An Indirect Electrochemical Detection Of Creatinine In Urine Samples Using A Boron-Doped Diamond Electrode

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Creatinine (CRE) is a metabolite from creatine and phosphocreatine and is generated through energy consumption in the muscle and tissue, which is filtered by the kidneys from blood into urine [1]. The CRE level in biological fluids, such as serum and urine, is a significant indicator of the body's renal functions and is vital in evaluating the body's hydration level, thyroidal malfunction, and muscular disorders [2]. Therefore, determining CRE in biofluids could provide related information about those functional processes, contributing to the health management and early diagnosis of acute diseases. Unlike blood, urine collection, handling, and disposal are simpler and more accessible, which is friendly to the long-term and frequent point-of-care testing and health monitoring with no disturbance to patient integrity. Boron doped diamond (BDD) electrode has been recognized as a kind of promising electrode material due to its wide potential window, low background current, excellent resistance to non-specific adsorption, and good stability [3], which is suitable for long-term electrochemical analysis in complex biofluids. In this work, the CRE in human urine was electrochemically determined indirectly by reacting with $NaNO_2$ on a bare BDD electrode. First, gradient concentrations of CRE from 100 – 2500 mg/L (approximately 0.88 – 22 mM) were determined in buffer solution with the addition of $NaNO_2$ (Fig.1 (a)). The linear relationship between reduction current and CRE concentration illustrated the possibility of creatinine determination by BDD (Fig.1 (b)). The Limit of detection of CRE in buffer solution is 178.7 mg/L (1.6 mM), which is lower than the healthy level of CRE in human urine (4.4 – 18 mM [4]). The spiked CRE in diluted urine samples determined by our method were compared with that from UV-Vis spectra based on the Jaffé method. The results showed a good agreement between both methods.

References

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[2] Pundir CS, Kumar P, Jaiwal R., Biosens. Bioelectron. 126 (2019) 707-724.
[3] Ogata G, et al., Nat Biomed Eng. 1 (2017), 654-666.
[4] Cánovas R, Cuartero M, Crespo GA., Biosens. Bioelectron. 130 (2019) 110–124

Figures

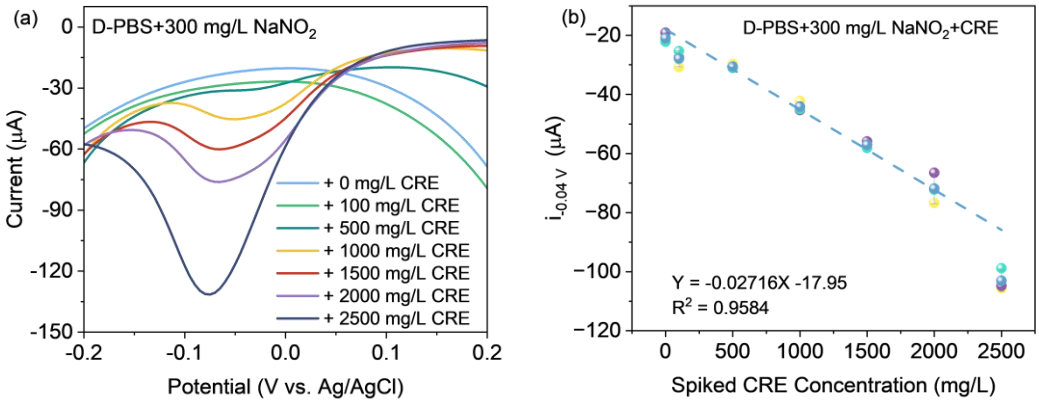

Figure 1: (a) Differential pulse voltammetry of 0-2500 mg/L CRE in D-PBS (Dulbecco's Phosphate Buffered Saline, pH=6.4) with addition of 300 mg/L $NaNO_2$. (b) The plot of reduction current at -0.04 V (vs. Ag/AgCl) with each CRE concentration.