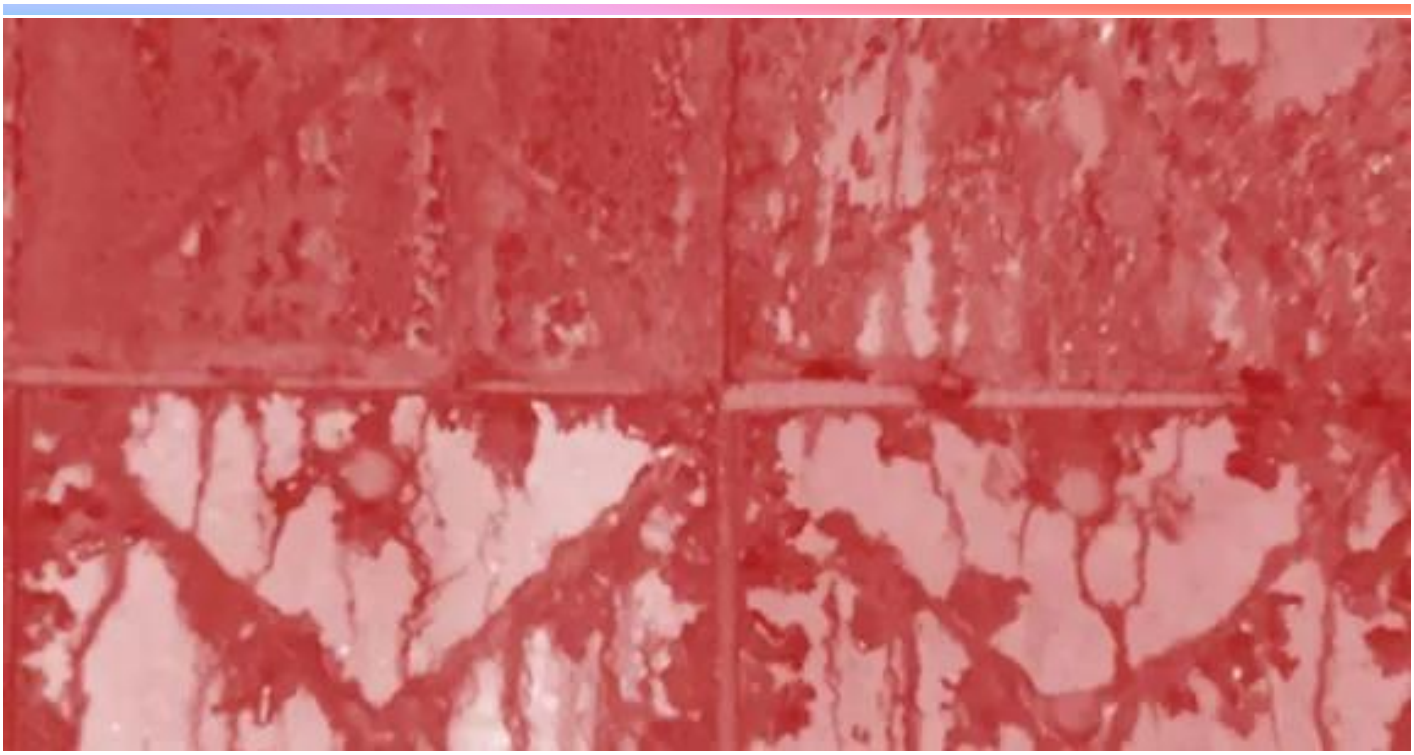


Bio-based anticorrosion additives part 2

21 January 2026, 10:55

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Applications, sectors and biomass-driven formulation logic

As outlined in the first article of this series, bio-based anticorrosion additives combine environmental advantages with functional corrosion-protection mechanisms. Their actual value, however, becomes clear at application level. Corrosion environments vary widely across sectors, and so do performance requirements, regulatory constraints and economic considerations.

