, and punica granatum	HEDP	weight loss, polarization, and impedance.	azadirachta, cordia, eucalyptus, Hibiscus and punica was predominantly under cathodic control, while inhibition by momordica and jasminum was predominantly under anodic control.	13
14	mild steel	H_2SO_4	thyme, coriander, hibiscus, anis, black cumin and Garden cress.		a.c , d.c electrochemical techniques and Potentiodynamic polarization	mixed-type inhibitors.	14
15	mild steel		Eucalyptus (leaves), Hibiscus (flower), and Agaricus		weight loss (under static as well as dynamic conditions) and polarization methods.	Langmuir , Freundlich adsorption isotherms. Agaricus extract was found to be predominantly a cathodic inhibitor, while the extracts of Eucalyptus and Hibiscus were found to be mixed inhibitors.	15
16	Mild steel	1 M HCl and 0.5 M H_2SO_4	Murraya koenigii leaves		weight loss, electrochemical impedance spectroscopy (EIS), linear polarization and potentiodynamic polarization techniques.	Langmuir adsorption isotherm. (Q, ΔH^*, and ΔS^*)	16
17	Mild steel	1N HCl	Murraya koenigii		weight loss, gasometric studies, electrochemical polarization , AC impedance measurements and SEM studies. Tem 30-80°C.	The protective film formed on the surface	17
18	Mild steel	2.0 M H_2SO_4	alcoholic extracts of Medicago Sative (MS)	10% EtOH	chemical (weight-loss (ML), hydrogen evolution(HE)), electrochemical (potentiodynamic polarization (PDP) and impedance spectroscopy (EIS)) techniques. A scanning electron microscopy (SEM)	mixed type inhibitors, Langmuir adsorption isotherm.	18

19	C38 steel	1 M HCl	Oxandra asbeckii plant (OAPE)		potentiodynamic polarization and electrochemical impedance spectroscopy (EIS). Tem 25-55 °C.	mixed-type inhibitor. Langmuir adsorption isotherm. Surface analysis (Raman)	19
20	Mild steel	H_2SO_4	ethanol extracts from leaves (LV), bark (BK) and roots (RT) of Nauclea latifolia		weight loss and gasometric techniques. Tem 30-60 °C	The adsorption characteristics of the inhibitor were approximated by the thermodynamic-kinetic model of El-Awady et al.	20
21	C38 steel	1 M HCl	An alkaloids extract from Annona squamosa		Potentiodynamic polarization and AC impedance methods	mixed-type inhibitor , Langmuir's adsorption isotherm, non-cytotoxic substance.	21
22	Al	2 M HCl	Chromolaena odorata L. (LECO)		gasometric and thermometric techniques. Tem 30-60 °C	Langmuir adsorption isotherm. applications in metal surface anodizing and surface coating in industries.	22
23	Mild steel	H_2SO_4	ethanol extract of ITHeinsia crinata/IT		weight loss, thermometric , hydrogen evolution techniques and IR spectroscopy.	adsorption inhibitor . Temkin and Frumkin adsorption	23
24	Mild steel	1 M HCl and 0.5 M H_2SO_4	Dacryodis edulis (DE)		gravimetric and electrochemical techniques..	DE extract was found to inhibit the uniform and localized corrosion of carbon steel in the acidic media,	24
25	Al	HCl	ethanolic extract of the leaves of Ananas sativum		weight loss and hydrogen evolution methods.	Langmuir adsorption isotherm, activation energies (E_a), activation enthalpy (Δ^o), and activation entropy (Δ^o)	25
26	Mild steel	1 mol· L^{-1} HCl and 1 mol L^{-1} H_2SO_4	alkaloid extract of Kopsia singapurensis		electrochemical techniques, viz., potentiodynamic polarization, AC impedance, (SEM), (FTIR) spectroscopy	anodic type inhibitor in HCl and as a mixed type in H_2SO_4. Scanning electron	26
27	Al	1M HCl	Ipomoea invulcrata (IP)		weight loss technique. kinetic and thermodynamic techniques. Tem 30-60 °C , KI and KSCN	Langmuir adsorption isotherm	27
28	Mild steel	H_2SO_4	leaves (LV), root (RT) and seeds (SD) extracts of Azadirachta indica		weight loss and gasometric techniques.	Freundlich adsorption isotherm.	28
29	Mild steel	1N HCl	acid extract of dry Emblica officinalis leaves		weight loss, potentiodynamic polarization and impedance studies.	mixed type ,Langmuir, Temkin, Freundlich and Flory-Huggins adsorption isotherms	29

30	Mild steel	1N phospho-ric acid	Tributes terrestris L alcoholic extract		mass loss , FT-IR , SEM and polarization techniques. Temp 303 and 333 K.	Temkin's adsorption isotherm , mixed type inhibitor ,activation energy (Ea), free energy of adsorption (ΔG_{ads}), heat of adsorption (Q_{ads}), enthalpy of ad-sorption (ΔH) and ent-ropy of adsorption (ΔS)	30
31	Mild steel	1M H_2SO_4	acid extract of Euphorbia hirta		weight loss measurement.	Temkin adsorption isotherm	31
32	Mild steel	1N phospho-ric acid	Acalypha indica L. alcoholic extract (AIAE)		mass loss ,FT-IR, SEM and polarization techniques. Temp 303 and 333 K.	Temkin's adsorption isotherm, activation energy (Ea), free energy of adsorption (ΔG_{ads}), heat of adsorption (Q_{ads}), enthalpy of ad-sorption (ΔH) and ent-ropy of adsorption (ΔS)	32
33	Mild steel	2.0 M H_2SO_4	Ruta Chalepensi (RC) extracts	10% ethyle alcohol (EtOH)	chemical methods (hydrogen evolution (HE) , mass loss(ML)) , electrochemical (poten-tiodynamic polarization (PDP) , Impedance (EIS)) methods, and SEM	mixed type inhibitors, Langmuir isotherm, equilibrium constant of adsorption Kads. and the standard free energy of adsorption $\Delta G°_{ads}$.,	33
34	Mild steel	1M HCl	Justicia gendarussa extract (JGPE)		weight loss , electro-chemical techniques, AFM and ESCA. Temp 25°C	mixed-type inhibitor, Langmuir adsorption isotherm	34
35	Mild steel	industrial water	radish leaves and black cumin		potentiodynamic pola-rization, electroche-mical impedance spectroscopy, and mass loss measurements. Temp 30 to 80 °C and velocity range of 1.44 to 2.02 m s^{-1}	anodic inhibitors, Flory-Huggins isotherm model, black cumin providing better protection than radish leaves.	35
36	Mild steel	2 M HCl and 1 M H_2SO_4	Baphia nitida plant extract	KCl , KBr KI	hydrogen evolution method.	cationic inhibitor ,the synergistic effect was in the order KCl < KBr < KI, apparent activation energy, E_a, and the heats of adsorption, ΔH_{ads},	36
37	Mild steel	H_2SO_4	indigenous flora (e.g. Allii Cepae Bulbus, Agrimonia Eupatoria-Herba, Fagus Silvatica, Juglans Regia etc).		potentiodynamic polarisation	mixed-type inhibitors	37
38	Mild steel	1M H_2SO_4	Allium Sativum (AS), Juglans Re-gia (JR) and Pogo-stemon Cablin (PC)		potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) techniques.	mixed-type inhibitors , AS extract could serve as an effective inhibitor	38

