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Review Paper

Green corrosion inhibitors for aluminium and it's alloy: An overview

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Abstract

Corrosion is anatural process, unavoidable but it's a controllable. Corrosion inhibitors are extensively used for the protection of metals and equipment and they are required to be acceptable and eco-friendly. Some of the investigators were tried to use natural products as green inhibitors to prevent corrosion. Recently, a huge interested for the use of naturally occurring inhibitors extracted from plants have been emerged. Most of the natural products are non-toxic, biodegradable and readily available due to environmental concerns. In this review paper, corrosion ninhibition of various types of aluminium and it's alloy, medium and green inhibitors have been reported. The inhibitor is chemically adsorbed on the surface of the metal and forms a protective thin film with inhibitor effect or by combination between inhibitor ions and metallic surface Corrosion of aluminium and its inhibition was analyzed by weight loss (Gravimetric), temperature effect (Gasometric), Potentiodynamicpolarization and Electrochemical Impedance Spectroscopy (EIS) were employed. The protective films formed on metal surface have been analyzed by various techniques such as Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), Response Surface Methodology (RSM), FT-IR (Fourier Transform-Infrared Spectroscopy), UV (Ultra Violet)-Visible spectra, X-ray Diffraction spectroscopy (XRD), Energy Dispersive X-ray Spectroscopy (EDX), Electrochemical Frequency Modulation (EFM). The present review paper is an overview of works published on green inhibitors for protection of aluminium and it's alloy from corrosion.

Keywords: Corrosion, aluminium, Green inhibitors, Potentiodynamic Polarization, EIS, SEM.

Introduction

Corrosion is defined as the deterioration of metal or its properties due to interaction between metal and its environment. The tendency of a metal to corrode depends on the grain structure of the metal, its composition as formed during alloying. Aluminium is a chemical element with the symbol Al with atomicnumber 13. It is a silvery-white, soft, non-magnetic and ductile metal in the boron group. By mass, aluminium makes up about 8% of the earth's crust, where it is the third most abundant element (after oxygen and silicon) and also the most abundant metal. The chief ore of aluminium is bauxite. Aluminium and its alloys have proved to be strategically important materials and have extensive use in many industries. They are used in the automotive, aviation and aerospace industries, in the making of household appliances. Corrosion prevention would be more practical than trying to eliminate it completely.

The use of inhibitors is one of the most practical options to protect metal from corrosion. Corrosion inhibitors are chemical compounds generally added in small concentrations to corrosive solution to reduce corrosion rate. Corrosion inhibition occurs via adsorption of their molecules on the corroding metal surface and efficiency of inhibition depends on the mechanical, structural and chemical characteristics of the adsorption layers formed under particular conditions.Various type of inhibitors like organic, inorganic and green or natural can be used. Due to toxic and costly nature of organic and inorganic inhibitors recently eco-friendly inhibitors called green inhibitors were useful. Most of the natural products are non-toxic, bio-degradable and readily available in plenty. Various parts of plants – seeds, leaves, flowers, fruits, stem and barks etc., have been used as corrosion inhibitors. Natural products containing the necessary elements such a Oxygen (O), Carbon (C), Nitrogen (N) and Sulphur (S). Which are active in organic compounds, assist in adsorption of these compounds on aluminium or aluminium alloys to form a film that protects the surface and hinders corrosion. In this review, corrosion inhibition of aluminium and it's alloy by using various plant extracts was discussed.

Metals used: Green inhibitors were used to control the corrosion of various gradesaluminium[2,4,6-12,14-25,27,31-34,36,38,41,45-50,52,56-58,60-63,66-84,87,88,90-92,94-97,100,102,104-107,109-119,121,123,124,126,128-133,136-140,142,143,145,146,150,152,153,156-159,161-172,174] such as aluminium alloy[44,64,65,86,134,135,148], Al-Mg[1], Al-2.5Mg[3], 2S & 3RS Al[5], Al-Zn-Mg[13], Cu-Al[26], AA1060[28,103], AA1100[30], AA3003[35,59,89,99,122,125,173], AA8011[37,149,151], Zn-Al[39,155], AA5083[40], Al-Mg-Si[42], AA1060[29,51,53,54], AA7075[55], AA5754[85], Al-Si[93], Al-Cu-Mg[101], AA2024[108], AA2S[120], AA5052[127,147], Al-Zn[144], Al-Si-Fe/SiC[154], AA6063[98,141,160], VTES Al[174].

Medium: In this overview, various plant extracts for corrosion control of aluminium and its alloy in acidic or alkaline environments has been investigated. This review is mainly focused on acidic medium[1,2,4-6,9-12,14-18,20,22,26,28-39,41,43,44,47,50-54,56,57,59-76,78,79,82,83,87,88,91-98,101-122,125,126,128-133,137-149,151-164,166-174] and some are alkaline medium like sodium hydroxide[2,8,13,19,20,23-25,27,45,48,49,58,77,80,81,87,90,100,112,124,134-136,138,150], potassium hydroxide[12,89,99], sodium chloride[2,3,7,21,55,85,127], sodium carbonate[165], sea water[40,42] and Biodiesel[123]have been used.

Plant materials as green inhibitors: Corrosion inhibitors are used various parts of the plant extracts such as, Leaves[1-3,5,11,12,18,23,24,31-33,37,38,40,41,43,44,45,50,51,53,54,56,57,59,64,65,67,69,74,78-83,88,89,91,93,95-98,100,103,107,108,112-114,118,119,123,125,128,130-133,135,139,140,142,144-147,149,151,153,155,157,158,163,164,171,173], Seeds[11,23,27,30,39,58,71,73,75,76,87,92,99,101,105,106,108,110,121,122,124,136,137,156,159,160,169,170], Fruits[8,22,36,49,52,55,60,68,70,84,87,94], Peel[115,129,148,155], Bark[9,134], Stem[4,48,49,63,111,116,154,166], Flower[25,143,150], Seed oil[47,61,72,85,162,165,172], roots[28,117], Exudates gum[15-17,20,29,102,104,167] Grain [141], Natural compound (directly used as a powder form)[66,7,21,42,109,127] and Plant extract [6,10,13,14,19,26,34,35,46,77,86,90,126,152,161].

Plant Extracts used: Various solvents likeaqueous solution[1,3,6,8,13,18-20,24,25,34,46,48-50,53,55,58,66,68,73,76,80,81,87,92,94,96,97,101,105,108-112,117,123,128,130-133,136,137,143,144,146,150,152,157-159,163,168,170,174], alcoholic [2,4,9,10,14-17,29,30,33,40,43,47,50-54,56,60,67,69-72,74-76,78,79,82-85,93,95,98,102-104,106,118,119,122,124,145,154,155,156,166,167], acidic[5,11,12,26,28,31,32,35-39,41,44,50,57,59,62,64,65,86,91,113-115,121,129,147-149,173], hot water[88,116], NaCl[63,127], KOH [12,89,99], NaOH[23,27,45,77,90,100,134,135,164], Acetone[22] and Dichloromethane[107,142] were accustomed to extract the phyto-chemicals of various plant materials.

Additives to study synergistic effect: In some cases, additives such as KI[12,16,17,28,31,39,41,57,74,96,108,112,116], KBr[12,16,17,74,96], KCl[12,16,17,39,74,96], Zn^{+}[28,25,117], NaI[18,34], NaCl[19] and KSCN[31]were used in combination with green inhibitor to study their synergistically action.