This second article focuses on:

- Where and how bio-based additives are applied
- Which biomass sources are relevant
- How formulation logic links material properties to real-world corrosion challenges

Explore all articles in this series

- Small but powerful ingredients of eco-friendly coatings
- Bio-based additives: make use of your residual waste
- From Field Residue to High-Performance Coatings
- Repurposing eggshell waste as functional coating fillers
- From agricultural waste to performant coatings
- Are bio-based isocyanates in polyurethane coatings a good idea?
- Bio-based anticorrosion additives part 1
- Bio-based anticorrosion additives part 2 ? *Current article*
- Smarter coating formulation with analytics
- How to select bio-based binders for coatings

Application domains and sector-specific requirements

Construction and infrastructure

In construction, corrosion protection primarily targets reinforcing steel in concrete, structural beams and exposed metal components in bridges, tunnels and high-rise buildings. Chloride ingress from de-icing salts and carbonation processes accelerate reinforcement corrosion, leading to cracking and reduced load-bearing capacity.

Protective systems typically combine primers, sealers and water-repellent topcoats. Bio-based additives such as tannins and lignosulfonates are used in primers and concrete-related systems to reduce chloride penetration and slow carbonation. Their role is mainly inhibitive and barrier-enhancing, extending service life under outdoor exposure.

Marine and offshore environments

Marine conditions represent some of the most aggressive corrosion environments. Salt spray, high humidity, cyclic wet-dry exposure and biofouling place extreme demands on coating systems for ships, offshore platforms and port infrastructure.

Multi-layer architectures dominate, combining sacrificial primers, epoxy mid-coats and UV-resistant topcoats. Within these systems, bio-based inhibitors and smart additives are increasingly evaluated to reduce maintenance frequency and environmental impact. Examples include chitosan-based tie-coats with encapsulated bio-inhibitors for self-healing effects, as well as bio-derived components that reduce under-deposit corrosion associated with fouling.

Automotive, rail and aerospace

Vehicles are exposed to road salts, humidity and temperature fluctuations. Corrosion protection must therefore balance durability, appearance and process compatibility. Electro-coat primers, zinc-rich layers and waterborne topcoats dominate current practice.

Bio-based additives are primarily introduced to support low-VOC formulations and sustainability targets. Tannin-assisted passivation in waterborne primers and lignin-modified epoxy systems are

explored to maintain chip resistance and limit corrosion creep. In rail and aerospace, additional constraints such as weight reduction, fire resistance and UV stability guide formulation choices.