39	X52 mild steel	20 % (2.3 M) H_2SO_4	Cotula cinerae, Retama retam and Artemisia herba alba plants		Weight-loss determinations and electrochemical measurements	mixed-type inhibitors.	39
40	Mild steel	1N H_2SO_4	acid extract of dry Nyctanthes arbortristis (Night Jasmine, Coral Jasmine) leaves		weight loss and polarization studies.	mixed typeinhibitor, IE 90%	40
41	Mild steel	H_2SO_4	Combretum bracteosum leaves		The gravimetric and hydrogen evolution (via the gasometric assembly) measure-ments. Temp 30-60°C.	Frumkin adsorption isotherm, can be used in chemical cleaning and pickling processes	41
42	Mild steel	1N HCl	Eclipta alba		weight loss, potentio-dynamic polarization and impedance methods	mixed type inhibitor, Langmuir adsorption isotherm.	42
43	Mild steel	HCl	Jasminum grand-florum (JG), Jas-minum auricula-tum (JA), Oleum palmarosae (OP), Ocimum basilicum (OB), and Vetive-ria zizanioides (VZ) oils.		Stevenson chamber tests	inhibition efficiency up to 90% for mild steel.	43
44	Mild steel	1M HCl	Citrus aurantiifolia [CAL] leaves		weight loss measure-ments and electro-chemical studies.	mixed type inhibitor , IE up to 97.51% , Langmuir, Temkin, Freundlich, Frumkin, Flory-Huggins and the kinetic thermodynamic model,	44
45	Mild steel	basic solution	leaves, latex and fruit from the Calotropis procera and Calotropis gigantea		mass loss method and thermometric method.	IE up to 80.89%	45
46	Al at pH 12		Hibiscus rosa-sinensis (white)	Zn^{2+}	weight loss method , AC impedance and FTIR methods	cathodic inhibitor.	46
47	Mild steel	H_2SO_4	Ethanol extract of Aloe vera		- Gasometric (Hydrogen evolution) and thermometric methods. Temp 303 and 333 K	chemical adsorption isotherm	47
48	Mild steel	1M HCl and H_2SO_4	Acid extract of Solanum tuberosum		Weight loss , Potentio-dynamic polarization, Electrochemical Impedance Spectro-scopy (EIS) and SEM techniques. Temp 303, 313 and 323 K	mixed type inhibitor , Temkin adsorption isotherm.	48
49	Copper and Al	0.1M HCl	Zenthoxylum alatum		Weight loss measurement and potentiometry polarization technique	Langmuir adsorption isotherm.	49
50	Mild steel	H_2SO_4	ITCalotropis procera/IT		weight loss, electrochemical, SEM and UV methods.	Tempkin adsorption isotherm, inhibition of corrosion in industries	50

51	2205 and 2507 duplex stainless steels	HCl and H_2SO_4	Honey, Mugwort oil , eucalyptus oil		Electrochemical technique	For 2507 steel eucalyptus oil -anodic inhibitor	51
52	Mild steel	2M HCl and 1M H_2SO_4	calyx extract of Hibiscus sabdariffa		gasometric technique.	Langmuir isotherm, mixed-inhibitor	52
53	Mild steel	2M HCl and 1M H_2SO_4	Occimum viridis (OV), Telferia occidentalis (TO), Azadirachta indica (AI) and Hibiscus sabdariffa (HS) leaves, Garcinia kola (GK) seeds.		kinetic and activation parameters . Temp 30 and 60 °C	both protonated and molecular species could be responsible for the inhibiting action of the extracts.	53
54	Mild steel	1M HCl	Phaseolus aureus seed		weight loss method and potentiodynamic polarization technique.	mixed type inhibitor, IE 93%	54
55	Mild steel	HCl and H_2SO_4	leaves and seeds (LVSD) extracts of Phyllanthus amarus		weight loss and gasometric techniques.	Temkin isotherm.	55
56	Al	0.5 M HCl	Azadirachia Indica (AZI) plant	iodide ions	potentiodynamic polarization and impedance techniques.	Frewendlish adsorption isotherm	56
57	Al	0.5 M NaCl 2 M sodium hydroxide	damsissa (Ambrosia maritime, L.)		electrochemical techniques. Chemical gasometry technique	mixed-type inhibitor	57
58	Al	0.5 M NaOH and H_2SO_4.	Vigna unguiculata (VU) extract (agricultural waste material)		weight loss method electrochemical studies. Temp 30 and 60 °C	Freunlich and Temkin adsorption isotherms, anodic inhibitor	58
59	Mild steel	NaCl	Thymus vulgar L. plant		weight loss and potentiodynamic polarization studies.	Temkin's adsorption isotherm.	59
60	Mild steel	HCl and H_2SO_4	Datura stramonium		weight loss studies, electrochemical, SEM studies	a mixed mode inhibitor , Temkin adsorption isotherm	60
61	Al-Zn-Mg alloy	0.5 M NaOH	Hibiscus Teterifa		weight loss studies, Thermodynamic studie. Temp 30, 50 and 70°C s.	Langmuir adsorption isotherm.	61
62	Mild steel	2 M HCl	olive (Olea europaea L.) leaves		weight loss measurements, Tafel polarization, and cyclic voltammetry.	Langmuir adsorption isotherm.	62
63	Mild steel	H_2SO_4	Carica papaya (leaves (LV), seeds (SD), heart wood (HW) and bark (BK))		Gravimetric and gasometric techniques. Temp 30 and 60 °C	Langmuir and Temkin adsorption isotherms , used in chemical cleaning and picking processes	63
64	Mild steel	5% and 15% HCl	Zenthoxylum alatum plant extract		weight loss method, EIS, SEM, XPS and FT-IR. Temp 50-80 °C	Langmuir adsorption isotherm.	64
65	Mild steel	20, 50 and 88% aqueous orthophosphoric acid	Zenthoxylum alatum plant extract		weight loss and (EIS), XPS and FT-IR Temp 50-80°C.	extract is effective up to 70°C in 88% phosphoric acid medium	65

