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Review Paper

Natural products as green inhibitors for preventing corrosion of mild steel in NaOH and KOH solutions - A Review

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Abstract

Corrosion is the deterioration of a metal by chemical attack or reaction with its environment. Natural products were used for the protection of MS materials from corrosion. A percentage inhibition efficiency of inhibitors was carried out by various methods like WL and electrochemical methods such as PDP and EIS. Nature of films produce on metal surface was studied by FT-IR, UV-Visible spectroscopy, EDX and SEM methods. Physisorption of extract is best described by the Langmuir adsorption model. In this review paper, research works produced over the past background on the corrosion inhibition studies of MS in NaOH and KOH solutions by using a natural products as green inhibitors were presented.

Keywords: MS, NaOH, KOH, Natural Products, PDP, EIS, SEM.

Introduction

Corrosion is a natural phenomenon and its attack on metals has serious negative consequences. Corrosion is a huge problem whose economic consequences are disastrous and invaluable. Several techniques have been applied in order to reduce the corrosion of metals. The use of inhibitors was one of the most practical and efficient methods for protection against corrosion[1]. A corrosion inhibitor is generally referred to as a chemical substance that when applied in small quantities to a corrosive medium reduces the rate of corrosion of a metal or a metal alloy[2]. The use of natural products as corrosion inhibitors are interesting as they are eco-friendly, ecologically acceptable, readily available, inexpensive and can be used nowadays as ‘Green Inhibitors’.

The influence of inhibitors is often associated with physical or chemical adsorption. This phenomenon had been related to the presence of hetero atoms (N, O, S), and multiple bonds or aromatic rings in the inhibitor[3].

MS contains 0.05% to 0.25% by weight of carbon hence known as low carbon steel. MS is the commonly used alloy in the industries due to its remarkable features such as high thermal, low cost, easy availability, high strength, durability and electrical conductivities[4].

In this review study indicates only Langmuir adsorption isotherm. Percentage inhibition efficiency of these plant extracts was calculated by using weight loss (WL), and electrochemical tests, such as PDP and EIS measurement. The objective of the present review to summarize the results regarding corrosion inhibition of MS by using various Natural products as corrosion inhibitors in NaOH and KOH solutions published earlier than this review.

Corrosion inhibition study on MS in NaOH and KOH solutions by various Natural plant products are presented in Table-1 and Table-2 respectively.

Methodology

Solutions: In this Review, NaOH[5-16] and KOH[17,18] solutions has been investigated.

Natural products: Different parts of Natural plant such as, Leaves[5-7,9-10,13-16], Fruits[5], Roots[18], Latex[5], Oil[11,12] and Plant extract[8,18] were used as corrosion inhibitors.

Solvents: Solvents like Double distilled water[9,10] and Ethanol[5,14] were used to prepare plant extract.

Techniques: Various techniques like WL with temperature[7,8,14,16-18], WL with time[6,9-15,17], TM[5], PDP[8,12,14,18] and EIS[8] were employed.

Surface film analysis: Film formed on metal surface were studied by various techniques, like SEM[5,7,8,14,18], FT-IR spectroscopy [8,12,14,16],UV- spectroscopy[7], RSM[17] and EDX[18].

Adsorption isotherms: Langmuir adsorption isotherm[7,8,14,16,18] was suggested.

Table-1: Natural products as Green corrosion inhibitors for MS in NaOH solutions.

Natural product as Inhibitor	Solution	Techniques used	Findings	I.E. max. (in %)	Ref No.
Calotropis procera (CP) and *Calotropis gigantea* (CG) leaves, latex and fruit	0.5 and 1.0 M NaOH	WL, TM, SEM	Anodic-type of inhibitor	CP-Latex 80.18 WL, CG-Latex 80.89 WL	5
Carica papaya	0.5 M NaOH	WL with time	Effective inhibitor	53.8 WL	6
Lawsonia inermis	1 M NaOH	WL with temperature, SEM, UV spectra	Langmuir adsorption isotherm	95.97 WL	7
Mature *areca nut husk* (areca-nut)	0.5 M NaOH	WL with temperature, PDP, EIS, SEM, FTIR	Mixed-type of inhibitor. Langmuir adsorption isotherm	91.66 WL	8
Moringa oleifera [MO] and *Vitex doniana sweet* [VDS] leaf	0.5 and 1.0 M NaOH	WL with time	IE increased with the inhibitor concentrations	97.0 WL	9
Moringa Oleifera and *Psiduim Quajava* (Guava) leaves	0.5 and 1.0 M NaOH	WL with time	Corrosion rate decreased by > 60% in 0.5 M NaOH and by > 80 % in 1.0 M NaOH	--	10
Palm Oil	1 M NaOH	WL with time, Micrograph.	Prevent anodic dissolution.	--	11
Palm kernel Oil	1 M NaOH	WL with time, PDP, FTIR	WL increases with time	98.80 WL, 94.76 PP	12
Papaya (pawpaw) leaf	0.5 M NaOH	WL with time.	--	53.8 WL	13
Psidium guajava (Guava leaves)	12.5 M NaOH	WL with time and temperature, PDP, FTIR, SEM.	Mixed-type inhibitor. Langmuir adsorption isotherm	89.00 WL, 68.45 PP	14
Terminalia ivorensis leaves	3 M NaOH	WL with time.	---	77.05 WL	15
Thaumatococcus danielli (Sweet prayer) leaf	1 M NaOH	WL with temperature, FTIR.	Langmuir adsorption isotherm.	90.00 WL	16

Table-2: Natural products as corrosion inhibitor for MS in KOH solution.