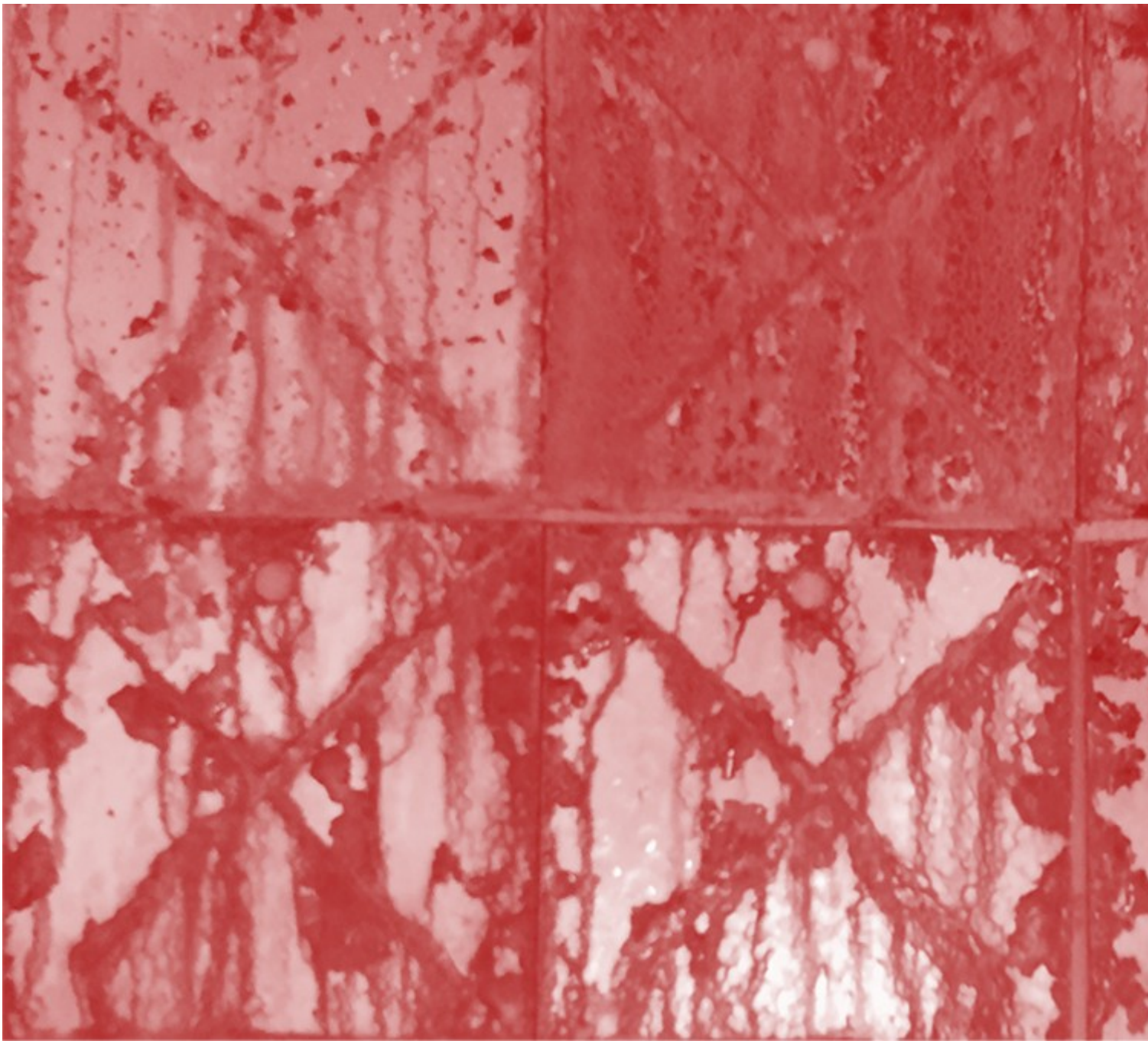
Industrial equipment and energy systems

Industrial assets operate across a broad spectrum of environments, from acidic process streams to arid, UV-intense locations. Pipelines, storage tanks, wind turbines and solar mounting structures require coatings that resist chemical attack, abrasion and weathering.

In oil and gas applications, protection against CO?- and H?S-induced corrosion remains critical. In renewable energy installations, long-term durability under salt-laden winds is key. Hybrid coating systems incorporating bio-based inhibitors are assessed for their ability to reduce environmental footprint while maintaining high performance.

Electronics and consumer goods

Smaller-scale applications such as electronic components, connectors and household appliances require thin, uniform corrosion protection to preserve functionality. Vapor-phase inhibitors and thin-film coatings are commonly used. Bio-based components are explored for moisture control and oxidation prevention in humid environments.



Biomass sources for anticorrosion additives

1. Polyphenols and tannins

Polyphenols include hydrolysable tannins and condensed tannins, derived from bark, leaves, fruits and agricultural by-products. Their multiple phenolic groups enable strong interaction with metal surfaces.

Key mechanisms:

- Formation of iron–tannate conversion layers through complexation
- Adsorption and chelation that suppress anodic dissolution
- Antioxidant activity stabilising organic binders

Formulation roles: they are applied in waterborne primers, passivating washes and post-treatments, often as alternatives to chromate-based rinses. Molecular weight distribution and pH control are critical to performance and leaching behaviour.

2. Chitosan

Chitosan is obtained by deacetylation of chitin from crustacean shells or fungal biomass. It is a film-forming, biodegradable polysaccharide with cationic character in mildly acidic conditions.