66	copper corrosion in saline water (3.4 % NaCl)	saline water (3.4 % NaCl)	Medicago sativa, Withania somnifera, Atropa belladonna and Medicago polymorpha		EIS, Potentiodynamic polarization method EDX	the complex formation of extract inhibitor molecules with copper causes a blocking barrier to copper corrosion.	66
67	Mild steel	2M HCl and 1M H_2SO_4	Azadirachta indica extract		gas-volumetric technique.	Langmuir isotherm, mixed inhibitor,	67
68	Mild steel	1M H_2SO_4	Chamomile (Chamaemelum mixtum L.), Halfabar (Cymbopogon proximus), Black cumin (Nigella sativa L.), and Kidney bean (Phaseolus vulgaris L.)		(EIS) and potentiodynamic polarization techniques	mixed-type inhibitors, Langmuir, Flory-Huggins, and the kinetic-thermodynamic model	68
69	Mild steel	1M H_2SO_4	damsissa (Ambrosia maritime, L.) plant extract		weight-loss measurements , potentiodynamic polarization , (EIS) techniques. Temp 25°C to 40°C	mixed-type inhibitor, Langmuir, Frumkin. Flory-Huggins, and the kinetic-thermodynamic model.	69
70	Mild steel	Aqueous medium	Acid extract of the Datura metel		electrochemical and weight loss methods	Tempkin and Langmuir adsorption isotherms, use in the inhibition of corrosion in industries	70
71	Mild steel	H_2SO_4	Allium sativum extract		weight loss method and hydrogen evolution	Langmuir isotherm as well as the thermodynamic-kinetic model, free energies and equilibrium constant also determined	71
72	Mild steel	(60 ppm of Cl^-)	aqueous extract of rhizome (Curcuma longa L.) powder	Zn^{2+}	weight loss method, FTIR, UV-fluorescence, Electrochemical studies.	Forms synergistic effect, protective film consists of a Fe^{2+}-curcumin complex and zinc hydroxide ($Zn[OH]_2$).	72
73	Al (pH 11 and 12)	NaOH	aqueous extract of garlic	Zn^{2+} (CTAB) sodium sulphite	weight loss method, FTIR.	The protective film was analysed	73
74	Mild steel	100 ppm NaCl	Ricinus communis leaves		weight loss method, electrochemical studies	IE 84% in 300 ppm, anodic inhibitor, formations of iron-organic complex reduced the corrosion of mild steel in neutral system	74
75	Mild steel	100 ppm NaCl	Ricinus communis leaves		weight loss method, electrochemical studies	cathodic inhibitors on the fourth day, about 84% IE in 300 ppm	75
76	C-steel, nickel and zinc	acidic, neutral and alkaline solutions	henna (lawsonia) leaves		polarization technique	For C-steel and nickel, IE increases in the order: alkaline < neutral < acid, while in the case of zinc it increases in the order: acid< alkaline < neutral, mixed inhibitor, Langmuir adsorption	76

77	Al	HCl	Peepal (Ficus Religeosa).		Mass loss and thermometric methods	IE dependent upon the concentrations of the inhibitor and the acid.	77
78	N80 steel	15% HCl	formaldehyde and an alcoholic extract of plant leaves		weight loss and potentiostatic polarisation measurements. Temp up to 363 K	Forms synergistic effects, anodic inhibitors, Frumkin or Langmuir adsorption isotherm, Thermodynamic parameters also calculated	78
79	Al	HCl	Carica papaya (CP) and Azadirachta indica (AI)		weight loss, thermometric and hydrogen evolution techniques. Temp 30-40°C	Freundlich, Temkin and Flory -Huggins adsorption isotherms , E_a, ΔG_{ads} and Q_{ads} values calculated	79
80	316 stainless steel	5% HCl	Medicago polymorpha Roxb	room tempe-rature.	Electrochemical techniques, potentiodynamic polarization, and open circuit potential (OCP) studies	adsorption isotherm, the additives simultane-ously decelerated the anodic process, in-tensified the cathodic process and provided a stable passive state	80
81	Mild steel	1N HCl , 1N H_2SO_4 and 1 N HNO_3	acid extract of seeds, leaves and bark of Prosopis Juliflora (PJ).		weight loss method. Temp 299 ± 2 K	the inhibition increased with the increase in the concentration of the additives for seeds leaves and bark in 1 N HCl, 1N H_2SO_4 and 1 N HNO_3	81
82	Al	2.0 M HCl	the mucilage extracted from the modified stems of prickly pears,(opuntia)		weight loss, thermometry, hydrogen evolution and polarization techniques	Langmuir adsorption isotherm. thermodynamic parameters were calculated	82
83	Mild steel	0.1M HCl .	juice extracts of Mangifera Indica (mango)	ambient tempe-rature.	The weight-loss and potential measurement techniques	the juice(s) of bark and leaves 5ml/100ml of 0.1 M HCl gives high inhibition efficiency	83
84	Mild steel	0.1M HCl .	TL and BR inhi-bitors from green tea and rice bran		weight loss method , polarization techniques	cathodic inhibitor,	84
85	Mild steel	0.5M HCl , 0.5M H_2SO_4	bitter leaf (Vernonia Amygdalina) extract		weight loss method , polarization techniques, ambient temperature of 28°C and elevated temperature of 80°C	Effective in 0.5M HCI at 28°C	85
86	Al, copper and brass	acid chloride and sodium hydroxide	leaves of date palm, phoenix dactylifera, henna, Lawsonia inermis, and corn		weight loss, solution analysis and potential measurements.	Temkin isotherm, date palm and henna extracts were found highly effe-ctive in reducing corro-sion rate of steel in acid chloride solutions and aluminum in sodium hydroxide solutions.	86

87	Al-2.5Mg alloy	3 % NaCl	the third acidic phenolic subfraction of Rosemary leaves extract		Potentiodynamic polarization curves. High-pressure liquid chromatography in the reverse phase (HPLC-RP). Temp 25 °C	ferulic acid is responsible for the inhibition action of the third acidic phenolic subfraction of the aqueous extract of rosemary, cathodic type corrosion inhibitor, Freundlich adsorption isotherm,	87
88	Mild steel	0.2M HCl	bark and leaf solution extracts of mango (Mangifera Indica)	ambient temperature	weight-loss method and potential measurement technique.	1 mL of the combined extracts/100 mL of sulfuric acid, shows (70.15% IE) at 0.2 and 0.5 mL/100 mLis also effective but the magnitude of IE was below average.	88
89	Mild steel	0.2M HCl	bark and leaf solution extracts of mango (Mangifera Indica)	ambient temperature	weight-loss method	At 1.0ml/100ml of 0.2M dilute sulphuric acid concentration gives good IE	89
90	Mild steel	HCl	acid extract of Andrographis Paniculata		mass loss method, Tafel polarisation method and impedance studies.	plant extract has the potential to serve as corrosion inhibitor.	90
91	Mild steel	0.1M HCl	juices extracted from anacardium occidentale (cashew)	ambient temperature	Weight-loss and potential measurement techniques	At 2ml/100ml of 0.1 M HCl gives good IE	91
92	Mild steel	Aqueous medium	Eucalyptus (leaves), Hibiscus (flower), and Agaricus		weight loss and polarization methods.	Langmuir as well as Freundlich adsorption isotherms, IE Agaricus (85%), Hibiscus (79%), and Eucalyptus (74%), agaricus extract – cathodic inhibitor, Eucalyptus and Hibiscus - mixed inhibitors.	92
93	Mild steel	600 and 1200 mg H_2S/1 in 3% NaCl aqueous solution and pH of 3	Coumarines plants: Nigella Saliva (Family Ranunculacease) Coriandrum Sativum (Family Umbelliferea) Ricinus communis (Family Euphorbiaceae).		galvanostatic anodic and cathodic polarization measurements. Temp 25°C	the percentage inhibition of the undertesting extracts of these three plants and also preparation of fatty matters and coumarin fractions were mentioned.	93
94	Mild steel	0.5M H_2SO_4	Carica papaya and Azadirachta indica leaves		Weight-loss techniques. Temp 30°C and 40°C.	At 30°C IE Carica papaya (87.5% at 1.25×10^{-s} gdm^{-3}) is a better inihibitor than Azadirachta indica (75.95% at 1.25×10^{-3} gdm^3).	94
95	Mild steel	H_2SO_4	Amaranthus		Weight-loss techniques	Freundlich adsorption , chemisorption.	95

