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Green Corrosion Inhibitors from Natural Sources: A Sustainable Approach

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1. Introduction

Corrosion is an unavoidable and costly problem that affects metals used in industrial, agricultural, household, and infrastructural applications. It results in material degradation, economic loss, and environmental hazards. According to global estimates, nearly 3-4% of GDP is lost annually due to corrosion-related damage. Traditional corrosion inhibitors -such as chromates, nitrites, amines, and phosphate-based additives-are effective but often toxic, non-biodegradable, and environmentally unsafe.

In recent years, the focus has shifted toward green corrosion inhibitors (GCIs), derived from plants, natural polymers, microorganisms, and agro-waste materials. These natural materials are inexpensive, renewable, eco-friendly, and compatible with sustainable development goals. Green inhibitors are rich in organic molecules containing heteroatoms(N, O, S), aromatic rings, alkaloids, polyphenols, and flavonoids, which adsorb onto metal surfaces and form protective films.

This article discusses the chemistry, mechanism, efficiency, and recent research developments related to natural-source green corrosion inhibitors.

2. Chemistry Behind Green Corrosion Inhibition

Green inhibitors typically function by adsorption on metal surfaces. Their chemical constituents contain:

$\prod$-electrons (aromatic rings, unsaturated bonds) Lone pairs on oxygen, nitrogen, sulfur atoms (in alkaloids, amino acids)

Polar functional groups (-OH, -COOH, -NH2), Tannins and polyphenols, which form coordination complexes with metal ions

These chemical groups allow natural molecules to interact with metal surfaces through physisorption, chemisorption, or mixed adsorption mechanisms, forming a thin protective barrier that reduces oxidation and dissolution of metal ions.

3. Mechanism of Action

Green corrosion inhibitors follow multiple protection pathways:

3.1. Physical Barrier Formation

Organic molecules from plant extracts adsorb onto metal surfaces and create a compact hydrophobic film, blocking electrolyte access and oxygen penetration.

3.2. Complex Formation with Metal Ions

Polyphenols, tannins, and amino acids form stable chelate complexes with Fe2+ or Fe3+ ions on steel surfaces, reducing their reactivity.

3.3. Surface Charge Modification

Adsorption of natural molecules alters the surface energy and electrochemical potential, making the metal less susceptible to corrosion reactions.

3.4. Antioxidant Action

Many plant molecules possess antioxidant properties that neutralize free radicals, reducing oxidative corrosion pathways.

4. Plant-Based Natural Corrosion Inhibitors

Plants are the most widely explored source of green inhibitors due to their rich secondary metabolites.

4.1. Leaf Extracts

Leaves contain high amounts of flavonoids, glycosides, and phenolic acids.

Examples:

Azadirachta indica (Neem) contains azadirachtin and nimbin. rich in anthocyanins and tannins.

Lawsonia inermis (Henna) contains lawsone, a quinone molecule.

These compounds adsorb effectively on mild steel and aluminum, providing 80-95% inhibition efficiency in acidic media.

4.2. Seed and Fruit Extracts

Seeds contain oils, proteins, and alkaloids.

Pomegranate peel extract - rich in ellagic acid and punicalagin.

Grapefruit seeds - contain limonoids and polyphenols.

Black pepper - contains piperine, which enhances adsorption through its aromatic ring and nitrogen atom.

4.3. Bark and Wood Extracts

Bark is rich in tannins (excellent chelating agents).

Acacia nilotica

Terminalia arjuna

Mangrove bark extract (Rhizophora species)

Tannins offer strong chemisorption and show >90% inhibition in many studies.

5. Natural Polymers and Biopolymers

Biopolymers are gaining attention because they form strong, uniform protective layers on metal surfaces.

5.1. Chitosan- Derived from chitin (crustaceans), containing amine groups. Forms chelate layers on iron and steel; efficiency: 80-92%.

5.2. Starch and Cellulose Derivatives

Hydroxypropyl cellulose and carboxymethyl cellulose can b-ind strongly with metal ions. These polymers are biodegradable and non-toxic.

5.3. Proteins and Amino Acids

Amino acids like cysteine and methionine contain sulfur and nitrogen, enhancing adsorption.

6. Microbial and Algal Corrosion Inhibitors

6.1. Algal Extracts

Marine algae contain polysaccharides and polyphenols.

Brown algae (Sargassum sp.) provide phlorotannins that inhibit iron corrosion in saline environments.

6.2. Bacterial Biopolymers

Some bacteria produce natural polymers (like EPS - extracellular polymeric substances) that act as surface-protective agents.

7. Agro-Waste as Corrosion Inhibitors

Utilizing agricultural waste aligns with green chemistry principles.

Examples:

Banana peels

Tea waste

Rice husk extract

Groundnut shells

These waste materials contain tannins, flavonoids, and lignin that act as natural inhibitors.

8. Factors Influencing Efficiency

The performance of natural inhibitors depends on:

Extract concentration Higher concentration generally increases protection up to an optimal limit.

Temperature - Higher temperatures may cause desorption, reducing effectiveness.

Solvent used for extraction Ethanol extracts usually show higher efficiency than water extracts.

Metal type and surface condition Smooth surfaces allow stronger adsorption.

pH and corrosive medium Acidic solutions require stronger inhibitor concentrations.

9. Advantages of Natural Corrosion Inhibitors

Eco-friendly and biodegradable

Low cost and easily available

High inhibition efficiency (70-97%)

Non-toxic and safe for industrial applications

Renewable and sustainable

Minimal environmental impact compared to synthetic inhibitors

10. Limitations and Challenges

Complex composition of plant extracts may cause variable results

Less stable under extreme temperature conditions

Large-scale extraction andstandardization are required

Need for long-term durability studies. Modern research focuses on nanomodification, synergistic blends, and green solvent extraction to overcome these challenges.

Conclusion

Green corrosion inhibitors derived from natural sources present a promising, sustainable alternative to toxic synthetic inhibitors. Their rich chemical composition, eco-friendly nature, and high efficiency make them ideal for industrial applications ranging from structural steel protection to oil and gas pipelines. While challenges such as standardization and long-term stability remain, ongoing research is rapidly improving their applicability.

The shift toward natural inhibitors aligns with green chemistry, sustainable materials engineering, and global environmental safety goals. As industries move

toward cleaner technologies, green inhibitors will continue to play a major role in corrosion control.

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References

1. *Raja, P. B., & Sethuraman, M. G. (2008). Natural products as corrosion inhibitor for metals in corrosive media. Materials Letters, 62, 113-116.*
2. *Verma, C. et al. (2021).Corrosion inhibition properties of environmentally benign materials. Journal of Molecular Liquids, 326, 115229.*
3. *Umoren, S. A., et al. (2019). Plant extracts and their corrosion-inhibiting constituents: A review. Chemical Engineering Communications, 207(4), 534-555.*
4. *Singh, A., et al. (2022). Green corrosion inhibitors: Recent advancements. Journal of Cleaner Production, 330, 129896.*
5. *El-Etre, A. Y. (2003). Inhibition of aluminum corrosion using natural honey. Corrosion Science, 45, 2485-2495.*
6. *Quraishi, M. A., et al. (2023). Biopolymer-based corrosion inhibitors: A sustainable approach. Progress in Organic Coatings, 178, 107374.*