Electromediated biofilm destruction by conductive polymer layers

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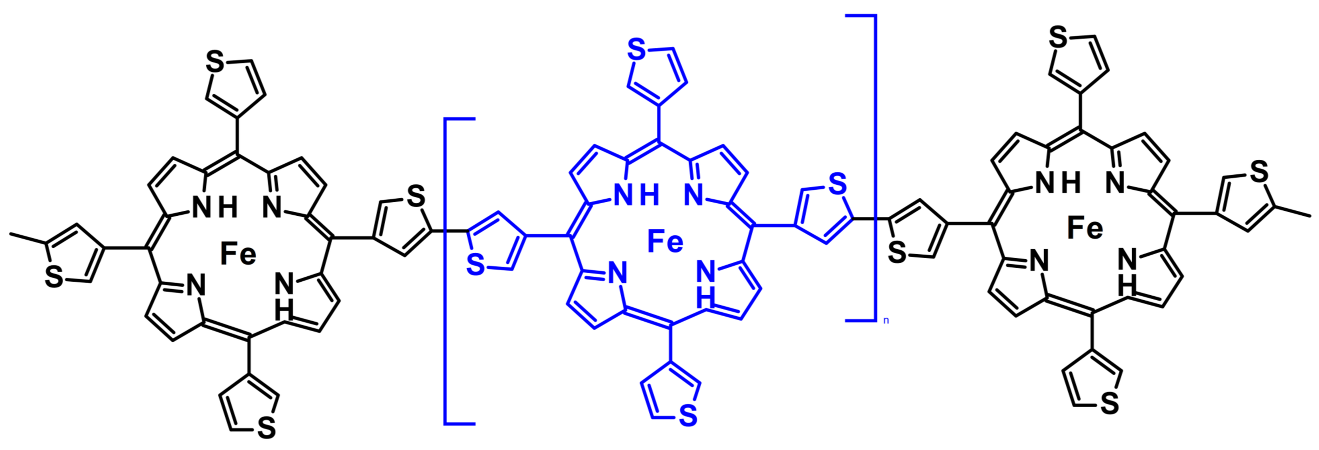
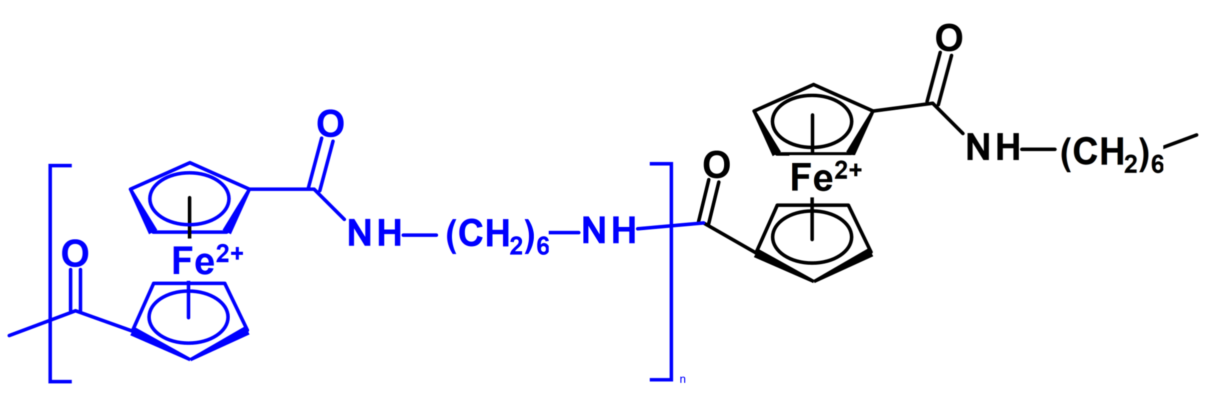
INTRODUCTION