96	Mild steel	0. 1N HCI	Calotropis Procera (CPE) and Diospyros Mesipiliformis (DME) plant extracts		Polarization curves and weight loss measurements	both extracts provide adequate inhibition of corrosion of mild steel, but DME is more efficient than CPE.	96
97	Mild steel	HCl	Papaia, Poinciana pulcherrima, Cassia occidentalis and Datura stramonium seeds and Papaia, Calotropis procera B, Azydracta indica and Auforpio turkiale sap		Weight-loss determinations and electrochemical measurements	All extracts except Auforpio turkiale and Azydracta indica shows IE 88%-96% in 1 N HCl. Both the cathodic evolution of hydrogen and the anodic dissolution of steel are inhibited.	97
98	Mild steel	5% HCl	Both aqueous and alcoholic extracts of seven aloe plants		weight loss measurements	IE 70-82%	98
99	tin	nitric acid	a) Ammi mijus L; b) Ammi visnaga L; c) Ficus carica L, and d) Glycyrrhiza glabra.		thermometric method	The degree of inhibition of these extracts increases in the order a approximately equals b greater than c greater than d.	99
100	Mild steel	2 M HCl	olive (*Olea europa ea* L.) leaves		weight loss measurements, Tafel polarization, and cyclic voltammetry.	Langmuir adsorption isotherm. olive extract decreases the charge density in the transpassive region.	100
101	Mild steel	0.5M H_2SO_4	Acetyl thiourea chitosan polymer (ATUCS)		potentiodynamic polarization, electrochemical impedance spectroscopy (EIS) measurements, (SEM) technique	ATUCS has shown very good (IE) in 0.5 M sulphuric acid solution reaches to 94.5% for 0.76 mM concentration.	101
102	Mild steel	20, 50 and 88% aqueous orthophosphoric acid	Zenthoxylum alatum plant extract		weight loss , electrochemical impedance spectroscopy (EIS). (XPS and FT-IR). Temp 50–80 °C.	IE is effective up to 70 °C in 88% phosphoric acid medium.	102
103	Mild steel	1 M HCl and 0.5 M H_2SO_4	*Murraya koenigii* leaves		weight loss, electrochemical impedance spectroscopy (EIS), linear polarization and potentiodynamic polarization techniques.	Langmuir adsorption isotherm. thermodynamic parameters (Q, ΔH^*, and ΔS^*)	103
104	Mild steel	1 M HCl	seed extract of Cyamopsis tetragonaloba		weight loss method and potentiodynamic polarization technique.	IE 92%. Langmuir and Temkin adsorption isotherm	104

105	Mild steel	1 M HCl	mango, orange, passion fruit and cashew peels		electrochemical impedance spectroscopy, potentiodynamic polarization curves, weight loss measurements and surface analysis.	Langmuir adsorption isotherm.IE increases with increasing extract concentration and decreases with temperature.	105
106	Al	NaOH	abrusprecatorius	ambient temperature	weight loss and polarization techniques	suitable adsorption isotherms were tested graphically	106
107	Mild steel	Drinking water	gum exudate from Acacia seyal var. seyal		potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) techniques. Temp 30°C	IE 95 % gum concentration ≥400 ppm, anodic inhibitor, IE decrease with temp	107
108	Mild steel	H_2SO_4	Combretum bracteosum		The gravimetric and hydrogen evolution measurements. Temp 30-60°C.	Frumkin adsorption isotherm. Kinetic parameters calculated, used in chemical cleaning and pickling	108
109	Al	1 M HCl	root of ginseng		weight loss techniques. Temp 30-60 °C.	IE 93.1% at 30 °C at 50 % v/vconcentration of ginseng. Freundlich adsorption isotherm, thermodynamic parameters calculated	109
110	Al	0.5 M NaOH and H_2SO_4.	Vigna unguiculata (VU) extract		weight loss techniques electrochemical studies. Temp 30 and 60^{o}C.	Freunlich and Temkin adsorption isotherms	110
111	Mild steel	HCl	ginger		weight loss measurement.	IE increases with temperature. activation energy of adsorption are determined.	111

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REFERENCES

[1] O.K.Aboia, A.O. James, "The effects Of Aloe vera extract on Corrosion and Kinetics of Corrosion process of zinc in HCl Solution", *Corrosion Science 52(2), (2010) pp.661-664.*

[2] N.O.Eddy, S.A.Odoemelam, "Inhibition of corrosion of mild steel in acidic medium using ethanol extract of Aloe vera", *Pigment and Resin Technology 38(2), (2009), pp.111-115.*

[3] M.E.I-Sayed, O.Y.Mansour, I.Z.selim, M. M. Ibrahim, "Identification and utilization of banana plant juice and its liquor as anti-corrosive materials", *Journal of Science and Industrial Research 60(9), (2001), pp.738-747.*

[4] S.H.Tantawi, I.Z.Selim, "Improvement of concrete properties and reinforcing steel inhibition using a natural product admixture*", Journal of Materials Science and Technology 12(2), (1996), pp.95-99.*

[5] A.Bouyanzer, B.Hammouti, L.Majidi, "Pennyroyal oil from Mentha pulegium as corrosion inhibitor for steel in M HCl*", Materials Letters, Volume 60, Issue 23, October (2006), pp.2840-2843.*

[6] A.K. Satapathy., G.Gunasekaran, S.C. Sahoo, Kumar Amit, P.V.Rodrigues. "Corrosion inhibition by Justicia gendarussa plant extract in hydrochloric acid solution", *Corrosion science, Volume 51, issue 12, December (2009), pp.2848-2856.*

[7] F.S.de Souza, A.Spinelli, "Caffeic acid as a green corrosion inhibitor in mild steel", *Corrosion science, Volume 51, issue 3, March(2009), pp.642-649.*

