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Rapid Detection of *Proteus mirabilis* Using Disposable Electrochemical Sensors

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Introduction

Proteus mirabilis is a Gram-negative pathogen frequently isolated from clinical infections, predominantly those of the catheterised urinary tract and wounds. The possibility of severe complications of infection means rapid diagnosis is desired. In current clinical practice the detection of infection relies upon observation of patient symptoms, sampling and laborious culturing procedures. Electrochemical impedance spectroscopy (EIS) has emerged as a potentially suitable technology for real-time infection monitoring, with both *in-situ* and point-of-care applications.

Methods

Using disposable, screen-printed carbon electrodes and EIS, impedance spectra for numerous samples were obtained (Figure 1). Measurements of *P. mirabilis* growth in LB media were performed over 24 hours (average starting concentration 7.4×10^6 CFU/mL). Similarly, measurements were then carried out over 24 hours for washed cells in 0.9% w/v NaCl, where no growth occurred (average starting concentration 5×10^8 CFU/mL). Equivalent circuit modelling was performed using a Randle's circuit and the impedance spectra normalised to highlight time evolution.

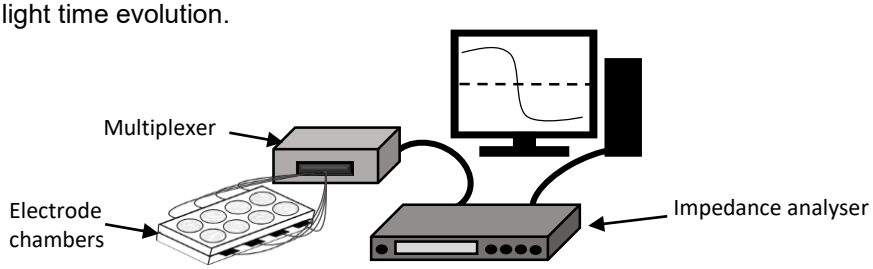

Figure 1. *Diagram of the experimental set up.*

Results & Discussion

The growth of *P. mirabilis* in LB media resulted in significant changes in normalised impedance after only 1 hour ($p<0.05$), including a reduction in normalised modulus at frequencies below 1 kHz and a mid-frequency phase trough. For a high concentration of washed cells in 0.9% w/v NaCl, significant normalised impedance changes were evident immediately and indicated cell adsorption to the sensors over time. These changes were, however, smaller and therefore suggest that metabolic mechanisms dominated the larger impedance response seen in LB. Furthermore, circuit modelling linked a significant reduction in charge transfer resistance after 24 hours to bacterial growth (average change -91% ± 3.5% vs a negative control average change of -45.9% ± 6.6%, $p=0.009$).

Conclusion

The ability of these low-cost carbon sensors to detect *P. mirabilis* was therefore demonstrated. Rapid detection of this pathogen highlighted the potential for this technology to be successfully adopted into a real-time infection monitoring device.

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