Our study presents two electrochemical strategies for enhancing the eradication of bacterial biofilms from conductive surfaces, with potential application in the context of medical implants. Both strategies rely on short-term electrochemical activation at a low voltage 1.1-2.0 V, which is highly desirable for potential bio-related applications. The first approach utilizes a polytetrathienylporphyrin (poly-3TTP) layer complexed with Fe^{2+} and Mn^{2+} ions, which catalyzes the generation of reactive oxygen species (ROS), promoting oxidative biofilm disruption. The second strategy employs a hydrophobic, insoluble ferrocene-based polyamide (Fc-PA) synthesized from 1,6-diaminohexane and 1,1′-ferrocenedicarboxylic acid. Upon anodic oxidation, ferrocene moieties convert into cationic ferrocenium units, resulting in a hydrophilic, bactericidal polycations. Both polymer coatings were applied to electrode surfaces and evaluated for their ability to disrupt *Staphylococcus aureus* biofilms. The results were published in European Polymer Journal in 2024.

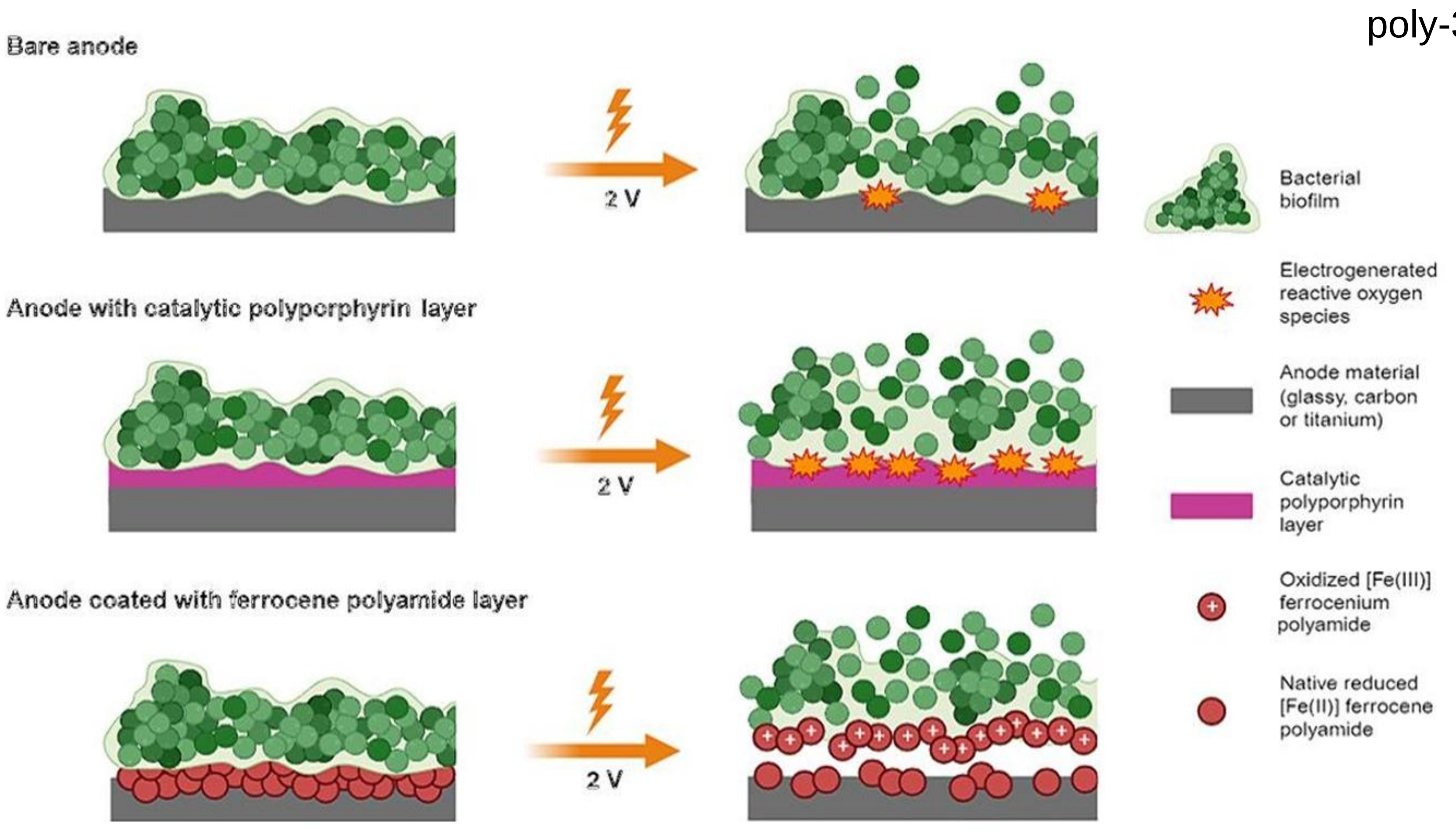
METHODOLOGY



Polytetrathienylporphyrin (poly-3TTP)