[8] P.C.Okafor, M.E.Ikpi, I.E.Uwah, E.E.Ebenso, U.J.Ekpe, S.A.Umoren, "Inhibitory action of Phyllanthus amarus extracts on the corrosion of mild steel in acidic media", *Corrosion Science, Volume 50 Issue 8, August(2008), pp., 2310-2317.*

[9] Janaina Cardozo da Rocha, Jose Antonio da Cunha Ponciano Gomes, Eliane D'Elia, "Corrosion inhibition of carbon steel in hydrochloric acid solution by fruit peel aqueous exta", *Corrosion Science , Volume 52, Issur 7, (July 2010), pp 2341-2348.*

[10] Letica Guerrerio da Trindade, Reinaldo Simoes Goncalves. " Evidence of caffeine adsorption on a low-carbon steel surface in ethanol*", Corrosion science, Volume 51- Issue 8,August (2009), pp 1578-1583.*

[11] E.A.Noor,. "Potential of aqueous extract of Hibiscus sabdariffa leaves for inhibiting the corrosion of aluminum in alkaline solutions", *Journal of Applied Electrochemistry 39(9), (2009), pp.1465-1475.*

[12] F.A.Ayeni, V.S.Aigbodion, S.A.Yaro, "Non-toxic plant extract as corrosion inhibitor for chill cast Al-Zn-Mg alloy in caustic soda solution", *Eurasian Chemico-Technological Journal 9(2), (2007), pp.91-96.*

[13] M.A.Qurasishi, "Naturally occurring products as corrosion inhibitors", *NACE Meeting papers, (2004).*

[14] E.Khamis, N.Alandis, "Herbs as new type of green inhibitors for acidic corrosion of steel", *Materialwissenschaf tund Werkstoffiechnik 33(9), (2002), pp.550-554.*

[15] A.Minhaj, P.A,Saini, M.A.Quraishi, I.H.Farooqi, "A study of natural compounds as corrosion inhibitors for industrial cooling systems", *Corrosion Prevention and Control 46(2),(1999), pp.32-38.*

[16] M.A.Quraishi, A.Singh, V.K.Singh, D.K.Yadav, A.K.Singh, "Green approach to corrosion inhibit-tion of mild steel in hydrochloric acid and sulphu-ric acid solutions by the extract of Murraya koenigii leaves*", Materials chemistry and Physics 122(1), (2010), pp.114-122.*

[17] A.Rmila, A.A,Prema, P.A.Sahayaraj, "Influence of Murraya koenigii(curry leaves) extract on the corrosion inhibition of carbon steel in HCl solution", *Rasayan Journal of Chemistry3(1), (2010) pp.74-81.*

[18] A.M.Al-Turkustani, S.T.Arab, L.S.S.Al-Qarni, " Medicago Sative plant as safe inhibitor on the corrosion of steel in 2.0M H2SO4 solution", *Journal of Saudi Chemical society, (2010).*

[19] M. Lebrini, F. Robert, A. Lecante. C. Roos. "Corrosion inhibition of C38 steel in 1M hydrochloric acid medium by alkaloids extract from Oxandra asbeckii plant", *Corrosion Science, (2010).*

[20] I,E.Uwah, P.C.Okafor, V.e,Ebiekpe. "Inhibitive action of ethanol extracts from Nauclea latifolia on the corrosion of mild steel in H_2SO_4 solutions and their adsorption characteristics*", Arabian Journal of Chemistry, (2010).*

[21] M.Lebrini, F.Robert, C.Roos, "Inhibition effect of alkaloids extract from Annona squamosa plant on the corrosion of C38 steel in normal hydrochloric acid medium", *International Journal of Electrochemical Science 5(11), (2010), pp.1678-1712.*

[22] I.B.Obot, N.O.Obi-Egbedi. "An interesting and efficient green corrosion inhibitor for aluminium from extracts of Chlomolaena odorata L. in acidic solution", *Journal of Electrochemistry 40(11), (2010), pp.1977-1984.*

[23] N.O.Eddy, A.O.Odiongenyi, "Corrosion inhibition and adsorption properties of ethanol extract of IT Heinsia crinata / IT on mild steel in H_2SO_4", *Pigment and Resin Technology 39(5), (2010), pp.288-295.*

[24] E.E.Oguzie, C.K.,Enenebeaku, C.O.Akalezi, S.C.Okoro, A.A.Ayuk, E.N.Ejike, "Adsorption and corrosion-inhibiting effect of Dacryodis edulis extract on low-carbon-steel corrosion in acidic media", *Journal of Colloid and interface Science 349(1) , (2010), pp.238-292.*

[25] E.I.Ating, S.A.Umoren, I.I.,Udousoro, E.E.,Ebenso, A.P. Udoh, "Leaves extract of ananas sativum as green corrosion inhibitor for aluminium in hydrochloric acid solutions*", Green Chemistry Letters and Reviews 3(2), (2010), pp.61-68.*

[26] P.B.Raja, A.A.Rahim, H.Osman, K.Awang "Inhibitory effect of Kopsia singapurensis extract on the corrosion behavior of mild steel in acid media", *Wuli Huaxue Xuebao/Acta Physico-Chimica Sinica 26(8), (2010), pp.2171-2176.*

[27] I.B.Obot,N.O.Obi-Egbedi,S.A.,Umoren, E.E.Ebenso, "Synergistic and antagonistic effects of anions and ipomoea invulcrata as green corrosion inhibitor for aluminium dissolution in acidic medium". *Internal Journal of Electrochemical Science 5(7), (2010), pp.994-1007.*

[28] P.C.Okafor, E.E,Ebenso,U.J.Ekbe, "Azadirachta indica extracts as corrosion inhibitor for mild steel in acidic medium". *International Journal of Electrochemical Science 5(7), (2010), pp.978-993.*

[29] R.Saratha, V.G.Vasudha, "Emblica Officinalis (Indian Gooseberry) leaves extract as corrosion inhibitor for mild steel in 1 N HCL medium*". E-Journal of Chemistry 7(3), (2010), pp.677-684.*

[30] M.Sivaraju, K.Kannan, "Eco-friendly inhibitor (Tributes terrestris L) for mild steel corrosion in 1N Phosphoric acid". *Asian Journal of Chemistry 22(1), (2010), pp.233-244.*

[31] P.K.Kasthuri, A.Arulanantham, "Eco-friendly extract of Euphorbia hirta as corrosion inhibitor on mild steel in sulphuric acid medium". *Asian Journal of Chemistry 22(1), (2010), pp.430-434.*

[32] P.K.Sivaraju, A.Arulanantham, "Inhibitive properties of plant extract (Acalypha indica L.)on mild steel corrosion in 1N phosphoric acid". *International Journal of ChemTech Research 2(2), (2010).*

[33] A.M.Al-Turkustani, S.T.Arab, L.S.S.Al-Qarni, "The use of Ruta chalepensias corrosion inhibitor for steel corrosion in 2M sulphuric acid solution". *Oriental Journal of Chemistry 26(2), (2010), pp.437-454.*

