Targeting the Redox Activity of Biofilms
Kasid Khan*, Dr. Ritu Kataky and Dr. Gary Sharples
Department of Chemistry, Durham University, Lower Mountjoy, DH1 3LE | Email: kasid.khan@durham.ac.uk

Bacterial Biofilms

Biofilms are diverse aggregates of microorganisms that are enclosed in an extracellular polymeric substance which can adhere to various surfaces. Biofilm formation occurs via three main stages. Initial adhesion to conditioning film via adsorption, growth of colonies which secrete an EPS matrix and finally dispersion of bacteria due to fluid shear, starvation or environmental pressures.

Bacterial biofilms are associated with many diseases including cystic fibrosis. They are robust and more difficult to treat than planktonic bacteria:
- Slow penetration due to protective EPS matrix
- Resistant phenotypes due to local differentiation
- Antagonised antibotic action due to altered microenvironments

Exogenous mediators could maximise the current generated by Pseudomonas fluorescens biofilms. To do this they must:
- Have the ability to penetrate cell membranes
- Have a potential which does not limit cell voltage
- Rapidly regenerate
- Have good solubility and stability in the electrolyte
- Not display cytotoxicity
- Not be consumed by bacteria as a nutrient
- Not affect metabolic processes

Electrodes were prepared by adding 200 µL of 20 mM mediator solution and 100 µL mineral oil to 0.15 g graphite before mixing to form a paste which was loaded in a platinum electrode. Electrochemical measurements were performed using a three-electrode cell in 10 mM PBS.

2.2,6,6-Tetramethylpiperidine 1-oxyl (TEMPO)

Electrodes were prepared by adding 200 µL of 20 mM mediator solution and 100 µL mineral oil to 0.15 g graphite before mixing to form a paste which was loaded in a platinum electrode. Electrochemical measurements were performed using a three-electrode cell in 10 mM PBS.

2.2,6,6-Tetramethylpiperidine 1-oxyl (TEMPO)

Electrodes were prepared by adding 200 µL of 20 mM mediator solution and 100 µL mineral oil to 0.15 g graphite before mixing to form a paste which was loaded in a platinum electrode. Electrochemical measurements were performed using a three-electrode cell in 10 mM PBS.

2.2,6,6-Tetramethylpiperidine 1-oxyl (TEMPO)

Electrodes were prepared by adding 200 µL of 20 mM mediator solution and 100 µL mineral oil to 0.15 g graphite before mixing to form a paste which was loaded in a platinum electrode. Electrochemical measurements were performed using a three-electrode cell in 10 mM PBS.

The Effect of MnO2 on the Electrochemical Activity of Biofilms

After background measurements, the mediator doped electrodes were immersed in a lysogenic broth culture of Pseudomonas fluorescens to promote biofilm formation.

\[ C_c = \frac{1}{2mn(V_f - V_i)} \int V_f I(V) dV \]

Electrode | Specific capacitance / mF \( g \)\(^{-1}\) | 48 h | 72 h | 96 h | 188 h
---|---|---|---|---|---
Undoped | 19.01 | 24.91 | 32.52 | 35.33
TEMPO | 9.05 | 5.74 | 8.44 | 5.37
Menadione | 23.37 | 33.32 | 48.65 | 28.81
Dopamine | 34.85 | 40.24 | 44.21 | 31.04

Table 1. Specific capacitance calculated for the four graphite paste electrodes during biofilm maturation.

Conclusion

- Prepared and characterised redox mediator doped graphite paste electrodes.
- Immobilised Pseudomonas fluorescens biofilms on electrode surfaces.
- Probed the electrochemical activity of biofilms and confirmed the formation of redox active species during biofilm maturation using CV, DPV and SWV.
- Menadione and dopamine facilitated electron transport, showing increased response signals but cytotoxicity of TEMPO reduced current generated.

References
5. E. Knowles, R. Kataky, MChem project, 2017