DEVELOPMENT OF A FITTING ALGORITHM AND MOBILE APPLICATION FOR PORTABLE ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY

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Introduction: Electrochemical impedance spectroscopy (EIS) is a technique that utilizes alternating-current (AC) signals for analyzing charge transfer and chemical reaction kinetics. This technique has several clinical applications including biomolecular detection. While many potentiostats have been developed to make EIS more accessible, such as HELPStat, current portable potentiostat designs with EIS capabilities rely on external hardware for control of the device or for data analysis, limiting designs to non-portable applications.

Methods: To address this issue, a Levenberg-Marquardt fitting algorithm was implemented in the HELPStat firmware, allowing approximation of charge transfer resistance from empirical impedance measurements. The developed algorithm was compared to a MATLAB script, and both were evaluated using impedance data for ideal Randles circuits as well as potassium ferricyanide and cortisol aptamer binding Redox reactions. Results were analyzed using paired t-tests comparing absolute value of residuals and root-mean-squared-error (RMSE). In addition, an Android application was developed to perform bidirectional communication between the HELPStat potentiostat and a mobile device using Bluetooth Low-Energy (BLE), with a serial monitor being used to confirm that potentiostat measurements were being configured as expected.

Results: Testing of the fitting algorithm demonstrated a statistically significant difference between the developed algorithm and a similar MATLAB implementation. Further analysis revealed that the developed fitting algorithm had statistically comparable or lower errors. In addition, testing with a cortisol aptamer was able to successfully differentiate between 1.5 ng/ml and 7 ng/ml samples of cortisol. By developing a novel Android application and enabling true wireless functionality through BLE, we enable a better bridge of communication between user and device.

Conclusion: We developed a fitting algorithm in device firmware along with a novel Android application that allows device control and data analysis with the HELPStat potentiostat. By implementing this without dependence on external hardware, we enable device portability for point-of-care applications.