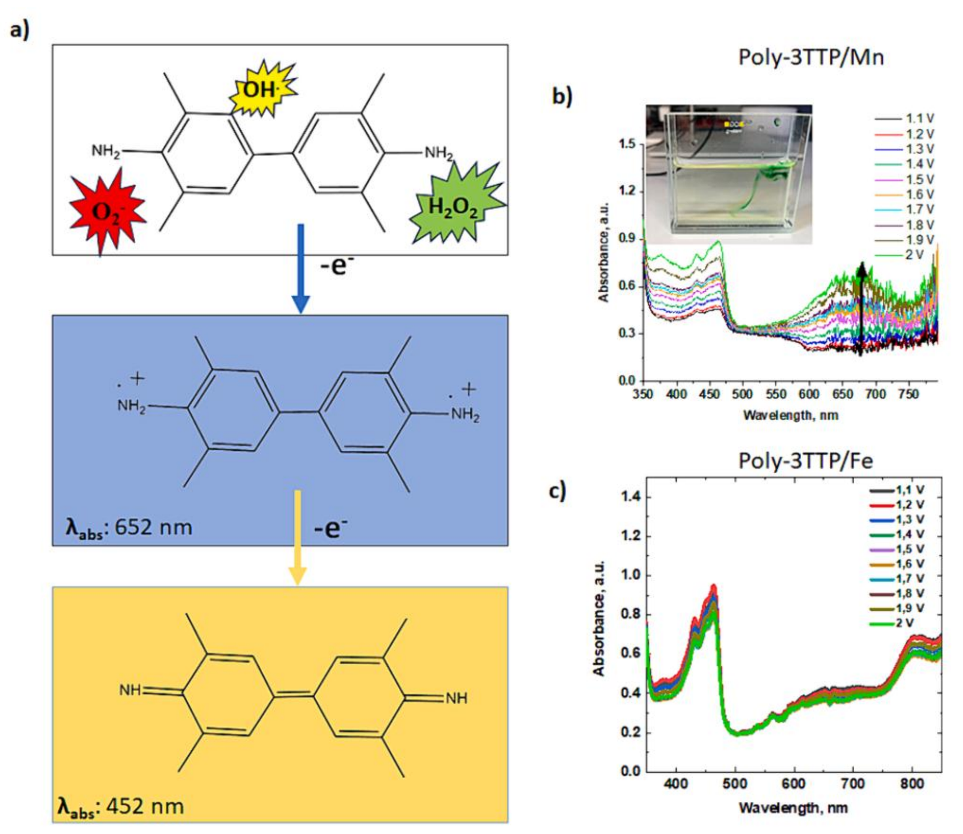


Ferrocene polyamide (Fc-PA)

