Aqueous Biopolymeric Coatings for Corrosion Protection of Galvanized Steel

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Introduction

Organic coatings are amongst the most popular and efficient means for the protection of metallic surfaces [1]. However, the production of these coatings is fundamentally dependant on petroleum resources, resulting in materials with slow degradation rates that accumulate as environmental pollutants [2]. Consequently, there is a demand for organic coatings that are prepared from sustainable/renewable resources.

Lignin is the second most abundant biopolymer on earth and is the main constituent of the waste stream of wood-processing industries [3]. The combination of lignin and cellulose in composite films/coatings previously demonstrated promising barrier performances against water and oxygen permeation [4, 5].

Following a previous study on the performance of lignin as an anticorrosion coatings [6], this work investigated the corrosion protection capability of a water-borne composite coating based on colloidal lignin particles (CLPs) and TEMPO-Oxidized cellulose nanofibrils (TOCN) for galvanized steel [7].

Results

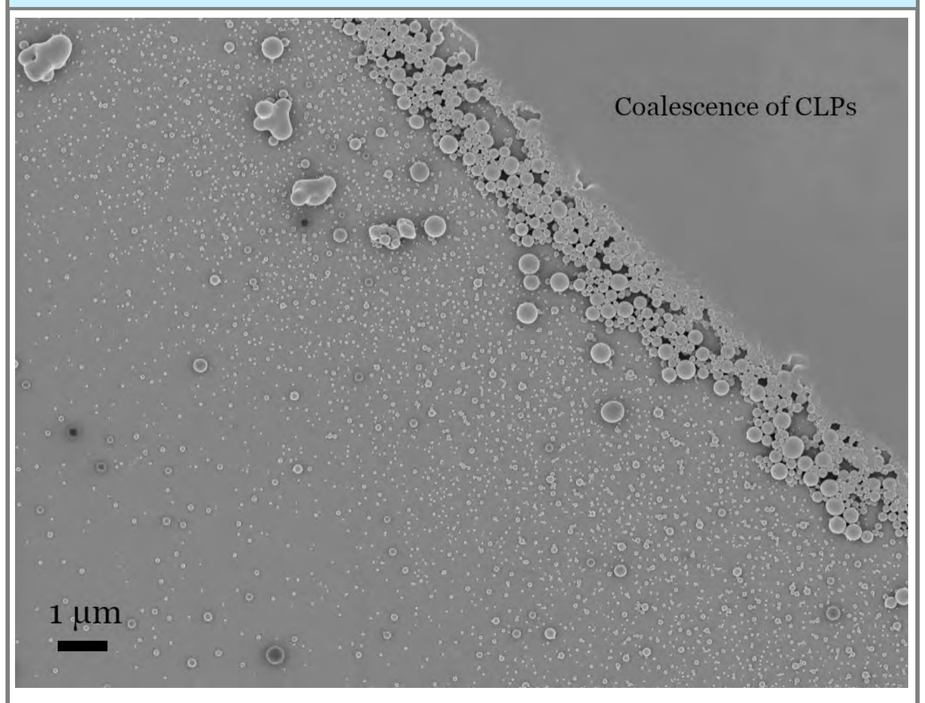

Figure 1. SEM micrograph of CLPs after drying on a silicon surface. Lignin particles demonstrated spherical morphologies and underwent coalescence during drying.
The coalescence is resulted from the action of the utilized solvent (DEGBE).

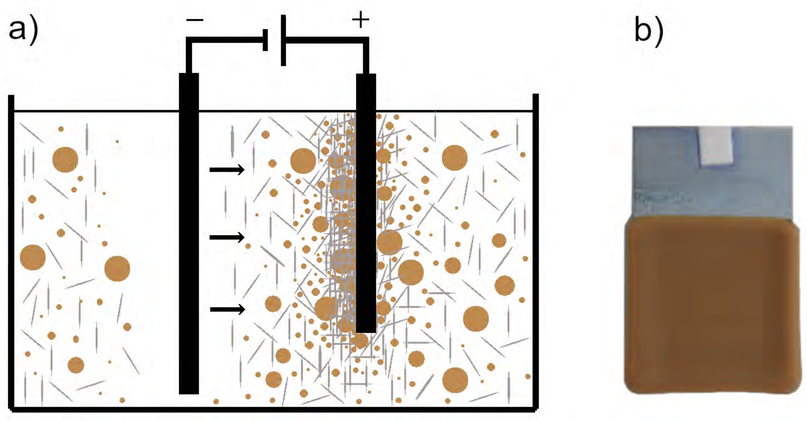

Figure 2. (a) The schematic of electrophoretic deposition (EPD) of negatively charged biopolymers (CLPs shown as brown spheres and TOCN as gray lines), and (b) appearance of a biopolymeric coating immediately after the EPD process (2.5 cm × 4 cm dimension of steel substrate).

