MIMOSA TANNIN BIOMASS EXTRACT AS AN ENVIRONMENTALLY SAFE CORROSION INHIBITOR TO ENHANCE THE PROTECTIVE PROPERTIES OF RUST CONVERTER

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The study investigates the potential of Mimosa biomass extract as a green corrosion inhibitor in protective paint coatings. The extract's natural phenolic compounds enhance anticorrosive properties, offering an eco-friendly alternative to traditional inhibitors in coating formulations for improved steel surface protection.

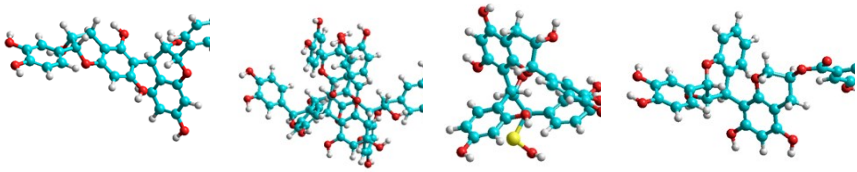
Keywords: green corrosion inhibitor, eco-friendly coatings, protective paint systems, anticorrosive properties, biomass-derived additives, sustainable materials

Introduction. The increasing demand for environmentally friendly corrosion protection technologies has driven the search for bio-based and sustainable alternatives to conventional rust converters and corrosion inhibitors. Among natural sources, plant-derived polyphenols, namely particularly tannins have shown promise due to their ability to chelate metal ions, form protective films, and exhibit antioxidant properties. Mimosa tannin extract, derived from Acacia mearnsii, is a rich source of condensed tannins with high reactivity toward metal surfaces, making it a potential candidate for green anticorrosion applications. The efficiency of polyphenol extraction and the resulting antioxidant activity are significantly influenced by the polarity and composition of the solvent system used during extraction. Solvent systems based on mixtures of water and ethanol are particularly attractive due to their low toxicity, cost-effectiveness, and compatibility with green chemistry principles. Variations in solvent polarity affect both the yield and chemical profile of extracted tannins, which in turn determine their antioxidant performance.

This study focuses on the effect of solvent composition on the physicochemical properties, antioxidant activity, and anticorrosive efficiency of Mimosa tannin extract. Particular attention is given to the optimization of Water-Ethanol solvent ratios to enhance the extraction of active components and maximize the rust conversion performance.

The composition of Mimosa tannin extract (MET) is mainly represented by condensed tannins (condensed flavonoids), the main of which are Dimer isomer Catechin (C) Fisetinidol (F) (C-F); Tetramer isomer (C-C-F-F) Catechin (C) Fisetinidol (F); Dimer isomer (C-SF) Sulfited Catechin (C) Fisetinidol (SF); Dimer isomer (C-SF) Sulfited Catechin (C) Fisetinidol (SF); B-type interflavan

linkage (Fig. 1). This composition provides a high ability to complex with metals, antioxidant and anti-corrosion activity, as well as biological stability of the extract.



Dimer isomer Catechin (C) Fisetinidol (F) (C-F)

Tetramer isomer (C-C-F-F) Catechin (C) Fisetinidol (F)

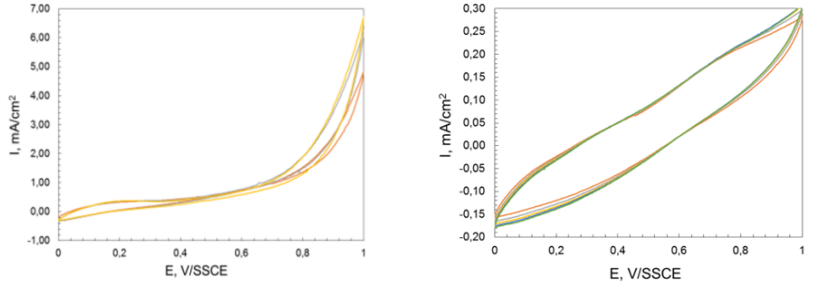
Dimer isomer (C-SF) Sulfited Catechin (C) Fisetinidol (SF)

B-type interflavan linkage

Fig. 1. Optimized molecular structures of the main representatives of the extractive part of Mimosa tannin.