[34] A.K.Satapathy,G.Gunasekaran,S.C.Sahoo,K.Amit, P.V.Rodrigues."Corrosion inhibition by Justicia gendarussa plant extract in hydrochloric acid solution". *Corrosion Science 51(12), (2009), pp.2848-2856.*

[35] A.M.,Badiea, K.N.Mohana. "Corrosion mechanism of low-carbon steel in industrial water and adsorption thermodynamics in the presence of some plant extracts*". Journal of Materials Engineering and Performance 18(9), (2009), pp.1264-1271.*

[36] V.O.Njoku, E.E.Oguzie. "Inhibitory properties of Baphia nitida extract in acid mild steel corrosion". *European Corrosion Congress 2009, EUROCORR 2009 2, (2009), pp.849-870.*

[37] I.Lingvay,D.I.Vaireanu,A.Cojocaru,L.Parvu,I.Major, S.Nita, C.Lingway. "Evaluation of inhibitive properties of environmentally friendly plant extracts using polarization curves". *European Corrosion Congress 2009, EUROCORR 2009 3, (2009), pp.1490.*

[38] C.Anca,M.Ioana,D.I.Vaireanu,L.Iosif,L.Carmen,C. Simona, "Estimation of inhibition efficiency for carbon steel corrosion in acid media by using natural plant extracts". *Revista de Chimie 60(11), (2009), pp.1175-1180.*

[39] M.Dakmouche, S.Ladjel, N.Gherraf, M.Saidi, M. Hadjaj, M.R.Ouahrani, "Inhibition effect of some plant extracts on the corrosion of mild steel in H_2SO_4 medium". *Asian Journal of Chemistry 21(8), (2009), pp.6176-6180.*

[40] R.Saratha, V.G.Vasudha, "Inhibition of mild steel corrosion 1N H_2SO_4 medium by acid extract of nyctanthes arbortristis leaves". *E-Journal of Chemistry 6(4), (2009), pp.1003-1008.*

[41] P.C.Okafor, I.E. Uwah, O.O.Ekerenam, U.J.Ekpe, "Combretum bracteosum extracts as eco-friendly corrosion inhibitor for mild steel in acidic medium". *Pigment and Resin Technology 38(4), (2009), pp.236-241.*

[42] M.Shyamala, A.Arulanantham, "Eclipta alba as corrosion pickling inhibitor on mild steel in hydrochloric acid". Journal of Materials Science and Technology 25(5), *(2009),* pp.633-636.

[43] N.Poongothai, T.Ramachanderan, M.Natesan, S.C.Murugavel, "Corrosion inhibition of mild steel by essential oils in an HCl environment". *Materials Performance 48(9), (2009), pp.52-56.*

[44] R.Saratha, S.V.Priya, P.Thilagavathy, "Investigation of citrus aurantiifolia leaves extract as corrosion inhibitor for mild steel in 1 M HCL". *E-Journal of Chemistry 6(3), (2009), pp.785-795.*

[45] S.Kumar, S.Arora, M.Sharma, P.Arora, S.Prakash Mathur, "Synergistic effect of Calotropis plant in controlling corrosion of mild steel in basic solution". *Journal of the Chilean Chemical Society 54(1), (2009), pp.83-88.*

[46] S.Rajenderan,J.Jeyasundari,P.Usha,J.A.Selvi,B.Narayanasamy,A.P.P.Regis,P.Renga, "Corrosion behaviour of aluminium in the presence of an aqueous extract of hibiscus rosasinensis*". Portugaliae Electrochimica Acta 27(2), (2009), pp.153-164.*

[47] N.O.Eddy, S.A.Odoemelam, "Inhibition of corrosion of mild steel in acidic medium using ethanol extract of Aloe vera*". Pigment and Resin Technology 38(2), (2009), pp.111-115.*

[48] P.Bothi Raja, M.G.Sethuraman, "Solanum tuberosum as an inhibitor of mild steel corrosion in acid media*". Iranian Journal of Chemistry and Chemical Engineering 28(1), (2009), pp.77-84.*

[49] J.S.Chauhan, "Anticorrosion behaviour of zenthoxylum alatum extract in acidic media". *Asian Journal of Chemistry 21(3), (2009), pp.1975-1978.*

[50] P.B.Raja, M.G.Sethuraman, "Inhibition of corrosion of mild steel in sulphuric acid medium by ITCalotropis procera/IT". *Pigment and Resin Technology 38(1), (2009), pp.33-37.*

[51] J.H.Potgieler, P.Olubambi, N.P.Thanjekwayo, "The effect of selected plant extracts on the corrosion behaviour of duplex stainless steels". *EUROCORR 2008-European Corrosion Congress: Managing Corrosion for Sustainability, Book of Abstracts, (2008), pp.78-79.*

[52] E.E Oguzie, "Corrosion inhibitive effect and adsorption behaviour of Hibiscus sabdariffa on mild steel in acidic media". *Portugaliae Electrochimica Acta 26(3), (2008), pp.303-314.*

[53] E.E.Oguzie, "Evaluation of the inhibitive effect of some plant extracts on the acid corrosion of mild steel". *Corrosion Science 50(11), (2008), pp.2993-2998.*

[54] R.Rajalakshmi, S.Subhashini, S.Leelavathi, R.F. Mary, "Efficacy of sprouted seed extracts of Phaseolus aureus on the corrosion inhibition of mild steel in 1m HCl". *Oriental Journal of Chemistry 24(3), (2008), pp.1085-1090.*

[55] P.C.Okafor, M.E.Ikpi, I.E.Uwah, E.E.Ebenso, U.J. Ekpe, S.A.Umoren, "Inhibitory action of Phyllanthus amarus extracts on the corrosion of mild steel in acidic media". *Corrosion Science 50(8), (2008), pp.2310-2317.*

[56] S.T.Arab, A.M.Al-Turkustani, R.H.Al-Dhahiri, "Synergistic effect of Azadirachta Indica extract and iodide ions on the corrosion inhibition of aluminium in acid media". *Journal of the Korean Chemical Society 52(3), (2008), pp.281-294.*

[57] A.M.Abdel-Gaber, E.Khamis, H.Abo-ElDahab, S.H.Adeel, "Inhibition of aluminium corrosion in alkaline solutions using natural compound". *Materials Chemistry and Physics 109(2-3), (2008), pp.297-305.*

[58] S.A.Umeron, I.B.Obet, L.E.Akpabio, S.E.Etuk, "Adsorption and corrosive inhibitive properties of vigna unguiculata in alkaline and acidic media". *Pigment and resin technology 37(2), (2008), pp.98-105.*

[59] P.Premkumar, K.Kannan, M. Natesan, "Thyme extract of Thymus vulgar L. as volatile corrosion inhibitor for mild steel in NaCl environment". *Asian Journal of Chemistry 20(1), (2008), pp.445-451.*

[60] P.B.Raja, M.G.Sethuraman, "Studies on the inhibitive effect of Datura stramonium extract on the acid corrosion of mild steel". *Surface Review and Letters 14(6), (2007), pp.1157-1164.*

