Super-nonwettable and superoleophilic fluoropolymer-modified electrodeposited polythiophene coatings for corrosion protection

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Background and objective

Corrosion and oil spills pose significant environmental and economic challenges worldwide. Corrosion damages infrastructure, leading to costly repairs and safety risks, and oil spills devastate ecosystems, harming wildlife and coastal communities. Electroactive coatings, such as polythiophene (PTH), offer a promising solution. These coatings can be applied to metal surfaces efficiently by electrodeposition, providing a protective barrier against corrosion by inhibiting oxidation reactions. Moreover, polythiophene exhibits hydrophobic and oleophilic properties, making it ideal for oil-water separation applications. When coated on porous substrates, it selectively absorbs oil, repelling water, facilitating efficient oil spill cleanup. The multifunctionality of polythiophene highlights its potential to address both corrosion and oil spill challenges sustainably. However, its poor adhesion to metal surfaces limits its practical application.

This project aims to investigate enhancing polythiophene adhesion on substrates by employing a silane coupling agent, whilst sustaining anti-wettability for prolonged exposures in corrosive media via application of fluoropolymer as topcoat, for improved performance and practical applications.

Coating Preparation

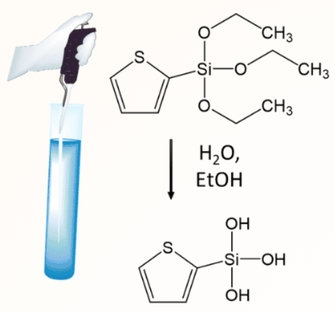
Silane pre-treatment

1 Degreasing

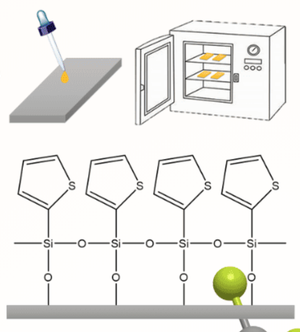