Methodology

1. Solution (150 g/L) of Kraft Lignin (KL) in diethylene glycol monobutyl ether (DEGBE)
2. Solvent exchange in water (1:10 Volumetric ratio of solution:water) ⟶ CLPs
3. TOCN suspension (1 or 2 g/L) + CLPs dispersion (1:1 Volumetric ratio)
4. Electrophoretic deposition (EPD, 0.5 or 3 V)
5. Drying and characterization of coatings (SEM, Cross-cut adhesion, EIS)

Results

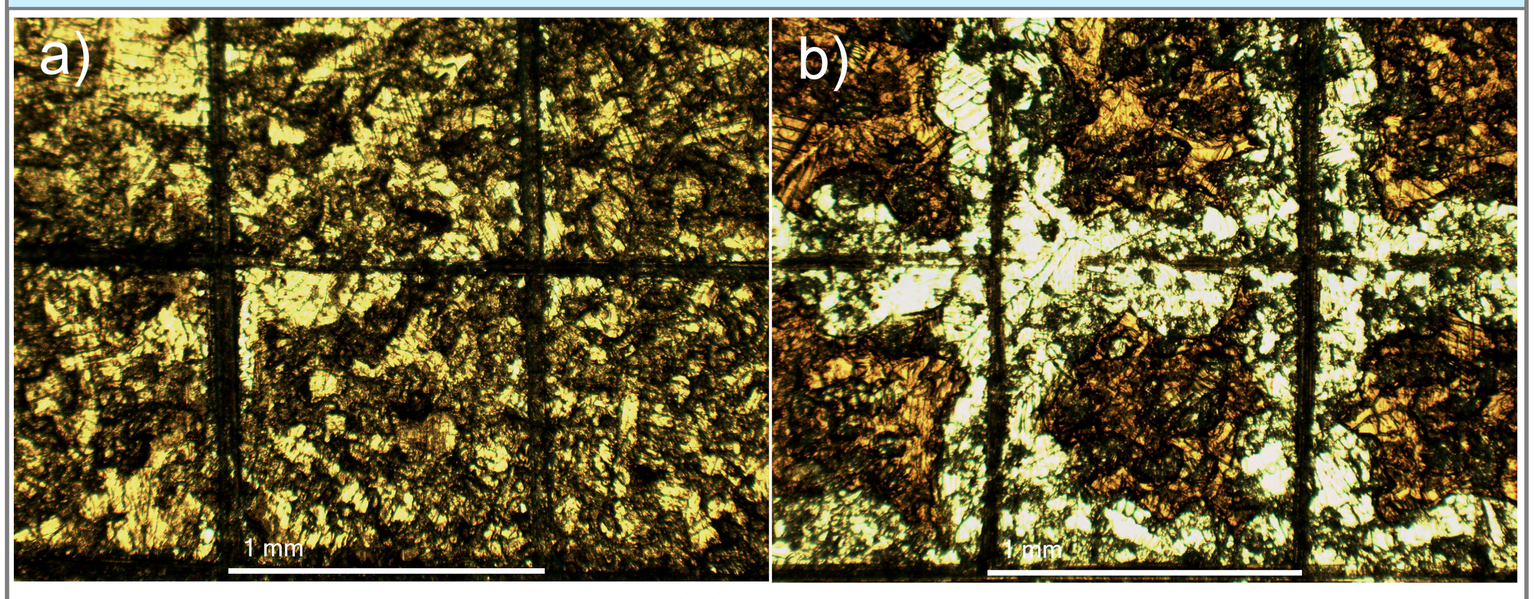

Figure 3. Optical microscopy images of coated steel after cross-cut adhesion measurements. (a) Coatings deposited at 0.5 V with 1 g/L TOCN concentration (0.1 T–0.5 V), and (b) at 3 V with 2 g/L TOCN concentration (0.2 T–3 V).