Methods: Various methods such as Weight loss method[2,4-6,9,10,13-15,17,22,23,26-30,33,37,38,40,47-54,56-64,66-72,75-86,88-90,94-108,110,112,113,115,116,118,119,122-124,129-147,149-164,166-173], Hydrogen evolution (Gasometric)[4,6,11,12,16,19,41,43-45,52,64,65,68,72,80,81,91,105,107,108,114,136,166], Potentiodynamic polarization[1,3,4,18-20,47,48,51,52,55,61,67,71-73,80-82,85,86,90,92,97,102,106,107,109-111,113,117,123,124,126,130-132,134,135,140-142,146-148,150,152,153,154,158,161,162,165,167,170,174], Electrochemical Impedance Spectroscopy (EIS)[1,11,16,18-20,44,47,48,51,55,59,67,71-73,81,82,92,93,96,97,105-111,113,117,121,122,124,126,127,130-135,137,142,148,150,152,153,158,160-162,165,167,170,173,174], Synergistic effect[8,12,16-19,25,28,31,34,39,41,57,74,96,108,112,116,117] and Kinetic parameters: Rate constant and Half- life period[11,30,31,62,66,87,143,145,167] were used for investigation of corrosion mechanism and to calculate the percentage of inhibition efficiency of different green inhibitors.

Temperature effect: The percentage of inhibition efficiency of green inhibitors has been calculated at room temperature[2,4-6,9,10,13-15,17,22,23,26-30,33,37,38,40,47-54,56-64,66-86,88-90,94-108,110,112,113,115-119,122-124,129,130-147,149-164,169-173] and also at high temperatures[4,6,7,9,10,12,14,15,17,29,41,46,54,56,57,60,63,66,67,68,69,70,74-79,83,84,87,92,94-98,100,102-104,111,112,115,116,118,119,129,130-132,139,140,143,145,151-154,157,164,167,169,172,174].

Adsorption isotherms: The adsorption isotherm model for phyto-chemicals present invarious green inhibitorsextract into the metallic surface has been studied. For this, different kind of adsorption isotherms, such as Langmuir[4,11,13,16,41,46-48,50-53,56-59,61-63,66-71,73,75,77,78,80,81,83-85,87,88,90-94,96-100,104,105,108,110-116,119,122-127,129-132,134-143,145-150,152,154,157,159,160,162,163,168,171-173], Freundlich[1,3,6,12,16,18,20,44,54,59,78,79,86,91,103,114,116,133,139,146,151], Temkin[2,6,15-17,20,29,55,59,60,64,65,76-78,82,87,91,93,94,99,100,102,103,107,114,116,139,147,149,150,161,167,172], Frumkin[43,83,91,95,114,137,172], Dubinin-Radushkevich[136] and Flory-Huggins[6,50,53,59,99,116,172] adsorption isothermwere suggested. Various thermodynamic parameters were calculated such as Gibb's free energy, Enthalpy of adsorption, Entropy of adsorption and some are shown El-Awady's kinetic-thermodynamic model[15,29,54,59,78,79,95,102,103,109,160].

Metal surface analysis: Green inhibitors areadded in corrosive solutions to prevent the corrosion of metal a protective films formed on metal surface which is confirmed by various surface morphological studied, like SEM[8,42-44,51,61,64-67,73,85,88,90,92,96,100,105,107,113,114,117,123,125,126,133-135,137,138,140,142,146,148,150,153,154,160-163,167,170,171], AFM[125,134,135,138,148,161], FT-IR[8,42,68,69,70,75,76,84,113,125,133,136,140,146,153,154,160,167,171,173], UV spectroscopy[69,75,76,153], Energy Dispersive X-ray (EDX) technique[69,75,76,125,126,153], X-Ray Diffraction (XRD)[133], IR spectroscopy, EFM[93,107,142,161], GC[154,162], LC-MS[110], GC-MS (Gas chromatography-Mass spectroscopy)[162], HPLC-RP [3], DFT [121,128], EDS [42,88], TED[122], LPR (Linear Polarization Resistance)[7,21,85,135], RSM (Response Surface Methodology)[118,140,173], Raman spectra[167] and Fluorescence spectra[117]. Various quantum chemical study were analyzed by HOMO and LUMO of molecular modeling[45,57,59,122,128,148,163].

Active phytoconstituents present in green inhibitors: Plant extraction products are acts as a good potential corrosion inhibitor foraluminium and it's alloy in various acidic, alkalineand other media.The active constituents of green inhibitors are varied from one plant species to another species but their structures are closely related to their number of organic molecule, e.g., *Lawsoniainermis* (Henna)[2,40,76,131]contains naphthoquinone, Phenolic compounds, Terpenoids, Sterols, Coumarin, Amino acid and Fatty acid. *Azadirachtaindica* (Neem)[6,70,114,119,139,157,158] contain Nimbolinin, Nimbin, Nimbidin, Nimbidol and Salannin. *Delonix regia* (Gulmohar)[11,120,143,152] contain carbohydrates, amino acids, tannins, flavonoids, phytosterols, alkanes, esters and anthocyanin pigments.Quercetin is one of the flavonoid compounds present in Red onion skin [22.]. *Aloe vera* [34] contain compounds such as salicylates, magnesium lactate, acemennan, lupeol, campestrol, sterol, linolenic, aloctin and anthraquinones. *Vernonia Amygdalina*[50] leaf extract contains alkaloid, saponins, flavonoids, tannins etc. *Morusnigra* (Black mulberry) [52] extract contains gallic acid, ascorbic acid, malic acid and citric acids.

Withania somnifera[56] contains many alkaloids like anaferin, anahygrine, betasisterol, chlorogenic acid, cystein, cuscohygrine, pesudotropine, scopoletin, somniferienetropanol, withanine, withananine etc. withaferin A and withanolides A-Y are the main steroidal lactones. Main constituent of *Spondiasmombin L.*[57] contain ascorbic acid, riboflavin, thiamine, and nicotinic acid. Azwain (*Trachyspermumcopticum*)[58,137] seed contain camphene, carvacrol, pcymene, dipentene, myrcene, a- and b- pinesnes, phenol, aand b-plellandrenes, g-terpinene, thymine, thymol, linoleic, oleic, palmitic petroselinic acid, resin acids.*Cuminumcyminum* (Cumin, Jeera)[71,159,170] contain Cuminaldehyde can be predominantly affecting the oxygen atom present in it. Castor seed contains the alkaloid ricinine. *Anogeissusleiocarpus* leaves[74] contain saponin, tannins, flavonoid, anthraquinones, cardiac glycosides, alkaloids and steroid. *Salvia Judica*[77] contain tannins, organic and amino acids, alkaloids and pigments, some triterpenoids, diterpenoids, mono-terpenoid, caffeic acid derivative, chlorogenic derivative, rosmarinic derivative and ferulic derivative. Date palm (*Phoenix dactylifera L.*)[88] leaves containin phytochemicals like phenolics, carotenoids, and flavonoids.

