A SIM Card-Type Biosensor for the Point-of-Care Determination of Creatinine in Urine

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Abstract: The development of medical diagnostic devices for point-of-care (POC) applications is of immense interest towards the establishment of decentralized health-care systems. The cost of miniaturized transducers, the need for elaborated modification of the sensing surface and the complexity of the assay workflow impede the widespread use of current biosensing technologies to POC applications. Herein, we report on the synthesis and characterization of pH responsive copolymers of methacrylic acid (MAA) and methylmethacrylate (MMA) at different MAA/MMA ratios and molecular weights, and their use in the development of a sim card-type responsive copolymer-modified paper-based biosensor for the point-of-care, drop volume determination of creatinine in urine. A vertical microfluidic channel was fabricated on a paper strip by wax printing. The channel was blocked by depositing PMAA/PMMA copolymer. Atop of the dry copolymer/paper surface, creatinine deiminase was immobilized by physical adsorption. The functionalized paper strip was sandwiched between two conductive tapes from which the top one was hole patterned to serve as a dosing well for the microfluidic channel. Data demonstrated, on the one hand, infinity resistance to vertical flow of the urine sample though the enzyme-free biosensor, and on the other hand, in the presence of immobilized creatinine deiminase, a creatinine concentration dependent flow rate due to the degradation of the pH responsive PMAA/PMMA copolymer by the enzymatically produced ammonia, as a result of the action of creatinine deiminase on creatinine. Under selected experimental variables, the detection range of the device was tuned [1] over 3-30 mM creatinine that covers the normal range of creatinine (5-17 mM) in urine. The biosensor was assembled on a SIM card holder incorporating a third conductive strip, which in combination with a low-cost reading unit offers an automatic on/off (addition of the sample/degradation of the membrane) function for the measuring of the degradation time, and a screen for displaying the determined concentration. The device was applied to the drop-volume determination of creatinine in 1+1 diluted urine sample (adjusted to pH 6.5). The relative error (%) with respect to a hospital method was <7.1%.

Acknowledgment: This research has been co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (project code:T1EDK-03341).

Reference

[1] Tzianni, E., Hrbac, J., Christodoulou, D., Prodromidis, M. (2020), A portable medical diagnostic device utilizing free-standing responsive polymer film-based biosensors and low-cost transducer for point-of-care application, *Sens. Actuators B*, 304, 127356