The characterisation and design improvement of a paper-based E.coli impedimetric sensor

P Bezuidenhout, S Kumar, M Wiederoder, J Schoeman, K Land; T-H Joubert

Abstract:
This paper describes the development and optimisation of a paper-based E. coli impedimetric biosensor for water quality monitoring. Impedimetric biosensing is advantageous because it is a highly sensitive, label-free, real-time method for the detection of biological species. An impedimetric biosensor measures the change in impedance caused by specific capture of a target on the sensor surface. Each biosensor consists of a pair of photo paper-based inkjet printed electrodes. An impedance analyser was used to measure the impedance at frequencies ranging from 1 kHz to 1 MHz at 1V. The parameters that were investigated to achieve enhanced sensor performance were buffer type, antibody attachment method, measurement frequency, electrode layout, and conductive material. A 0.04M PBS (phosphate buffered saline) solution achieves better results compared to a less conductive 0.04M PB (potassium phosphate dibasic) solution. The direct adsorption of anti-E. coli antibodies onto the sensor surface yielded better results than attaching the sensor to a lateral flow test. The resistive component had a greater impact on the detected impedance, therefore an optimal frequency of 1 MHz was identified. Geometrical electrode designs that maximise the resistive change between the electrodes were utilised. Both lower cost silver and bio-compatible gold ink were validated as electrode materials. The impedance change generated by the selective capture of E. coli K-12, ranging in concentration from 103 to 107 colony forming units per millilitre (cfu/ml), showed a detection limit of 105 cfu/ml.