[61] F.A.Ayeni, V.S.Aigbodion, S.A.Yaro, "Non-toxic plant extract as corrosion inhibitor for chill cast Al-Zn-Mg alloy in caustic soda solution". *Eurasian Chemico-Technological Journal 9(2), (2007), pp.91-96.*

[62] A.J. El-Etre, "Inhibition of acid corrosion of carbon steel using aqueous extract of olive leaves". *Journal of Colloid and Interface Science 314(2), (2007), pp.578-583.*

[63] P.C.Okafor, E.E.Ebenso, "Inhibitive action of Carica papaya extracts on the corrosion of mild steel in acidic media and their adsorption characterristics". *Pigment and Resin Technology 36(3), (2007), pp.134-140.*

[64] L.R.Chauhan,G.Gunasekaran, "Corrosion inhibittion of mild steel by plant extract in dilute HCl medium". *Corrosion Science 49(3), (2007), pp. 1143-1161.*

[65] G.Gunasekaran, L.R.Chauhan, "Eco friendly inhibitor for corrosion inhibition of mild steel in phosphoric acid medium". *Electrochimica Acta 49(25), (2004), pp.4387-4395.*

[66] H.A.El-Dahan, "Natural products as corrosion inhibitors for copper in saline water in presence of sulphide". *Egyptian Journal of Chemistry 49(5), (2006), pp.589-600.*

[67] E.E.Oguzie, "Adsorption and corrosion inhibitive properties as Azadirachta indica in acid solutions". *Pigment and resin Technology 35(6), (2006), pp.334-340.*

[68] A.M.Abdel-Graber,B.A.Abd-El-Nabey,I.M.Sidahmed,A.M.El-Zayady.M.Saadawy, "Inhibitive action of some plant extracts on the corrosion of steel in acidic media". *Corrosion Science 48(9), (2006), pp.2765-2779.*

[69] A.M.Abdel-Graber,B.A.Abd-El-Nabey,I.M.Sidahmed,A.M.El-Zayady.M.Saadawy, "Effect of temperature on inhibitive action of damsissa extract on the corrosion of steel in acidic media". *Corrosion 62(4), (2006), pp.239-299.*

[70] M.G.Sethuram,P.B.Raja, "Corrosion inhibition of mild steel by Datura metal in acidic medium". *Pigment and Resin Technology 34(6), (2005), pp.347-352.*

[71] P.C.Okafor, U.J.Ekpe, E.E.Ebenso, E.M.Umoren, K.E. Leizou, "Inhibition of mild steel corrosion in acidic medium by Allium sativum extracts". *Bulletin of Electrochemistry 21(8), (2005), pp.347-352.*

[72] S.Rajenderan, S.Shanmugapriya, T.Rajalakshmi, A.J.Amal Raj, "Corrosion inhibition by an aqueous extract of rhizome powder". *Corrosion 61(7), (2005), pp.685-692.*

[73] S.L.Priya, A.Chitra, S.Rajenderan, K.Anuradha, "Corrosion behaviour of aluminium in rain water containing garlic extract". *Surface Engineering 21(3), (2005), pp.229-231.*

[74] R.AnandaLouiseSathyanathan, S.Maruthamuthu, M.Selvanayagam, S.Mohanan, N.Palaniswamy, "Corrosion inhibition of mild steel by ethanolic of Ricinus communis leaves". *Indian Journal of Chemical Technology 12(3), (2005), pp.356-360.*

[75] R.Ananda Louise Sathyanathan, M.M.Essa, S.Maruthamuthu, M.Selvanayagam, N. Palaniswamy, "Inhibitory effect of Ricinus communis (Castro-oil plant) leaf extract on corrosion of mild steel in low chloride medium". *Journal of the Indian Chemical Society 82(4), (2005), pp.357-395.*

[76] A.Y.El-Etre, M.Abdallah, Z.E.El-Tantawy, "Corrosion inhibition of some metals using lawsonia extract". *Corrosion Science 47(2), (2005), pp.385-395.*

[77] T.Jain, R.Chowdhary, P.Arora, S.P.Mathur, "Corrosion inhibition of aluminum in hydrochloric acid solutions by peepal (Ficus Religeosa) extracts". *Bulletin of Electrochemistry 21(1), (2005), pp.23-27.*

[78] T.Emranuzzaman,Kumar, S.Vishwanatham, G. Udayabhanu, "Synergistic effects of formaldehyde and alcoholic extract of plant leaves for protection of N80 steel in 15% HCl". *Corrosion Engineering Science and Technology 39(4), (2004), pp.327-332.*

[79] E.E.Ebenso, U.J.Ibok, U.j.Ekpe, S.Umoren, E. Jackson, O.K.Abiola, N.C.Oforka, S.Martinez, "Corrosion inhibition studies of some plant extracts on aluminium in acidic medium". *Transactions of the SAEST (Society for advancement of Electrochemical Science and Technology) 39(4), (2004), pp.117-123.*

[80] T.K Soror, "New naturally occurring product extract as corrosion inhibitor for 316 stainless steel in 5% HCl". *Journal of Materials Science Technology 20(4), (2004), pp.463-466.*

[81] R.Chowdhary, T.Jain, M.K.Rathoria, S.P. Mathur, "Corrosion inhibition of mild steel by acid extracts of Prosopis Juliflora". *Bulletin of electrochemistry 20(2), (2004), pp.67-75.*

[82] A.Y. El-Etre, "Inhibition of aluminum corrosion using Opuntia extract". *Corrosion Science 45(11), (2003), pp.2485-2495.*

[83] C.A.Loto, A.I.Mohammed, Loto, "Inhibition evaluation of mango juice extracts on the corrosion of mild steel in HCl". *Corrosion Prevention and Control 50(3), (2003), pp.107-118.*

[84] Z.Liu , G.l.Xiong,. "Preparation and application of plant inhibitors". *Corrosion and Protection 24(4), (2003), pp.146-150.*

[85] C.A Loto,. "The effect of bitter leaf extract on the inhibition of mild steel in HCl and H_2SO_4". *Corrosion Prevention control 50(1), (2003), pp.43-49.*

[86] H.H.Rehan, "Corrosion control by water-soluble extracts from leaves of economic plants". *Materialwissenschaft und Werkstofftechnik 34(2), (2003), pp.232-237.*

[87] J.Radosevic, M.Kliskic, A.Visekruna, "Inhibition of corrosion of the Al-2.5Mg Alloy by means of the third acidic phenolic subfraction of aqueous extract of Rosemary[Inhibicija korozije Al-2,5Mg slitine pomoću treće kisele fenolne podfrakcije vodenog ekstrakta ružmarina]". *Kemija U Industriji/ Journal of Chemists and Chemical Engineers 50(10), (2001), pp.537-541.*