***Tinosporacordifolia* (Linn.)**[111] contain Berberine, Tembeterie and Palmetine. *Coriander* [121] seeds contain linalool, 3,7-dimethylacetate-2,6-octadien-1-ol, tetradecanoic acid, n-hexadecanoic acid, hexadecadien-1-ol, 6-octadecenoic acid, hexadecanoic acid, tetradecyl ester, hexadecadienoic acid, and methyl ester. Natural Honey[127] contain saccharides, organic acids, amino acids, polyphenols, mineral matter, aromatic substances, trace amounts of fat, enzymes and vitamins.*Ocimum sanctum* (Tulasi)[132] contains such as Ursolic acid, Eugenoln, linalool and germacrene. *Phyllanthus amarus*[146] has major chemical constituents are phyllanthusin D, phyllanthin, hypophyllanthin, quercetin, amarin, 1,2,8-trimethyl-7-vinylnaphthalene, etc. *Newbouldialaevis* leaf extract[147] contains tannins, alkaloids, saponnins and flavoniods. The presence of these constituents makes it suitable for corrosion inhibition considerations. *Terminalia ivorensis*[149] contain saponnin, alkaloids, tannins and flavonoids. *Peganum harmala*[141] contain Harmine and harmaline as main alkaloids. *Cordia Dichotoma*[160] contain amyrins, betulin, octacosanol, lupeol-3-rhamnoside, β-sitosterol, β-sitosterol-3-glucoside, hentricontanol, hentricontane, taxifolin-3, 5-dirhmnoside and hesperitin-7-rhamnoside. *Bassia muricata*[161] extract contain flavonoids and alkaloids which involves hetero atoms such as N, S, O, aromatic ring and π-electrons, through which they will be adsorbed on the metal surface and mitigate corrosion process. Major constituents of the *Artemisia Herba Alba* essential Oil (AHAEO)[162] contain camphor, chrysanthenone, 1,8-Cineol, α-Thujone and β-Thujone. Shatavari (*Asparagus Racemosus*)[163] have steroidal saponin-Shatavarin and Sarsasapogenin as active constituents. *Euphorbia neriifolia Linn*[164,168] contain various compounds like alkaloids, flavonoids, steroids, tannins, triterpenoids, saponins etc. which has O, N and S atoms with lone pair electrons to form co-ordinate bonding with metal. *Mentha pulegium*[165] contain menthone, geraniol, pulegone, isopulegyl acetate, nopol, cinnamyl alcohol, oocimenone and myristicin. *Ziziphus Jujube*[170] leaf extract contain Dihydides, ketones, amines, amides, alcohols, aromatic or phenolic compounds all have known inhibitory properties. *Ricinus Communis*[171] contain phytochemicals of alkaloids, cardiac glycosides, flavonoids, phenolics, phytates, saponins and tanins. *Sapiumellipticum leaf*[172] extract is rich in flavonoids, phenolics, alkaloids, saponins, tannins, terpenoids, steroids.

A list of various plant extract used as green corrosioninhibitors for aluminium and it'salloywasshown in Table-1.

Table-1: Green corrosion inhibitors for Aluminium and it's alloy in different media.

No.	Metal	Medium	Inhibitor	Additive	Methods	Findings	Ref.
1	Al-Mg Alloy	HCl	*Rosmarinus officinalis L.* leaves	-	Polarization and EIS methods	A Cathodic type of inhibitor, Freundlich adsorption isotherm	1
2	Steel and Al	0.1HCl, 0.1MNaOH, 0.1MNaCl	*Lawsonia Inermis* (Henna) leaves	-	Weight loss methods	Temkin adsorption isotherm, maximum Inhibition efficiency (I.E.) up to 99.8 % with NaOH	2
3	Al-2.5 Mg Alloy	3 % NaCl	*Rosemary* leaves	-	External standard method, polarization, HPLC-RP	Cathodic type of inhibitor, Freundlich adsorption isotherm	3
4	Al	2.0 M HCl	*Opuntia ficus* Mill. (Opuntia) stem	-	Weight loss with temperature, Hydrogen Evolution, Polarization methods	Langmuir adsorption isotherm, adsorption process is spontaneous, Shown pitting corrosion	4
5	2S, and	0.1 M HCl,	*Vernonia*	-	Weight loss,	A maximum I.E.up to 49.50	5

	3RS Al Alloy	0.1 M HNO_3	*amygdalina* (Bitter leaf)		corrosion rate, pH value	% for the 0.1 M HCl and 72.50% for 0.1 M HNO_3	
6	Al	HCl	*Carica Papaya* & *Azadirachta indica* plant extract	-	weight loss with temperature and hydrogen evolution methods	Freundlich, Temkin and Flory-Huggins adsorptionisotherms	6
7	Al	3 % NaCl	Rutin & Quercetin (Natural compounds)	-	Potentiodynamic polarization and Polarization resistance method, pH value, Electro-conductivity and temperature studies	Good corrosion Inhibitor.	7
8	Al	pH 11 and 12 NaOH	*Garlic* aqueous extract	Zn^{+2}	Surface examination study and FT-IR spectroscopy	study of the influence of N-cetyl N,N,N-trimethyl ammonium bromide (CTAB), a maximum I.E. up to 98.00 %	8
9	Al	1, 2 and 4 N HCl	*Ficus religeosa* (peepal) bark	-	Weight loss and thermometric methods	A maximum I.E. up to 96.90 %	9
10	Al	0.1 N and 0.5 N HCl	*Prosopis cineraria* plant extract	-	Weight loss and thermometric methods	A maximum I.E. up to 96.93 %	10
11	Al	HCl	*Delonix Regia* seed and leaves	-	Hydrogen evolution method, Kinetic and Electrochemical studies	First-order type of reaction and physiosorption based mechanism, Langmuir adsorption isotherm	11
12	Al	2 M HCl, 2 M KOH	*Sansevieria trifasciata* leaf	Halide salts KCl< KBr < KI	Gasometric technique and temperature studies	Freundlich adsorption isotherm and synergistic effect	12
13	Al-Zn-Mg Alloy	Caustic soda soln	*Hibiscus teterifa* Plant extract	-	Weight loss and adsorption method	Langmuir adsorption isotherm	13
14	Al	0.5,1,2N HCl 0.5,1,2N H_2SO_4	*Capparis deciduas* plant extract	-	Weight loss with temperature	The inhibition efficiency with inhibitor concentration	14
15	Al	0.1 M HCl	*Pachylobus edulis,Raphia hookeri* exudates	-	Weight loss with temperature	Temkin adsorption isotherm, adsorption process is spontaneous	15
16	Al	HCl	*Raphia hookeri* Exudates gum	I^-, Br^-, Cl^- ions	Gravimetric, gasometric and thermometric techniques, Electrochemical studies	synergistic effect, Freundlich, Langmuir and Temkin adsorption isotherms and addition ofhalides improves inhibition efficiency	16
17	Al	1 M HCl	*Pachylobus Edulis* exudate gum	Halide ion KI >	Weight loss and Thermodynamic methods	Synergistic effect and Temkin adsorption isotherm	17

