

DEVELOPMENT OF A DETECTOR FOR 3-NITRO-TYROSINE USING ELECTROGENERATED CHEMILUMINESCENCE WITH BIPOLAR ELECTROCHEMISTRY

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Biomarker 3-nitro-L-tyrosine (3-NT), associated with nitrosative stress, has been linked to various pathological conditions, including neurodegenerative and cardiovascular diseases. Therefore, its detection is important; however, traditional detection methods, such as mass spectrometry and chromatography, require expensive instrumentation and expertise. Electroanalytical techniques are of choice owing to their ability to detect in real-time and low-cost. However, it is usually susceptible to high noise. Translating the current signal to an optical signal, which exhibits simultaneous oxidation and reduction at the extremities of a bipolar electrode (BPE), may provide better detection limits, as optical signals are less susceptible to environmental noise. In this study, a novel electrochemiluminescence (ECL)-based detector utilising BPE was developed for the detection of 3-NT. The objective was to establish a cost-effective and highly sensitive detection method suitable for biomedical and environmental applications. The detector setup consisted of a BPE coupled with luminol-H₂O₂-based ECL reporting, where the reduction of 3-NT at the cathodic pole induced light emission at the anodic pole. The experiments optimised the luminol-to-H₂O₂ ratio of 2:13 and applied potential of 2.6 V to achieve maximum ECL intensity. The system was evaluated using image-based intensity analysis captured via a smartphone camera. Results demonstrated a linear correlation between 3-NT concentration and ECL intensity, with R^2 of 0.93, linear dynamic range of 1.00 $\mu\text{mol L}^{-1}$ to 80.00 $\mu\text{mol L}^{-1}$, calibration sensitivity of 0.075 luminescence intensity per $\mu\text{mol L}^{-1}$ and a detection limit of 1.00 $\mu\text{mol L}^{-1}$, significant improvement upon conventional methods such as cyclic voltammetry. The BPE-ECL platform developed has proven to be a robust, low-cost alternative to high-end detection techniques, offering advantages such as miniaturisation, portability, and potential integration with microfluidic devices for point-of-care diagnostics. Future improvements could include a continuous flow system at the anodic pole, coupled with an electrophoretic microchip at the cathodic pole, to detect multiple biomarkers separated by electrophoresis.

Keywords: Bipolar electrochemistry, Electrochemical sensor, Electrogenerated chemiluminescence, Luminol-H₂O₂, 3-nitro-L-tyrosine, Oxidative stress