Table 1. Dried mass and thickness of coatings.

Sample	Mass (g/m²)	Thickness (µm)
0.1 T–0.5 V	4.8 ± 0.4	1.3 ± 0.4
0.2 T–3 V	22.7 ± 1.8	5.3 ± 0.6

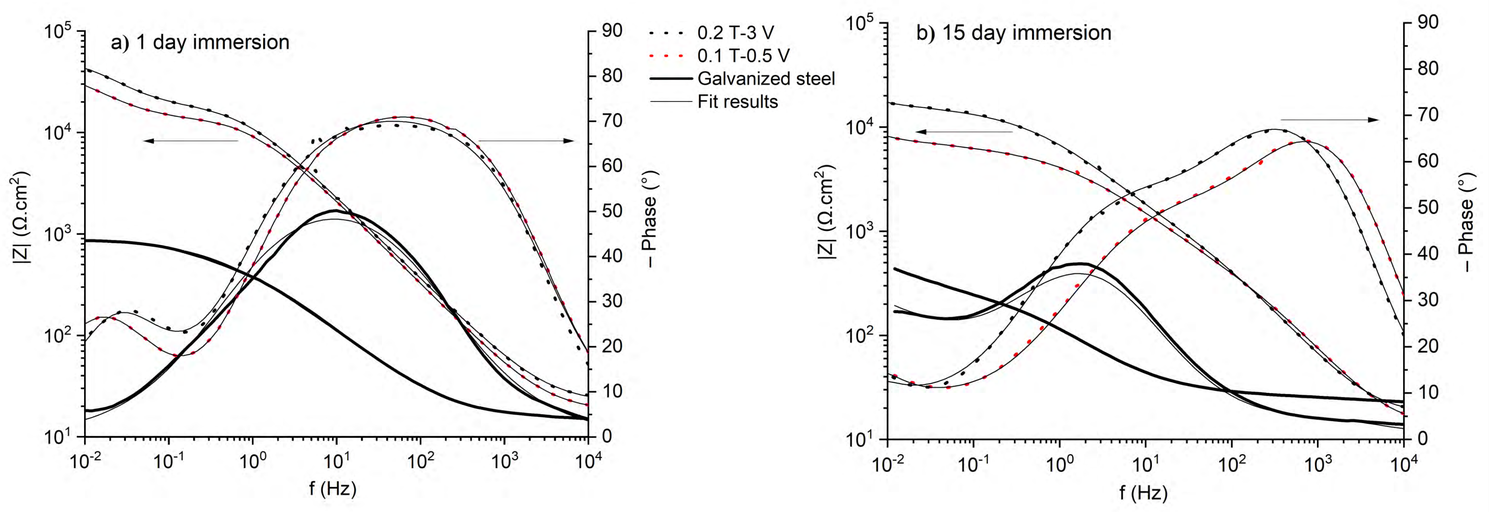

Figure 4. EIS Bode plots of coated steel surfaces after 1 day (a) and 15 days (b) of immersion in 3.5 % NaCl.

Table 2. Charge transfer (R_{ct}, kΩ·cm²) values obtained from fitting of EIS data.

Sample	1 day immersion	15 days immersion
HDG steel	0.9	0.2
0.1 T–0.5 V	27.0	6.0
0.2 T–3 V	34.0	13.7

Conclusions

- CLPs with a coalescing characteristic could be prepared.
- Electrophoretic deposition could be utilized for the preparation of aqueous coatings.
- Adhesion of TOCN-CLPs coatings on galvanized steel was affected by TOCN concentration and deposition potential.
- Coatings provided a relatively long-term corrosion protection for the steel surface.

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Acknowledgement:
This research was funded by Technology Industries of Finland Centennial/Jane and Aatos Erkko Foundations "Future Makers: Biorefinery Side Stream Materials for Advanced Biopolymer Materials (BioPolyMet)" and Academy of Finland (NoWASTE, No. 297962). Furthermore, this research made use of facilities provided by the RawMatTERS Finland Infrastructure (RAMI) at Aalto University, financed by the Academy of Finland. Additionally, we are grateful for the support of the FinnCERES Materials Bioeconomy Ecosystem.