				KBr > KCl.			
18	Al	0.5 M HCl	*Azadirachta Indica* leaves	0.01M NaI	polarization and EIS methods	Synergistic effect and Freundlich adsorption isotherm	18
19	Al	0.5MNaCl, 2 M NaOH	*Ambrosia maritime L.* (damsissa) Plant extract	0.5 M NaCl	Chemical gasometry technique, Potentiodynamic and EIS methods	A mixed type inhibitor and shown pitting potential	19
20	Al	0.5M NaOH, H_2SO_4	*Vigna unguiculata* husk-exudate	-	weight loss, polarization and EIS method	Freundlich and Temkin adsorption isotherms	20
21	Al	2 M NaCl	Citric acid	-	Potentiodynamic polarization, EIS and linear polarisation resistance (LPR) techniques	Mixed type inhibitor with a predominantly Cathodic action.	21
22	Al	2 M HCl	Red onion skin	-	weight loss, temperature study and half- life study	Langmuir adsorption isotherm, Physisorption action, first order reaction	22
23	Al	2 M NaOH	*Gossipium hirsutum L.* leaves & seeds	-	weight loss and temperature studies	A maximum I.E. for GLE up to 97.00 % I.E. while the GSE up to 94.00 %	23
24	Al	0.5 MNaOH	*Hibiscus sabdariffa* leaves	-	Electrochemical Methods	A mixed type Of nhibitor, Langmuir and Dubinin-Radushkevich adsorption isotherm	24
25	Al	NaOH (pH 12)	*Hibiscus rosasinensis* flower	Zn^{2+}	polarization, EIS method and FT-IR spectroscopy	A cathodic type of inhibitor and maximum I.E. up to 98.00%	25
26	Cu & Al	0.1 M HCl	*Zenthoxylum Alatum* plant extract	-	weight loss and polarization method	Langmuir adsorption isotherm	26
27	Al	4 N NaOH	*Abrus precatorius* seed	-	weight loss and polarization method	acts as an effective inhibitor	27
28	Al alloy AA 1060	1 M HCl	*Ginseng* root	KI	Weight loss with temperature	Synergistic effect, Freundlich adsorption isotherm and adsorption found to be a spontaneous process	28
29	Al AA 1060	0.02-2MHCl	*Raphia hookeri* Exudate gum	-	Weight loss and thermometric studies	Temkin adsorption isotherm and adsorption processis spontaneous	29
30	Al alloy AA 1100	0.5 M HCl	*Piper nigrum Linn.* seeds	-	weight loss, kinetic, adsorption and surface analysis method, FT-IR spectra	Kinetic- thermodynamic model, act as a good inhibitor, maximum I.E. up to 85.69 %	30
31	Al	1 M HCl	*Ipomoea invulcrata* leaves	KI and KSCN	weight loss, kinetic and thermodynamic studies	Langmuir adsorption isotherm	31

32	Al	2 M HCl	*Chlomolaena odorata L.* leaves	-	gasometric and thermometric method	Langmuir adsorption isotherm	32
33	Al	HCl	*Ananas sativum* leaves	-	weight loss, hydrogen evolution method	Langmuir adsorption isotherm	33
34	Al	0.5 M HCl	*Aloe Plant* extract	Iodide ion (NaI)	Hydrogen evolution and mass loss and electrochemical studies, SEM techniques	A mixed type of inhibitor and Freundlich adsorption isotherm	34
35	Al alloy AA 3003	0.5 M HCl	*Euphorbia hirta* And *Dialum Guineense* plant extract	-	Gravimetric and thermodynamic technique	Langmuir adsorption isotherm	35
36	Al	0.5 M HCl	*Cocos nucifera L.*	-	Chemical technique	Langmuir adsorption isotherm and maximum I.E. up to 93.00%	36
37	Al alloy AA 8011	0.5 M HCl	*Euphorbia Hirta* and *Dialum Guineense* leaf	-	Gravimetric, temperature study and thermodynamic parameter	Langmuir adsorption isotherm and adsorption behave a physisorption	37
38	Al	1 M HCl	*Gossipium hirsutum L.* leaves	-	weight loss and temperature studies	Langmuir adsorption isotherm and maximum I.E. up to 92.00%	38
39	Zn-Al alloy	2 M HCl	*Ocimum gratissium* seed	Halide Ion (KI and KCl)	Gravimetric and temperature studies	Synergistic effect and Freundlich adsorption isotherm	39
40	Al Alloy AA 5083	Sea water	*Lawsonia Inermis* (Henna) leaves	-	Weight loss, polarization, FT-IR and EIS measurement	Mixed type of inhibitor and predominantly to cathodic action	40
41	Al	2 M HCl	*Aningeria robusta* leaves	KI	Hydrogen evolution and temperature studies	synergism effect, Langmuir adsorption isotherm	41
42	Al-Mg-Si alloy	Sea water	Natural honey, Vanillin and Tapioca starch (TS)	-	Electrochemical techniques, SEM, EDS, FT-IR spectrum	Find out the molecular structure of these inhibitor	42
43	Al	2 M HCl	*Cola acuminata* leaves	-	Gasometric, adsorption studies and SEM	Frumkin adsorption isotherm	43
44	Al- alloy	2 M HCl	*Chromolaena odorata* leaves	-	Gasometric, adsorption studies, Tafel method and SEM	Freundlich adsorption isotherm,	44
45	Al	0.5M NaOH	*Bucolzia Coriacea* and *Cninodoscolu-schayansa* leaves	-	Gas volumetric, Molecular modeling technique	The structure evaluate	45

46	Al	1 M HCl	*Irvingia gabonensis* plant extract	-	Temperature and thermodynamic studies	Langmuir adsorption isotherm	46
47	Al	1 M HCl	*Anethum graveolens L.* oil	-	Weight loss, polarization and EIS methods	A cathodic type of inhibitor, Langmuir adsorption isotherm	47
48	Al	0.5M NaOH	*Bacopa monnieri* (Brahmi) stem	-	Weight loss, polarization and EIS methods	Langmuir adsorption isotherm	48
49	Al	1 M NaOH	*Piper longum* (Pipali) fruit and *Bacopa monnieri* (Brahmi) stem	-	Weight loss and chemical method	A maximum I.E.up to 95.00 % for *Piper longum* and 75.00 % for *Bacopa monnieri*	49
50	Al	1 M HCl	*Vernonia amygdalina* leaves	-	Gravimetric method	Langmuir and Flory-Huggins adsorption isotherms	50
51	Al-alloy AA 1060	1 M HCl	*Jasminum nudiflorum Lindl.* leaves	-	Weight loss, polarization, EIS and SEM methods	A cathodic type of inhibitor, Langmuir adsorption isotherm, physisorption and exothermic process, a maximum I.E. up to 90.00 %	51
52	Al	2 M HCl	*Morus nigra L.* (black ulberry) fruit	-	weight loss, polarization, EIS and hydrogen evolution method	Langmuir adsorption isotherm, spontaneous adsorption	52
53	Al-alloy AA 1060	1 M HCl	*Ocimum gratissimum* leaves	-	Gravimetric method	Langmuir and Flory-Huggins adsorption isotherms, order of inhibition efficiency: Distilled H_2O > C_2H_5OH > 1M HCl.	53
54	Al-alloy AA 1060	1 M HCl	*Treculia africana* leaves	-	Weight loss with temperature	Freundlich and El-Awady adsorption isotherms, first order kinetics was followed	54
55	Al-alloy AA 7075	3.5% NaCl	*Phoenix dactylifera L.* (date palm) fruit juice	-	Tafel plot, polarization and EIS	a slightly cathodic inhibitor, Temkin adsorption isotherm, a physisorption mechanism.	55
56	Al	0.5, 1, 2N HCl	*Withania somnifera* (A medicinal plant) leaves	-	Weight loss and temperature studies	Langmuir adsorption isotherm, the adsorbed layer is unimolecular, a maximum I.E. up to 99.28%	56
57	Al	0.5M H_2SO_4	*Spondias mombin L.* leaves	KI	Gravimetric, Temperature study and Quantum chemical study	synergistic effect, Langmuir adsorption isotherm, spontaneous, exothermic and physisorption	57
58	Al	0.5M NaOH	*Trachyspermum Copticum* (Azwain) seed	-	Weight loss and electrochemical methods	mixed type of inhibitor, Langmuir adsorption isotherm and maximum I.E. up to 94.00%	58
59	Al-alloy	0.4 M HCl	*Aspilia africana*	-	Gravimetric, electrochemical	Langmuir, Temkin, Freundlich and Flory-Huggins	59