Key mechanisms:

- Electrostatic interaction with metal oxides
- Formation of dense hydrogen-bonded films
- Antimicrobial activity in fouling-prone environments

Formulation roles: chitosan serves as primer binder, adhesion promoter or component in multilayer barrier systems. Chemical modification improves solubility, flexibility and chelation capacity, while crosslinking enhances wet strength.

3. Lignin and lignosulfonates

Lignin originates as a by-product of pulp, paper and bioethanol production. Its aromatic structure provides hydrophobicity and chemical stability.

Key mechanisms:

- Antioxidant and UV-screening effects
- Mild corrosion inhibition through chelation and adsorption
- Indirect protection via coating stabilisation

Formulation roles: lignin is used as biopolyol precursor, reactive diluent or nanoparticle filler. Lignosulfonates function as dispersants for pigments while contributing secondary inhibition.

4. Vegetable oils and fatty acids

Vegetable oils from soybean, rapeseed, sunflower or linseed serve as renewable feedstocks for binders and inhibitors.

Key mechanisms:

- Hydrophobic barrier formation
- Crosslinked networks in alkyd and polyurethane systems
- Adsorption-type inhibition by fatty amide derivatives

Formulation roles: applications include alkyd resins in primers, epoxidized oils as plasticisers, and fatty-derived inhibitors for temporary protection and pipelines. Oxidative curing behaviour requires careful control.

5. Nanocellulose

Nanocellulose is produced by breaking down cellulose fibres into nanoscale structures with high surface area and strength.

Key mechanisms:

- Creation of tortuous diffusion paths for water and ions
- Reinforcement of coating networks
- Carrier function for active inhibitors with triggered release

Formulation roles: nanocellulose acts as rheology modifier, binder component or delivery platform for corrosion inhibitors. Surface modification is essential to balance moisture sensitivity and barrier performance.

Hybrid and nano-enabled systems

As discussed in the first article, hybrid architectures increasingly define advanced corrosion-protection strategies. Bio-based polymers are combined with inorganic nanoparticles to achieve synergistic effects.

Typical concepts include:

- Chitosan or lignin nanoparticles loaded with benign inorganic inhibitors
- Nanocellulose carriers enabling pH-triggered release at defect sites
- Biomass-derived graphenic carbons to enhance barrier and electrical insulation

These systems reduce total inhibitor dosage while extending service life and maintaining low-VOC formulations. Proper dispersion and validation under realistic exposure conditions remain essential.

Conclusion

Bio-based anticorrosion additives translate sustainability ambitions into practical coating solutions across sectors. Each biomass source contributes distinct chemical functionality, from polyphenolic passivation to hydrophobic barrier formation and nano-enabled delivery.

When integrated into hybrid coating systems, these additives support durable corrosion protection while aligning with circular-economy principles. As sourcing becomes more standardised and formulation knowledge matures, bio-based solutions increasingly meet or exceed conventional performance benchmarks.

Overview of the series

Bio-based anticorrosion additives are no longer experimental concepts. They are becoming functional components in primers, topcoats, surface treatments and process fluids. By combining adsorption, chelation, hydrophobic film formation and antioxidant stabilisation, they offer protection while supporting sustainability goals.

As outlined in the first article of this series, biobased corrosion-inhibiting additives are driven by system-level mechanisms, regulatory and market drivers, and the shift toward waterborne and low-VOC coating systems.

Discover the other article in the series:

- Part 1: context, mechanisms, drivers and system-level insights

Discover the VLAIO COOCK+ AddBIO project

Sirris is involved in research on the conversion of residual biomass into functional anticorrosion and hydrophobic additives within the VLAIO COOCK+ AddBIO project.

Discover the VLAIO COOCK+ AddBIO project

Are you considering bio-based solutions for corrosion protection?

Get in touch with Pieter Samyn to exchange insights and assess opportunities together.

Contact us

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