2 Activation

3 Silanization

3a Hydrolysis

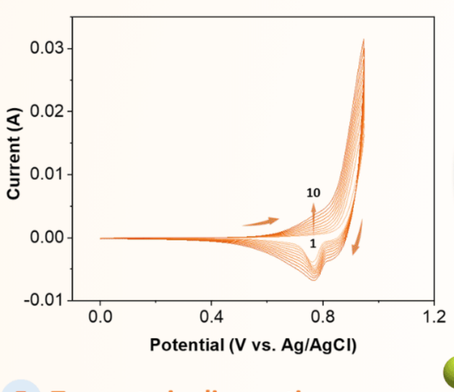


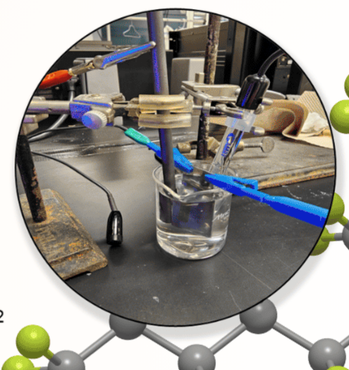
3b Condensation

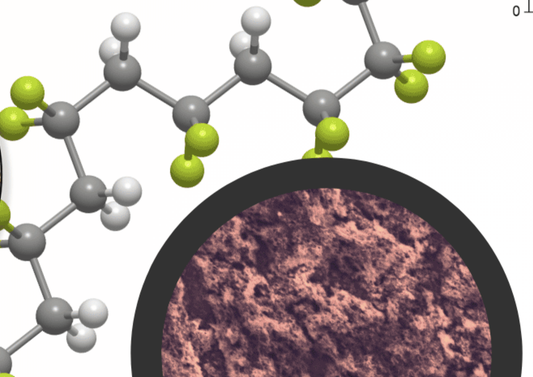


Polythiophene

4 Electrodeposition via cyclic voltammetry

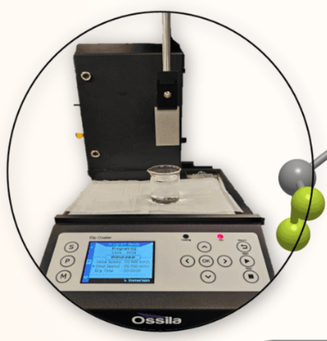






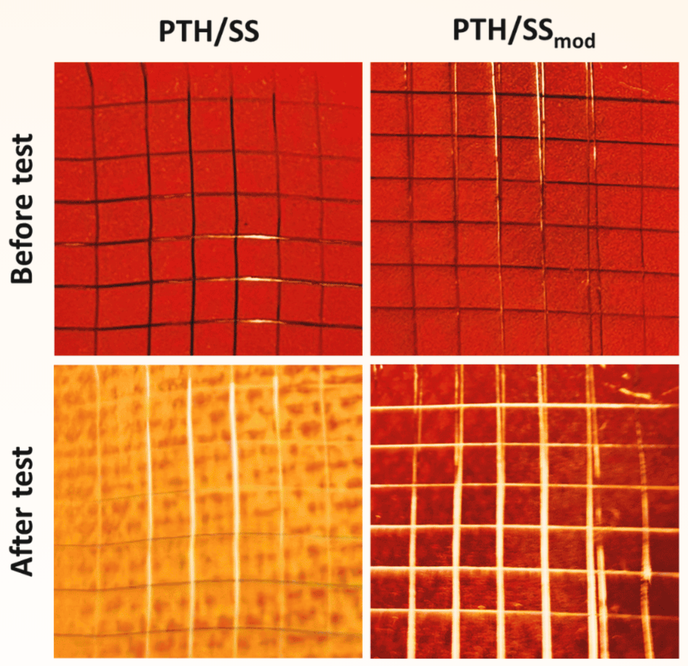
5 Topcoat via dip-coating

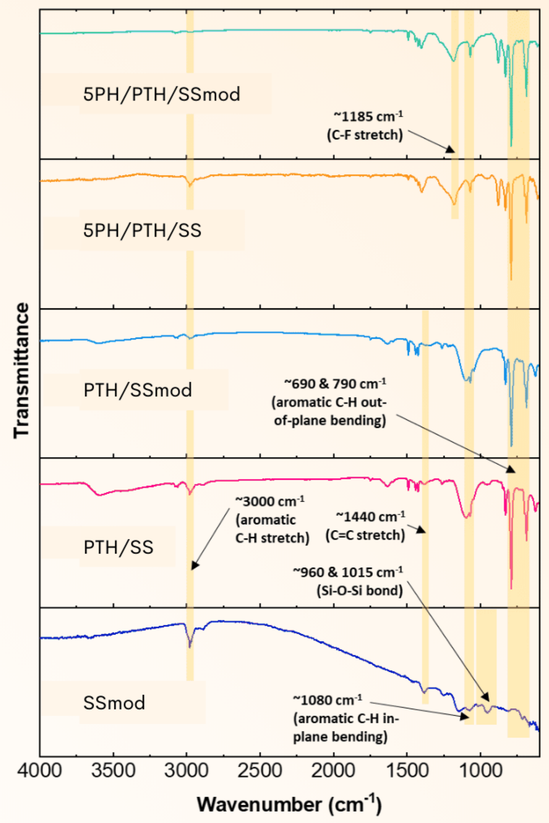
PVDF-HFP

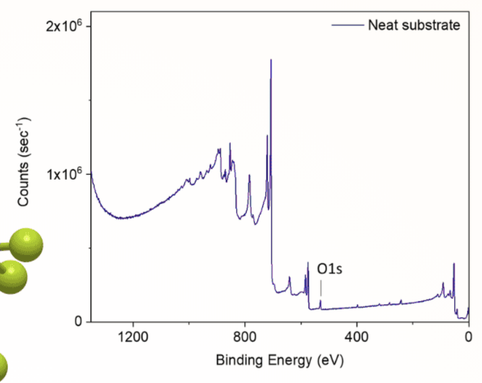


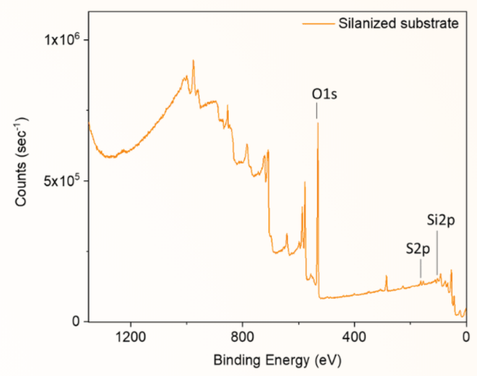
Electropolymerized polythiophene/ PVDF-HFP on silanized substrate

Substrate Silanization





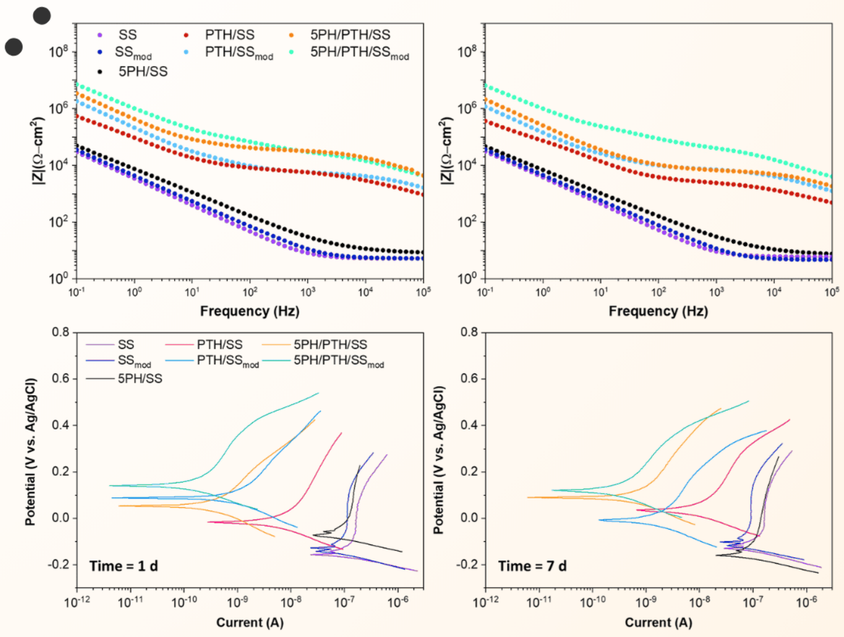




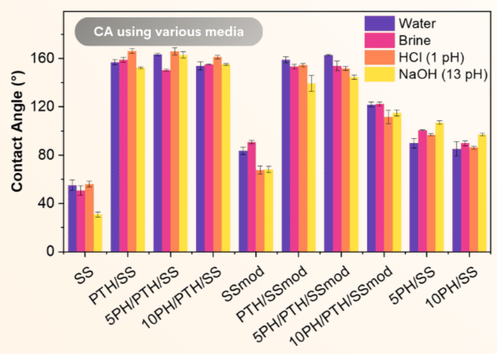
Element	Atomic %	
	Before	After
O	7.05	51.30
Cr	12.83	13.47
Fe	64.91	12.28
C	5.94	14.29
Ni	6.04	3.15
Si	n/d	3.62
S	n/d	1.90