	AA 3003		leaves		techniques and Quantum studies (HOMO and LUMO)	isotherms,	
60	Al	1.5 M H_2SO_4	*Chrysophyllu-malbidum* (African star apple) fruit	-	Weight loss, Thermometric methods	Temkin adsorption isotherm, adsorption process is spontaneous	60
61	Al	2 M HCl, 2 M H_3PO_4	*Ricinus communis* (Castor oil)	-	Weight loss with different time, polarization and SEM	A mixed type of inhibitor, Langmuir adsorption isotherm, a maximum I.E.up to 75.75 % in HCl and 82.35 % in H_3PO_4	61
62	Al	2.0 M HCl	*Nypa fruticans* (Nipah) frond, stalk and husk	-	Weight loss and Kinetic studies	Langmuir adsorption isotherm, detected by inductively coupled plasma (ICP-OES)	62
63	Al	0.5, 1, 2, 3N HCl	*Ocimum Basilicum* (EB), *Ocimum Canum* (EC) and *Ocimum sanctum* (ES) stem	-	Weight loss and thermometric methods	Langmuir adsorption isotherm, a maximum I.E. up to 97.09% in 0.5 N HCl	63
64	Al-alloy	2.5M HCl	*Rauvolfia vormitoria* leaves	-	Weight loss, hydrogen evolution method and microstructural studies, SEM	Temkin adsorption isotherm	64
65	Al-alloy	2M HCl	*Vernonia amygdalina* leaves	-	Hydrogen evolution method, Microstructural studies, adsorption studies and SEM	Temkin adsorption isotherm	65
66	Al	2M HCl	*Pectin* powder	-	Weight loss with temperature studies, kinetic parameters and SEM	A maximum I.E.up to 91.00 %, Langmuiradsorption isotherm	66
67	Al	0.5–3.0M HCl and H_3PO_4	*Dendro calamus-brandisii* leaves	-	Weight loss with temperature , polarization, EIS and SEM	A mixed type of inhibitor in H_3PO_4, Langmuir adsorption isotherm in both acids, cathodic type of inhibitor in HCl. maximum I.E. up to 91.30% in 1.0 M HCl and 47.1% in 1.0 M H_3PO_4	67
68	Al	1 M HCl	*Coconut coir* dust extract	-	Weight loss with temperature studies, hydrogen evolution and FT-IR method	Langmuir adsorption isotherm	68
69	Al	1 M HCl	*Cassia alata* leaves	-	Weight loss and temperature studies, UV, FT-IR and EDX	Langmuir adsorption isotherm, It is a endothermic and spontaneous process	69

					spectral studies		
70	Al	HCl	*Azadirachta indica* fruit	-	Weight loss, thermodynamic method and FT-IR spectroscopy	Langmuir adsorption isotherm, a maximum I.E. up to 92.37 %	70
71	Al	1 N HCl	*Cuminum cyminum* (Cumin) seed	-	Weight loss, polarization and EIS method	A mixed type of inhibitor, Langmuir adsorption isotherm exothermic process.	71
72	Al	0.5M HCl	*Ocimum basilium L.* oil	-	Weight loss, polarization, hydrogen evolution and EIS method	acting as a localized corrosion attack, adsorption mechanism is exothermic process and physisorption, maximum I.E. up to 78.40 %	72
73	Al	1.0 M H_3PO_4	*Coriandrum sativum L.* seeds	-	Polarization, EIS, SEM and EDS method	Langmuir adsorption isotherm, a mixed type of inhibitor	73
74	Al	0.2, 0.4, 0.6, 0.8 M HCl	*Anogeissus-leiocarpus* leaves	KI, KCl, KBr	Weight loss with thermometric method	Synergistic effect and maximum I.E. up to 95.18% with KI	74
75	Al	1 N HCl	*Albizia* (Lebbeck seed)	-	Weight loss with temperature effect, UV, FT-IR and EDX method	Langmuir adsorption isotherm, adsorption process is exothermic and spontaneous	75
76	Al	0.5 N HCl	*Lawsonia inermis* seed	-	Weight loss with temperature effect, UV, FT-IR and EDX method	Temkin adsorption isotherm, adsorption process is exothermic, endothermic and spontaneous a maximum I.E. up to 84.52 %	76
77	Al	1 M NaOH	*Salvia judica* plant extract	-	Weight loss with temperature studies	Langmuir and Temkin adsorption isotherms	77
78	Al	2 M H_2SO_4	*Portulaca Oleracea* leaves		Weight loss with temperature studies	Langmuir, Freundlich and Temkin adsorption isotherms	78
79	Al	2 M H_2SO_4	*Manihot esculentum* leaves		Weight loss with temperature studies	Freundlich adsorption isotherm	79
80	Al	1 M NaOH	*Vitex negundo* leaves	-	Weight loss, gasometric, polarization and EIS method	Langmuir adsorption isotherm, a mixed type of inhibitor, and maximum I.E. up to 78.10 %	80
81	Al	1 M NaOH	*Solanum trilobatum* leaves	-	Weight loss, gasometric, polarization and EIS	Langmuir adsorption isotherm, a mixed type of inhibitor, and maximum I.E. up to 93.90 %	81
82	Al	0.5M H_2SO_4	*Prosopis laevigata* leaves	-	Weight loss, polarization and EIS method	Temkin adsorption isotherm, a cathodic type of inhibitor	82
83	Al	0.50M HCl	*Ficus carica* leaf	-	Weight loss with temperature effect and kinetic parameters	Langmuir, Frumkin adsorption isotherm and a maximum I.E. up to 91.34 %	83
84	Al	0.5 N HCl	*Ziziphus*	-	Weight loss with	Langmuir adsorption	84