[88] C.A.Loto, "The effect of mango bark and leaf extract solution additives on the corrosion inhibition of mild steel in dilute sulphuric acid – part 2". *Corrosion Prevention and Control 48(2), (2001), pp.59-64.*

[89] C.A. Loto, "The effect of mango bark and leaf extract solution additives on the corrosion inhibition of mild steel in dilute sulphuric acid – part I". *Corrosion Prevention and Control 48(1), (2001), pp.38-41.*

[90] S.P.Ramesh,K.P.Vinod Kumar, M.G.Sethuraman, "Extract of andrographis paniculata as corrosion inhibitor of mild steel in acid medium". *Bulletin of Electrochemistry 7(3), (2001), pp.141-144.*

[91] C.A.Loto, A.I.Mohammed, "The effect of cashew juice extract on corrosion inhibition of mild steel in HCl". *Corrosion Prevention and Control 47(2), (2000), pp.50-56.*

[92] A.Minhaj,P.A.Saini,M.A.Quraishi, I.H. Farooqi, "A study of natural compounds as corrosion inhibitors for industrial cooling systems". *Corrosion Prevention and Control 46(2), (1999), pp.32-38.*

[93] Y.F.Barakat, A.M.Hassan, A.M Baraka, "Corrosion inhibition of mild steel in aqueous solution containing H_2S by some naturally occurring substances". *Materialwissenchaft und Werkstofftechnik 29(7), (1998), pp.365-370.*

[94] E.E.Ebenso, J.J.Udofot,U.J.EkpeIbok, "Studies on the inhibition of mild steel corrosion by some plant extracts in acidic medium". *Discovery and Innovation 10(1-2), (1998), pp.52-59.*

[95] N.Nigam, K.Srivastava, "Role of amaranthus-A wild plant on the dissolution of mild steel in acidic medium". *Journal of the Institution of Engineers (India) Chemical Engineering Division 68(3), (1998), pp.89-92.*

[96] G.H.Awad, "Effect of some plant extracts on the corrosion of mild steel in 0.1N Hydrochloric acid solutions". *[No source information available], (1985).*

[97] F.Zuchhi, I.H.Omar, "Plant extracts as corrosion inhibitors of mild steel in HCl solutions". *Surface Technology 24(4), (1985), pp.391-399.*

[98] R.M.Saleh, And A.El Alim, Mahesan, A.A.El Hosary, "Corrosion inhibition by naturally occurring substances: Constitution and inhibiting property of Aloe plants". *Corrosion prevention and Control 30(1), (1983), pp.9-10.*

[99] M.E.Ibrahim, A.M.El-Khrisy,E. M.M.Al-Abdallah, A.Baraka, "Evaluation of the Inhibitor Action of certain Natural Substances Used as Corrosion Inhibitors-1. In the Dissolution of Tin in Nitric Acid". *Mo Metalloberflanche Beschichten won Metall und Kunstsoff 35(4), (1981), pp.134-136.*

[100] A.Y.El-Etrs. "Inhibition of acid corrosion of carbon steel using aqueous extract of olive leaves". *[accepted 25 may 2007]. Available online 12 july (2007).*

[101] A.M.Fekry. R.Riham Mohamed, "Acetyl thiourea chitosan as an eco-friendly inhibitor for mild steel in sulphuric acid medium". *[accepted 5 november 2009]. Available online 26 november (2009).*

[102] G.Gunasekaran, L.R. Chauhan, "Eco friendly inhibitor for corrosion inhibition of mild steel inphosphoric acid medium". *[accepted 12 april 2004]. Available online 9 june (2004).*

[103] M.A.Quraishi, Ambrish Singh, Vinod Kumar Singh, Dileep Kumar Yadav, Ashish Kumar Singh. "Green approach to corrosion inhibition of mild steel in hydrochloric acid and sulphuric acid solutions by the extract of Murraya koenigii leaves". *[accepted 26 february 2010]. Available online 24 march (2010).*

[104] S.Subhashini, R.Rajalakshmi, A. Prithiba, Mathina, "Corrosion mitigating effect of Cyamopsis Tetragonaloba seed extract on mild steel in acid medium". *E-Journal of Chemistry 7(4), (2010) pp.1133-1137.*

[105] J.C.Da Rocha, J.A.da Cunha Ponciano Gomes, E .D'Elia, "Corrosion inhibition of carbon steel in hydrochloric acid solution by fruit peel aqueous extracts". *Corrosion Science 52(7), (2010) pp.2341-2348.*

[106] R.Rajalakshmi, S.Subhashini, M.Nanthini, M. Srimathi, "Inhibiting effect of seed extract of abrus precatorius on corrosion of aluminium in sodium hydroxide". *Oriental Journal of Chemistry 25(2), (2009), pp.313-318.*

[107] I.Buchweishaija, G.S. Mhinzi, "Natural products as a source of environmentally friendly corrosion inhibitors: The case of gum exudates from Acacia seyal var.Seyal". *Portugaliae Electrochimica Acta 26(3), (2008), pp.257-265.*

[108] P.C.Okafor, O.O.Uwah,I.E.,Ekerenam, U.J.Ekpe, "Combretum bracteosum extracts as eco-friendly corrosion inhibitor for mild steel in acidic medium". *Pigment and Resin Technology 38(4), (2009), pp.236-241.*

[109] I.B.Obot, N.O.Obi-Egbedi,Ginseng root: "A new efficient and effective eco-friendly corrosion inhibitor for aluminium alloy of type AA 1060 in hydrochloric acid solution". *International Journal of Electrochemical Science 4(9), (2009), pp.1277-1288.*

[110] S.A.Umoren, I.B.Obot, L.E.Akpabio, S.E.Etuk, "Adsorption and corrosive inhibitive properties of Vigna unguiculata in alkaline and acidic media". *Pigment and Resin Technology 37(2), (2008), pp.98-105.*

[111] A.Bouyanzer, B.Hammouti, "Naturally occurring ginger as corrosion inhibitor for steel in molar hydrochloric acid at 353 K". *Bulletin of Electrochemistry 20(2), (2004), pp.63-65.*

REZIME

ZELENA KOROZIJA INHIBITORIMA - PREGLED

Da biste zamenili ekološki opasne hromate, nekoliko ne-hromata su korišćeni kao inhibitori korozije. Ekstrakti biljnih materijala na vrhu liste biljnih ekstrakata su ekološki, nisu toksični i lako dostupni. Ovi ekstrakti sadrže mnoge sastojke. Oni sadrže nekoliko organskih jedinjenja, kao što su polarni atoma O, N, P i S. Oni su adsorbovani na metalnu površinu preko ovih polarnih atoma I formiraju se zaštitne folije. Adsorbovanje ovih sastojaka pokoravaju različite izoterme adsorpcije. Filmovi su bili analizirani od strane mnogih tehnika, kao što su AFM, FTIR, UV zračenje, fluorescenca spektrima i SEM.

Ključne reči: *zeleni inhibitori, inhibitori korozije ekološki, prirodni proizvod, biljni materijali*