Natural product as Inhibitor	Solution	Techniques used	Findings	Maximum inhibition efficiency (%)	Ref. No.
Calopogonium mucunoides Leaf	1M KOH	WL with time and temperature, RSM	--	90.12 WL	17
Pentaclethra macrophylla Bentham	0.5M KOH	WL with temperature, PDP, SEM, EDX	Mixed type of inhibitor. Langmuir adsorption isotherm.	84.02 WL	18

Abbreviations: EDX: Energy-dispersive X-ray spectroscopy, EIS: Electrochemical impedance spectroscopy, FTIR: Fourier-transform infrared spectroscopy, TM: Thermometric method, KI: Potassium iodide, WL: Weight loss, PDP: Potentiodynamic polarization, SEM: Scanning electron microscopy, MS: Mild steel, UV-vis: Ultraviolet-visible spectroscope, RSM: Response Surface Methodology, IE max (%): Maximum inhibition efficiency.

Discussion

Phytoconstituents of plant extract: For NaOH solution: *Calotropis proceraand Calotropis plant gigantea*[5,19] contain cardiac glycosides, flavonoids, terpenoids, steroids, phenolic compounds, proteins etc. *Carica papaya*[6, 20] leaf extract contains tannins and phytic acid. *Lawsonia inermis* (Henna)[7, 21] contains phenols, coumarin and fatty acid. *Mature areca nut husk*[8,22] extract contains poly-phenolic compounds, alkaloids, flavonoids, tannins, protein, fibre, fats, saponins, terpenoids and steroids.

Moringa oleifera[9,10,23] contain Quercetin and Luteolin as main components. *Vitex doniana sweet*[9] contain alkaloids, flavonoids, phenols, saponin, steroids and tannin. *Palm oil*[11] contain fatty acids, Palmitic acid or hexa decanoic acid. *Palm kernel oil*[12] contain fatty acids like lauric acid, myristic acid, palmitic acid, oleic acid and linoleic acid. Papaya *(pawpaw*) leaf[13] contain alkaloid, saponins, tannin, flavonoid and phenols. *Psiduim Quajava* (Guava) leaf[10,14,24] extract contains flavonoids, tannins, triterpenoids, saponins, sterols, alkaloids and carbohydrates.

Terminalia ivorensis[15] leaves contain flavonoids, terpenoids, alkaloids, tannins, Saponins, cardiac glycosides, anthraquinones and steroids. Sweet Prayer (*Thaumatococcus danielli*) leaf[16,25] contains proteins, tannin, alkaloids, saponins, epicatechin, steroids, terpenoids, spartein, ribalinidine, rutin, phytic acid, and kaempferol.

For KOH solution: *Calopogonium mucunoides*[17,26] contain Alkaloids, Tannins, Flavonoids, Phenols, Saponin, Phytate and Oxalate. *Pentaclethra macrophylla Bentham*[18] roots contain tannins, alkaloids, carbohydrates, amino acids and proteins.

Mechanism of corrosion inhibition: Mechanism of corrosion inhibition process occurs by three ways; (i) Adsorption of inhibitor molecules on the metal surface might be physisorption (physical interaction) when electrostatic interaction takes place between the inhibitor molecules and metal surface, (ii) By sharing or transfer of electrons from inhibitor molecules to metal surface (chemical bond) which results in chemisorption (chemical interaction) and (iii) The comprehensive adsorption route, in which the inhibitor molecules are adsorbed on the surface of metal and protective film forms on the metal surface and blocks the dissolution process by combination of both physical and chemical interactions[8].

The efficiency of corrosion inhibitor depends not only on the kind of the environment in which they act, the nature of the metal surface, and electrochemical potential at the interface, but also on the structure of the inhibitor itself, which includes the number of adsorption active centers in the molecule, their charge density, the molecular size, the mode of adsorption, the formation of metallic complexes, and the projected area of the inhibitor on the metallic surface.

Conclusion

In this review, various research works on MS corrosion in NaOH and in KOH solutions and it's inhibition efficiency by using different natural products as green inhibitors was presented. It is important to prevent the metal from corrosion through environment sustainable technology. Green corrosion inhibitor is one of the best solutions to mitigate the problem of corrosion in an alkaline medium. It is important to point out the green corrosion inhibitors are readily available, cheap and renewable and are both eco-friendly and ecologically acceptable. The percentage I.E of inhibitors was calculated using WL, PDP and EIS methods. Other methods like SEM, FT-IR, UV-Spectroscopy, RSM and EDX were also used to study the nature of surface film produce on metal. Langmuir adsorption isotherm was found as a most common isotherm. Plant extracts obtained corrosion I. E. above 53.8%, most of them around 80.2 to 98.8% (WL). Results obtained from weight loss data were in good agreement with the results obtained from PDP and EIS methods.

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