			mauritiana fruit		different time, kinetic, thermodynamic treatment and FT-IR	isotherm, a maximum I.E.up to 76.80 %	
85	Al and Al alloy (AA 5754)	3% NaCl	*Laurus nobilis L.* oil	-	Weight loss, polarization and SEM method	Langmuir adsorption Isotherm, Show pitting corrosion	85
86	Al Alloy	0.5 MHCl	*Camellia sinensis* (Green tea) plant extract	-	Weight loss and Potential measurement	Freundlich adsorption isotherm	86
87	Al	0.5,1.0,1.5M HCl 0.5,1,1.5,2M NaOH	*Cantaloupe* Juice and seeds	-	Chemical and Thermodynamic methods	Langmuir and Temkin isotherm	87
88	Al	1.0 M HCl	Date palm leaf	-	Gravimetric method, SEM and EDS techniques	Langmuir adsorption isotherm and inhibition process is spontaneous	88
89	Al- alloy AA 3003	0.25 M KOH	*Palisota hirsute* leaf	-	Gravimetric technique	A mixed type of inhibitor, adsorption process is spontaneous and a maximum I.E. up to 86.21%	89
90	Al	1.0 M NaOH	*Sinapis alba* plant extract	-	Weight loss, electrochemical polarization and SEM method	Langmuir adsorption isotherm, amixed type of inhibitor, a maximum I.E. up to 97.98%	90
91	Al	1.85 M HCl	*Carica papaya* leaf	-	Adsorption studies and hydrogen evolution method	Langmuir,Temkin, Freundlich, Frumkin adsorption isotherm was studied	91
92	Al	2 M H_2SO_4	*Carica papaya* seeds	-	Tafel polarization, EIS, SEM, kinetic and thermodynamic studies	Langmuir adsorption isotherm, a mixed type of inhibitor, maximum I.E. up to be 96.70%	92
93	Al and Al-Si Alloy	0.5 M HCl	*Phoenix dactylifera L.* aerial parts	-	polarization, EIS and EFM method	Langmuir and Temkin adsorption isotherm, a mixed type but dominantly act as a cathodic inhibitor	93
94	Al	0.5 M HCl	*Garlic* (Allium) aqueous extract	-	Weight loss with temperature	Langmuir, Temkin adsorption isotherms, adsorption process is an exothermic and spontaneous	94
95	Al	2 M H_2SO_4	*Sorghum bicolour* leaf	-	weight loss with temperature studies	Frumkin, El-Awady and Adejo-Ekwenchi adsorption isotherm	95
96	Al	0.5 mol/L	*Morinda tinctoria* leaves	Halide ion KCl, KBr,	weight loss with temperature and different immersion time,	Langmuir adsorption isotherm, a synergistic effect and adsorption	96

				KI	EIS and SEM method	process is spontaneous, a maximum I.E. up to 96.72 %	
97	Al	2 M HCl	*Melia azedarach L.* leaves	-	weight loss with temperature, polarization and EIS method	Langmuir adsorption isotherm, a maximum I.E. up to 97.30 %	97
98	Al-alloy (AA 6063)	0.5 N HCl	*Murraya koenigii* leaves	-	weight loss with temperature and chemical method	Langmuir adsorption isotherm, maximum I.E. up to 96.43 %	98
99	Al-alloy (AA 3003)	0.75 M KOH	*Xylopia aethiopica* seed	-	weight loss, adsorption studies	Langmuir, Temkin and Flory-Huggins adsorption isotherm, a maximum inhibition efficiency up to 84.53 %, the inhibition process is spontaneous	99
100	Al	1 M NaOH	*Mesem bryanthemum-nodiflorum* leaves	-	weight loss with temperature, kinetic and thermodynamic parameter and SEM method	Langmuir and Temkin adsorption isotherm, a maximum I.E. up to 95.10 %	100
101	Al-Cu -Mg Alloy	0.5 M HCl	*Sidaacuta* (*Wire weed)* leaves and seed	-	corrosion rate, weight loss, percentage protection, acid induced corrosion	a percentage protection increases from 37.42 % to 93.63 % within a ten day period	101
102	Al	1.0 M HCl	*Xanthan gum*	-	weight loss with temperature, polarization measurements	Temkin adsorption isotherms, a mixed type with predominant cathodic inhibitor.	102
103	Al alloy (AA 1060)	1 M HCl	*Jatropha curcas* leaves	-	weight loss with temperature studies	Temkin and Freundlich adsorption isotherms, a maximum I.E. up to 76.49%	103
104	Al	0.1 M HCl	*Ficus sycomorus* gum	-	gravimetric with temperature studies	Langmuir adsorption isotherm, exothermic, spontaneous process and physisorption which is first order type	104
105	Al	HCl	Olive seeds	-	weight loss, hydrogen evolution, surface examination study (SES) and EIS method	Langmuir adsorption isotherm, shown general and pitting corrosion, adsorption process is a spontaneous	105
106	Al	1 M HCl	Fennel seed	-	gravimetric, galvanostatic polarization and EIS method	a mixed type with predominance of cathodic inhibition	106
107	Al	1 M	*Melilotus*	-	weight loss,	Temkin adsorption isotherm,	107

		HCl	*officinalis* aerial part		hydrogen evolution, polarization, EIS, EFM and SEM method	a mixed type of inhibitor	
108	Al-alloy 2024	1M HCl	*Thymus algeriensis* leaves and seed	KI	weight loss, gasometric and EIS method	Langmuir adsorption isotherm, a synergistic effect and a maximum I.E. up to 78.70 %	108
109	Al	0.1 M HCl	*Lupine*	-	polarization, EIS and optical microscopic techniques	an anodic type inhibitor, inhibitors was studied by El-Awady et al. the nature of adsorption	109
110	Al	1.0 M HCl	*Trigonella foenum-graecum* (fenugreek) seeds	-	gravimetric, galvanostatic polarization and EIS method	Langmuir adsorption isotherm, a mixed type of inhibitor, Liquid chromatography-Mass spectrometry (LC-MS) analysis	110
111	Al	2 M H_2SO_4	*Tinospora-cordifolia Linn.* stem	-	temperature effect, polarization and EIS method	Langmuir adsorption isotherm, an anodic type of inhibitor	111
112	Al	1 M HCl and 0.5 M NaOH	*Cninodosculus-chayamansa* leaves	KI	weight loss with temperature	Langmuir adsorption isotherm	112
113	Al	0.5 M H_2SO_4	*Hibiscus sabdariffa* leaves	-	weight loss, polarization, EIS, SEM and FT-IR	Langmuir adsorption isotherm, a mixed type of inhibitor	113
114	Al	1.85M HCl	*Azadirachta indica* leaves	-	gasometric and SEM method	Langmuir,Frumkin, Freundlich and Temkin adsorption isotherm	114
115	Al	0.5 M H_2SO_4	*Breadfruit* peels	-	weight loss with temperature effect	Langmuir adsorption isotherm, adsorption process is spontaneous, a maximum I.E. up to 85.30 %	115
116	Al	0.5 M HCl	*Cissus populnea* stem	0.05 M KI	weight loss with temperature effect and a synergistic studies	Langmuir, Freundlich, Temkin and Flory-Huggins adsorption isotherms, a maximum I.E. up to 72.44 %	116
117	Al	H_2SO_4	*Betanin* beetroot root	Zn^{+2}	weight loss synergistic effect, Polarization, EIS, FT-IR and Fluorescence spectroscopy	an anodic type of inhibitor, Addition of N-cetyl-N,N,N-trimethyl-ammonium bromide (CTAB), maximum I.E. up to 98.00%	117