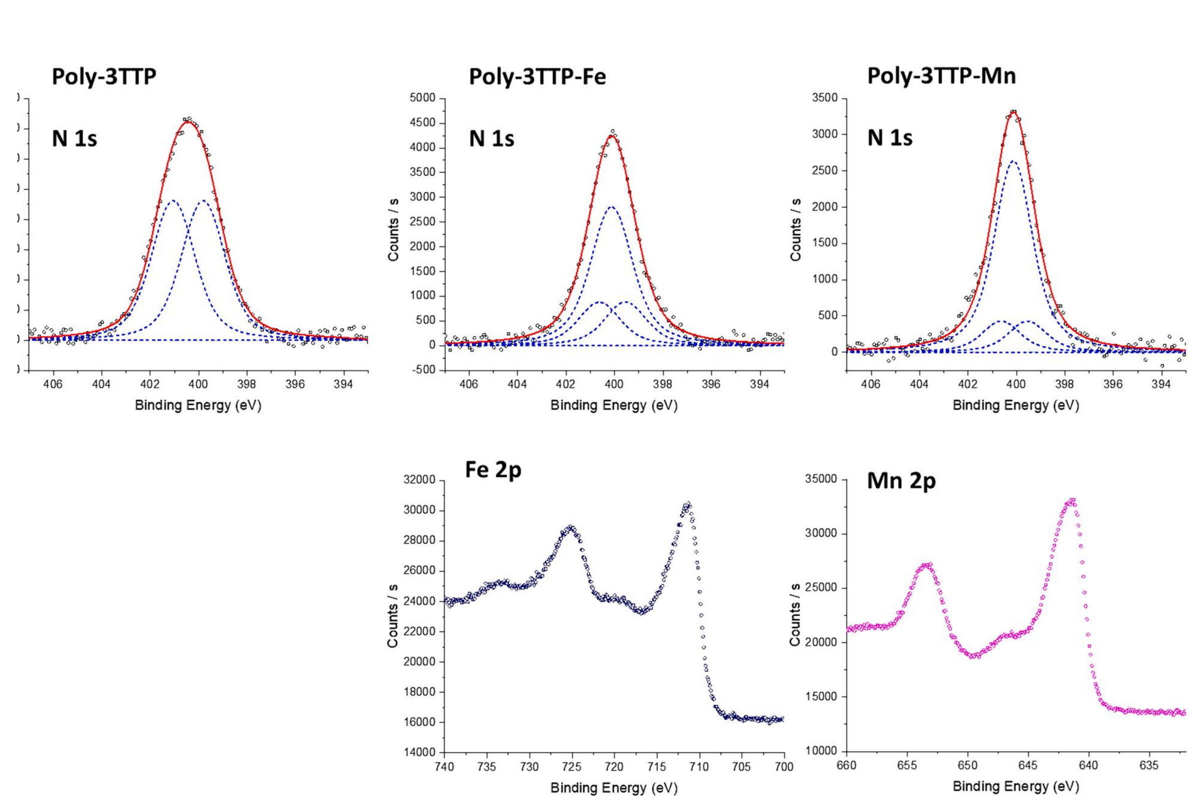


Approaches used in this study to enhance the destruction of bacterial biofilm

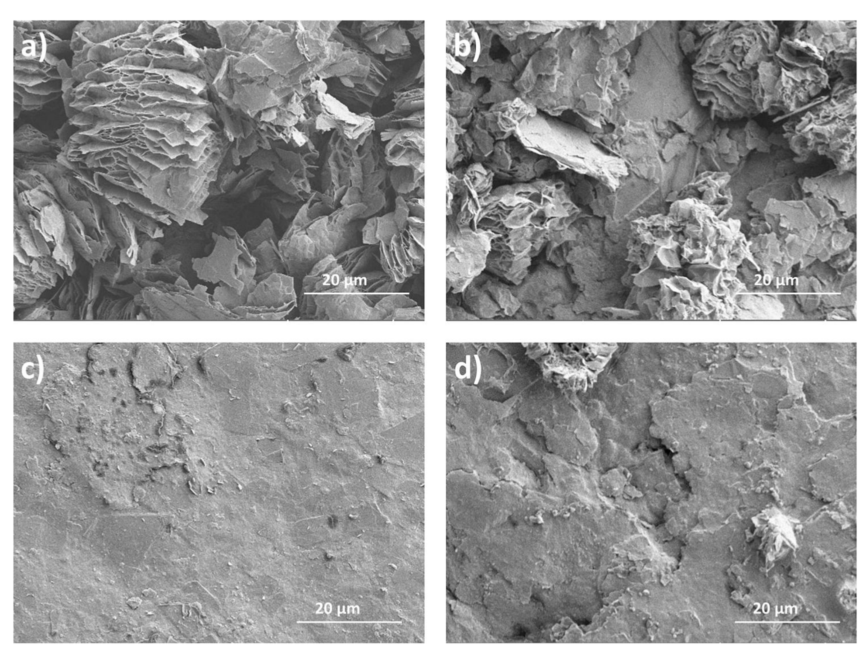
RESULTS



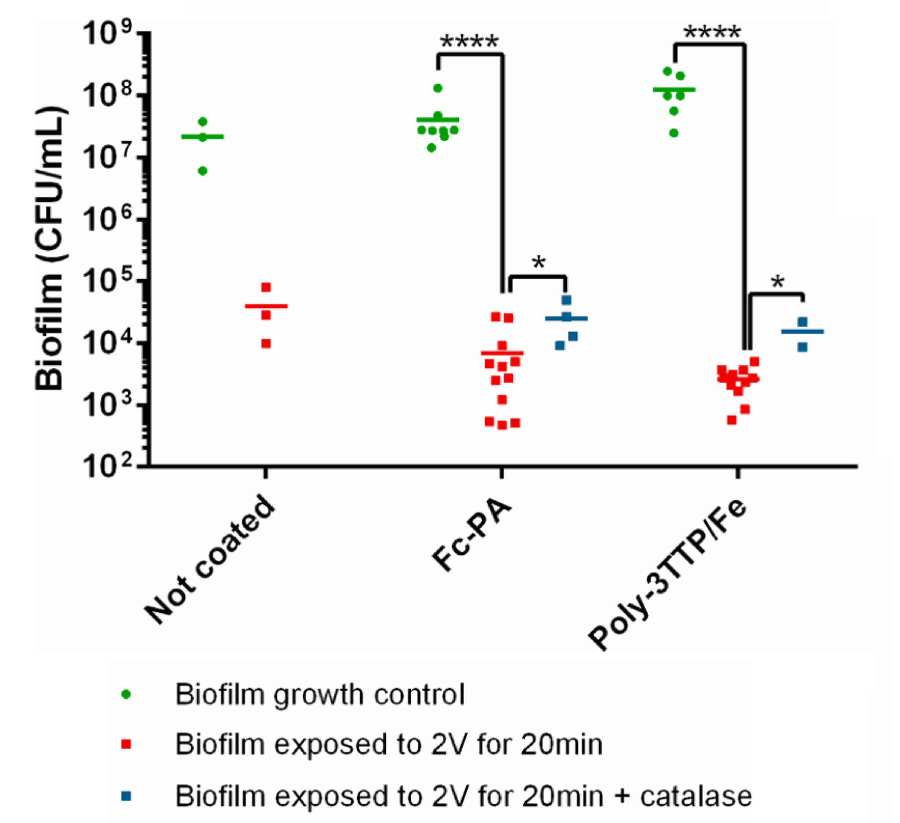
a) Structural changes of 3,3,5,5-tetramethylbenzidine across various redox states; b), c) UV–Vis spectra portraying the electrochemically generated dye on the poly-3TTP/Mn and poly-3TTP/Fe anode layer



High-resolution XPS spectra of polyporphyrin with Mn^{2+} and Fe^{2+} ions



SEM micrographs of a) poly-3TTP/Fe original film surface, b) poly-3TTP/Fe surface after chrono-potentiometric measurement, c) Fc-PA original film surface and d) Fc-PA film surface after chrono-potentiometric measurements.



Survival of *Staphylococcus aureus* bacteria in biofilms on uncoated electrodes, electrodes coated with ferrocene polyamide (Fc-PA), and Poly-3TTP/ Fe-coated electrodes.

CONCLUSION

The aim of this work was to improve the eradication of bacterial biofilms through innovative approaches involving polymer coatings on the anode. The catalytic approach showed a greater propensity to catalyze the formation of ROS in case of poly-3TTP/Fe than in poly-3TTP/Mn, confirming significance of the selected metal type. Moreover we did not observe any significant changes in the integrity of catalytically active poly-3TTP/Fe films, which confirms its durability compared to Fc-PA, which showed sensitivity to electrooxidation. However, the antimicrobial activity of the oxidized Fc-PA was noticed after 20 min exposure time, which is highly desirable for potential bio-related applications. These findings suggest a promising route for the development of smart, voltage-triggered, self-sterilizing coatings for biomedical devices

ACKNOWLEDGEMENTS

The authors gratefully acknowledge financial support from the project NETPHARM, project ID CZ.02.01.01/00/22_008/0004607, co-funded by the European Union, is gratefully acknowledged.