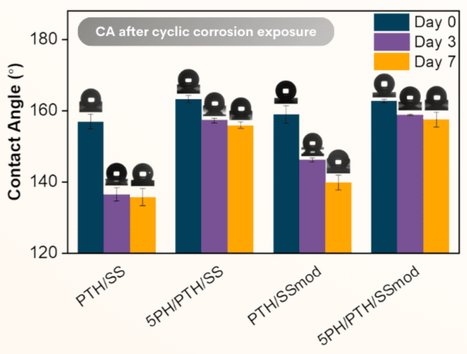
Corrosion testing

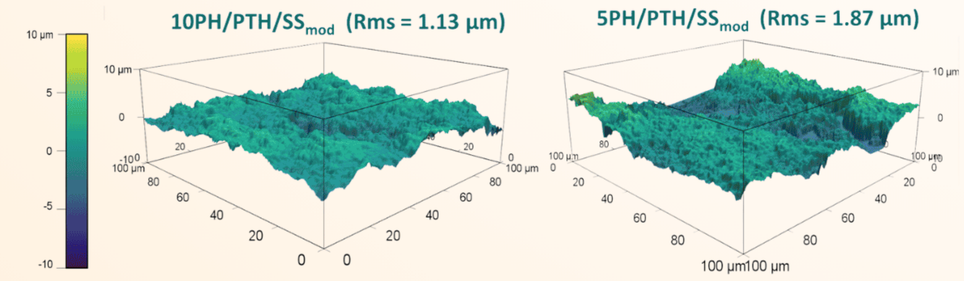
The combined use of potentiodynamic polarization and EIS techniques confirms the protective properties of electrodeposited PTH coatings enhanced by silane pretreatment and fluoropolymer topcoat inclusion. Higher ECORR and lower ICORR for pretreated and top-coated samples obtained highlight the effectiveness of this dual approach in providing durable and corrosion-resistant coatings. The pretreatment of the substrate provides a more compatible and protective base for the subsequent coatings, while the application of a dual-coating system offers a multi-layered defense against corrosion. Apart from these, higher corrosion protection efficiency was observed based on the higher impedance modulus obtained from EIS measurements.



Wettability and oil/water separation





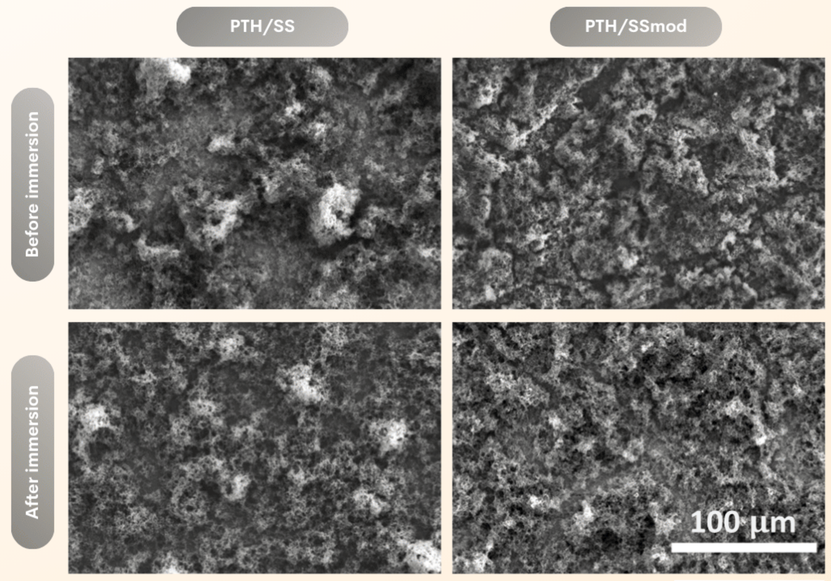


Conclusions and perspectives

Improved Adhesion and Durability: The use of silane coupling agents enhances the adhesion of PTH coatings to steel substrates, significantly reducing delamination and improving corrosion resistance and durability through a robust interfacial layer.

Enhanced Anti-Wettability: The application of fluoropolymers atop silane-pretreated surfaces imparts sustained hydrophobicity, crucial for corrosion protection by preventing water penetration and maintaining the substrate's resistance to wetting and corrosion.

Superoleophilicity/Superhydrophobicity for Diverse Applications: The study highlights the potential of superoleophilic/superhydrophobic coatings in oil/water separation applications, leveraging their unique surface properties for efficient separation processes and broader industrial applications.



Acknowledgment

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