118	Al	0.5 M and 2 M HCl	*Gongronema-latifolium* leaf	-	weight loss with temperature and statistical analysis	central composite design and response surfacemethodology a maximum I.E. up to 74.14%,	118
119	Al	0.5 M and 2 M HCl	*Azadirachta indica* leaf	-	weight loss and thermometric methods	Langmuir adsorption isotherm	119
120	Al-alloy 2S	HCl	*Delonix regia* extract	-	weight loss with time, hydrogen evolution at 30°C and polarization method	Langmuir adsorption isotherm	120
121	Al	1 M HCl	*Coriander* seeds	-	weightloss, EIS and quantum studies	Density Functional Theory (DFT)	121
122	Al-alloy (AA 3003)	0.1 M HCl	*Kola nitida* seed	-	weight loss, EIS and computational modeling studies	Langmuir adsorption isotherm, showing HOMO, LUMO and TED, adsorption process is a strong and spontaneous	122
123	Al	Bio-diesel	*Rosemary* leaves	-	weight loss, polarization and SEM method	Langmuir adsorption isotherm, a mixed type of inhibitor with predominant anodic	123
124	Al	1 M NaOH	*Piper longum* seed	-	weight loss, polarization and EIS studied	Langmuir adsorption isotherms, a mixed type of inhibitor, a maximum I.E. up to 94.00 %	124
125	Al-alloy (AA 3003)	0.1 M HCl	*Nicotiana tabacum* leaf	-	SEM, AFM, FT-IR and EDX techniques	Langmuir adsorption isotherm, a mixed type of inhibitor with a predominant cathodic effect	125
126	Al	2 M HCl	*Andrographis paniculata* plant extract	-	Tafel polarization, EIS, SEM and EDX method	anodic type inhibitor, at lower and a mixed type at higher inhibitor concentration, Langmuir adsorption isotherm, maximum I.E. up to 91.55 %	126
127	Al-alloy (AA 5052)	0.5 M NaCl	Honey (various types)	-	Electrochemical methods	Langmuir adsorption isotherm, a mixed type of inhibitor	127
128	Al	HCl	*Mesem bryanthemum-nodiflorum* leaf	-	Quantum chemical studies, using density functionaltheory (DFT)	a cathodic type of inhibitor, show HOMO and LUMO molecular modeling	128
129	Al	1 N HCl	*Cucurbita maxima* peel	-	weight loss with temperature effect	Langmuir adsorption isotherm, a maximum	129

						I.E. up to 99.00%	
130	Al	0.75, 1.0 and 1.25 M HCl	*Bacopa monnieri* (Brahmi) leaves	-	weight loss with temperature, polarization and EIS methods	Langmuir adsorption isotherm, a mixed type of inhibitor, a maximum I.E. up to 91.85%	130
131	Al	0.75 M HCl	*Lawsonia inermis* (Henna) leaves	-	weight loss with temperature, polarization and EIS methods	Langmuir adsorption isotherm, a mixed type of inhibitor, a maximum I.E. up to 85.34 %	131
132	Al	0.75 M HCl	*Oscimum sanctum* (Tulsi) leaves	-	weight loss with temperature effect, polarization and EIS method	Langmuir adsorption isotherm, a mixed type of inhibitor, a maximum I.E. up to 85.17 %	132
133	Al	1 M H_2SO_4	*Dryopteris cochleata* leaf	-	weight loss, EIS, X-ray diffraction, SEM and FT-IR method	Freundlich adsorption isotherm, a mixed type of inhibitor	133
134	Al-alloy	1 M NaOH	*Moringa oleifera, Terminalia arjuna* and *Mangifera Indica*	-	gravimetric, polarization, EIS, SEM and AFM method	Langmuir adsorption isotherm, all are mixed type of inhibitors	134
135	Al-alloy	1 M NaOH	*Cannabis sativa* (CS), *Rauwolfia serpentine* (RS), *Cymbopogon citratus* (CC), *Annona squamos*a (AS) and *Adhatoda vasica* (AV) leaves	-	weight loss, potentiodynamic and linear polarization resistance (LPR) techniques, EIS, SEM and AFM method	Langmuir adsorption isotherm, all are mixed type of inhibitors, a maximum I.E. up to 97.00 %	135
136	Al	0.25 M NaOH	*Apium graveolens L.* (Celery Seeds) seed	-	weight loss, and FT-IR method	Langmuir and Dubinin-Radushkevich isotherms, a maximum I.E. up to 93.33%	136
137	Al	0.5 N HCl	Azwain seed	-	weight loss, EIS and SEM method	Langmuir and Frumkinadsorption isotherms, a mixed type of inhibitor, a maximum I.E. up to 90.00 %	137
138	Al	0.5 M HCl and 0.1 M NaOH	*Areca* fat species	-	weight loss, Tafel, SEM and AFM method	Langmuir adsorption isotherm, a mixed type of inhibitor	138

139	Al	0.5 M HCl	*Azardirachta indica* (Neem) leaves ark's	-	weight loss with temperature effect	Langmuir, Freundlich and Termkin adsorption isotherm, maximum I.E. up to 85.00 %	139
140	Al	1 M HCl	*PawPaw* leaves	-	weight loss, thermometric, polarization, SEM, FT-IR and RSM method	Langmuir adsorption isotherm, a mixed type of inhibitor,maximum I.E. up to 80.58%	140
141	Al-alloy (AA 6063)	1 M HCl	*Peganum harmala* grain	-	weight loss and polarization method	Langmuir adsorption isotherm, a maximum I.E. up to 91.78 %	141
142	Al	1 M H_2SO_4	*Tecoma* leaf extract	-	weight loss, polarization, EIS, EFM and SEM method	Langmuir adsorption isotherm, a mixed type of inhibitor, a maximum I.E. up to 90.20 %	142
143	Al	1 M HCl	*Delonix regia* flower	-	weight loss with temperature effect, half-life and rate constant studies	Langmuir adsorption isotherm, an adsorption process is spontaneous, a maximum I.E. up to 87.70 %	143
144	Al-1.0wt % Zn alloy	0.5 and 1.0 M HCl	*Vernonia amygdalina* (bitter leaf), *Piper nigrum* (uziza), *Telfairia occidentalis* (ugu) leaves	-	Weight loss with different time in hrs.	It is an effectively inhibitor	144
145	Al	1 M H_2SO_4	*Persea americana* leaves	-	weight loss with temperature effect and Kinetics-thermodynamics parameters	Langmuir and Temkin adsorption isotherms	145
146	Al	1 M HCl	*Phyllanthus amarus* leaves	-	weight loss, potentiodynamic and linear polarization SEM and FT-IR method	Langmuir and Freundlich adsorption isotherm, a mixed type of inhibitor, an adsorption process is an exothermic and spontaneous	146
147	Al-alloy (AA 5052)	0.5 M HCl	*Newbouldia laevis* leaf	-	weight loss and polarization method	Langmuir and Temkin adsorption isotherm, an adsorption process is spontaneous, a maximum I.E. up to 87.00%	147
148	Al-alloy	1 M HCl	*Papaya* peel	-	Tafel, polarization, EIS, SEM, AFM and Quantum chemical studies	Langmuir adsorption isotherm, a cathodic type of inhibitor, shown HOMO	148