A rust converter composition has been developed, including 66.67% mimosa tannin extract as the main active ingredient, 27.78% oxalic acid, which helps dissolve rust, 0.56% silver nitrate, 2.77% etidronic acid as a corrosion inhibitor, 0.22% sodium tripolyphosphate and 1.111% sodium hexametaphosphate as complexing agents, as well as 2.222% citric acid to regulate pH and enhance the chelating effect.

For the composition of the rust converter, the effect of the type of solvent on the component composition of the mimosa tannin extract was investigated. It was found that the optimal use of 80% ethanol as an extractant is, since it is under these conditions that the highest content of active compounds in the extract is ensured, which contributes to the improvement of its antioxidant and anti-corrosion properties in the finished product (Fig. 2).



20Water/80EtOH 80Water/20EtOH

Fig. 2. Cyclic voltammograms for Mimosa tannin extracts obtained by different solvent systems.

The alcohol-water extract of mimosa tannins has better antioxidant properties compared to the extract obtained with a higher water content. This is due to the fact that the optimal ratio of alcohol and water forms a solvent polarity of 6.2, which allows for more efficient extraction of active phenolic compounds, which are responsible for neutralizing free radicals and preventing oxidative processes. Due to this, such an extract exhibits high antioxidant activity, which makes it more effective for use as a natural corrosion inhibitor.

The obtained results demonstrate that introducing Mimosa tannin extract (MTE) into the corrosive environment leads to a considerable decrease in both anodic and cathodic reaction rates, confirming its effective corrosion-inhibiting properties (Fig. 3) [1–4]. In the absence of the inhibitor, the corrosion potential was measured at –0.52 V vs SCE, while the addition of tannin caused a positive shift of this potential. Polarization curve analysis revealed that the corrosion current density significantly dropped from 16.2 $\mu A \cdot cm^{-2}$ to 0.52 $\mu A \cdot cm^{-2}$ upon the addition of tannic acid. Given the complex composition of tannin extracts, their detailed characterization remains a challenging task. Nonetheless, the high inhibition efficiency indicates that tannic acid performs effectively as a corrosion inhibitor in 3% NaCl solution. MTE primarily functions as a cathodic inhibitor, suppressing cathodic reactions by forming ferric tannate complexes on the surface of mild steel. The inhibitory mechanism of the extract is attributed mainly to two factors: adsorption of tannin molecules on the metal surface and complexation with metal ions.

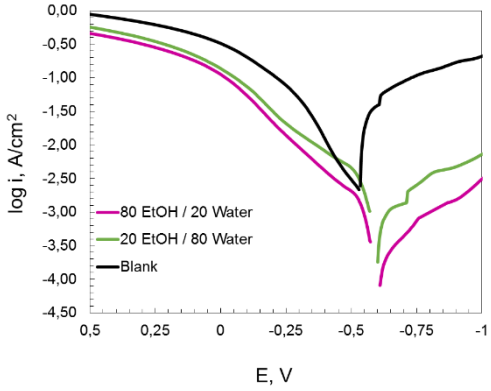


Fig. 3. Polarization plots of the samples immersed in 3 % NaCl solutions without and with different concentrations of MTE (0.5 g/L, immersion time 72 h, at 25 °C ± 2 °C).

The accelerated corrosion tests in the salt spray chamber demonstrated that the steel surfaces pretreated with the rust converter containing Mimosa tannin

extract and subsequently coated with a water-dispersion paint showed significantly improved corrosion resistance compared to untreated samples.

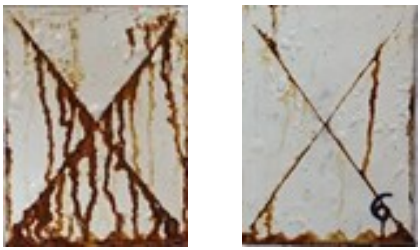


Fig. 4. Appearance of samples after salt spray chamber. Sample "0" is a plate painted in 2 layers without treatment with a converter. Samples 6 – formulations of water-dispersion coating with the composition and painted in 2 layers with Trior white radiator enamel.

Visual observations after 240 hours of exposure revealed minimal signs of blistering, rusting, or coating delamination on the pretreated surfaces, while the reference samples without rust converter showed evident corrosion spots and coating degradation. Adhesion of the coating remained high on the treated surfaces, with no significant underfilm corrosion observed.

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