						and LUMO	
149	Al-alloy (AA 8011)	0.5 M HCl	*Terminalia ivorensis* leaf	-	weight loss method	Langmuir and Temkin adsorptio n isotherm, adsorption process is chemisorption and physisorption, a maximum I.E.up to 89.56 %	149
150	Al	0.5 N, 0.3 N and 0.1N NaOH	*Chrys-anthemum* flower	-	weight loss, polarization, EIS and SEM method	Langmuir and Temkin adsorption isotherm, a cathodic type of inhibitor	150
151	Al-alloy (AA 8011)	1 M HCl	*Allamanda cathartica* leaves	-	weight loss with temperature effect	Freundlich adsorption isotherm, an adsorption process is spontaneous	151
152	Al	0.75 M, 1.0 M and 1.25 M HCl	*Delonix regia* (Gulmohor) plant extract	-	weight loss with temperature effect, polarisation and EIS method	Langmuir adsorption isotherm, a mixed type of inhibitor, a maximum I.E. up to 93.48 %	152
153	Al	1 M HCl	*Polygonatum-odaratum* leaves	-	weight loss with temperature effect, polarization, EIS, SEM, FT-IR, UV visible and EDX method	a mixed typeof inhibitor, a maximum I.E. up to 94.70 %	153
154	Al alloy Al-Si-Fe/ SiC	0.5 M H_2SO_4	*Acacia senegalensis* stem	-	weight loss with temperature effect, polarization FT-IR, GC-MS and SEM method	Langmuir adsorption isotherm, a maximum I.E. up to 92.66 %	154
155	Zn-Al 27 alloy	1.0 M and 1.5 M HCl	*Talinum Triangulare* leaf and *Musa sapientum* peel	-	weight loss method	a maximum I.E. up to 62.30 % and 63.27 % in 1.0 M HCl and in 40.54 and 38.45 % in 1.5 M HCl	155
156	Al	1 M HCl	*Citrus synensis* (Orange fruit) seed	-	weight loss and phytochemical analysis	a maximum I.E. up to 38.37%	156
157	Al	HCl	*Azadirachta indica* (Neem) leaf	-	weight loss with temperature effect and kinetic parameters	Langmuir adsorption isotherm, a maximum I.E. up to 96.41 %	157
158	Al	HCl	*Azadirachta indica* (Neem) leaf	-	weight loss, polarisation and EIS method	a mixed type of inhibitor	158

159	Al	HCl	*Cuminum cyminum* (Jeera) seed	-	weight loss with temperature effect and kinetic parameters	Langmuir adsorption isotherm, a maximum I.E. up to 88.39 %	159
160	Al-Alloy (AA 6063)	0.5 M HCl	*Cordia dichomota* seeds	-	weight loss, FT-IR, EIS and SEM method	Langmuir adsorption isotherm, El-Awady'smodel, a maximum I.E. up to 90.13 %	160
161	Al	1.0 M H_2SO_4	*Bassia muricata* plant extract	-	weight loss, polarization, EIS, EFM, SEM, AFM, activation and adsorption parameters	Temkin adsorption isotherm, a mixed type of inhibitor	161
162	Al	1 M HCl	*Artemisia herba alba* essential oil	-	weight loss, polarization, EIS, SEM, Chemical analysis by Gas chromatography and GC-MS	Langmuir adsorption isotherm, a mixed type of inhibitor, and a maximum I.E. up to 92.00 %	162
163	Al	1 M HCl	*Asparagus racemosus* (Shatavari) leaf	-	weight loss, quantum chemical analysis and SEM method	Langmuir adsorption isotherm, show HOMO and LUMO data, a maximum I.E. up to 72.28 %	163
164	Al	1, 2 and 3 N HCl	*Euphorbia neriifolia Linn.* aerial part	-	weight loss and thermometric method	a maximum I.E. for stem extract up to 94.92 %, 87.12 % for leaf extract and 80.25 % for flower extract	164
165	Al	0.1 M Na_2CO_3	*Mentha pulegium* essential oil	-	polarization and EIS method	a mixed type of inhibitor, a maximum I. E. up to 94.16 %	165
166	Al	2 M HCl	*Solanum xanthocarpum* leaves and stem	-	weight loss and hydrogen evolution method	a maximum I.E. up to 94.53% in leaves and 83.85% in stem extract	166
167	Al	1 M HCl	Guar gum		gravimetric and temperature effect, EIS, FT-IR, Raman spectra, SEM method	Temkin adsorption isotherm, a mixed type of a inhibitor	167
168	Al	1, 2 and 3 N HNO_3	*Euphorbia neriifolia Linn.* aerial part	-	Weight loss, thermometric, corrosion rate measure	Langmuir adsorption isotherm, a maximum I.E. up to 92.62 %	168
169	Al	HCl	*Foeniculum vulgare mill* (Fennel) seed	-	weight loss with temperature effect and kinetic parameters	Langmuir adsorption isotherm, a maximum I.E. up to 92.01 %	169
170	Al	HCl	*Cuminum*	-	weight loss,	a mixed type of inhibitor,	170

			cyminum (Jeeru) seed		polarization, EIS and SEM techniques	a maximum I.E. up to 88.39 %	
171	Al	1 M HCl	*Ziziphus jujube* leaf	-	weight loss, microscopic examination test, FT-IR, SEM method	Langmuir adsorption isotherm, a maximum I.E. up to 91.26 %	171
172	Al	1.0 M HCl	*Ricinus communis* (Castor oil)	-	Thermometric, gravimetric analysis and thermodynamic parameters	Langmuir, Frumkin, Temkim and Flory-Huggins isotherms, a maximum I.E. up to 83.93%	172
173	Al-alloy (AA 3003)	1 M HCl	*Sapium ellipticum* leaf	-	weight loss, EIS, FT-IR and RSM method	Langmuir adsorption isotherm, mixed type of inhibitor, a maximum I.E. up to 96.73%	173
174	Al and vynil-tri etoxy silane (VTES) coated Al	0.05 M H_3PO_4	*Garlic* extract	-	Temperature effect, polarization and EIS method	a maximum I.E. over 90.00 % being recorded	174
175	Al	0.5 M HCl	*Analgin* extract	-	weight loss with temperature effect, polarization , EIS, computational and AFM methods	Langmuir adsorption isotherm, mixed type of inhibitor, a maximum I.E. up to 92.00 %	175
176	Al	1 M H_2SO_4	*Hemerocallis fulva* Plant extract	-	weight loss with temperature effect, polarization, OCP, EIS, SEM with EDX, AFM, XPS (X-ray Photoelectron spectroscopic studies	Langmuir adsorption isotherm, mixed type of inhibitor, a maximum I.E. up to 89.00 %	176

Conclusion

In this review paper, research works produced over the past background on the corrosion of aluminium and it's alloy in various medium and their corrosion inhibition by using a various green (natural) inhibitors was presented. Pure aluminium metal and different aluminium alloy material were tested. Various solvents are used to formulate extracts of fruits, flower, leaves, seeds, roots, peels, bark, stem, seed oil and exudates gum. The inhibition efficiency increases with their concentration of the green (natural) inhibitors increased. A synergistic effect preference to the addition of halides (mostly used as a KI) was also reported. Weight loss (gravimetric), temperature effect and hydrogen evolution (gasometric) are the most of used methods to investigate the corrosion of inhibition efficiency to the evaluate green (natural) inhibitors. Some studieswere performed using Potentiodynamic polarization and EIS, for finding which type of inhibitor, whether it is anodic or cathodic or as mixed type. To study surface analysis of protective film formed on metalvarious study such as SEM, AFM, FT-IR, EFM, UV-Spectroscopy, EDX, X-Ray Diffraction (XRD), DFT, EDS, TED, LPR, RSM and Quantum Chemical study (HOMO and LUMO) of the molecular modeling were used. According to some author's adsorption isotherm occurred through the Langmuir, Freundlich, Temkin, Frumkin, Flory-Huggins and follow up El-Awady's Kinetic-thermodynamic model.

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