HANDHELD ANALYZER WITH DISPOSALBE LAB-ON-CHIPS FOR ELECTRICAL DETECTION OF ANESTHETIC PROPOFOL IN HUMAN SERUM

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ABSTRACT

This paper presents novel handheld analyzer with disposable lab-on-chips for electrical detection of anesthetic propofol in human serum samples for clinical diagnostics. The developed on-chip biosensors are based on molecularly imprinted conducting polymer techniques. In this paper, we have designed, fabricated, and characterized the developed system with disposable lab-on-chips for detection of propofol molecules. The response time of the developed propofol biochips is 21 seconds.

KEYWORDS

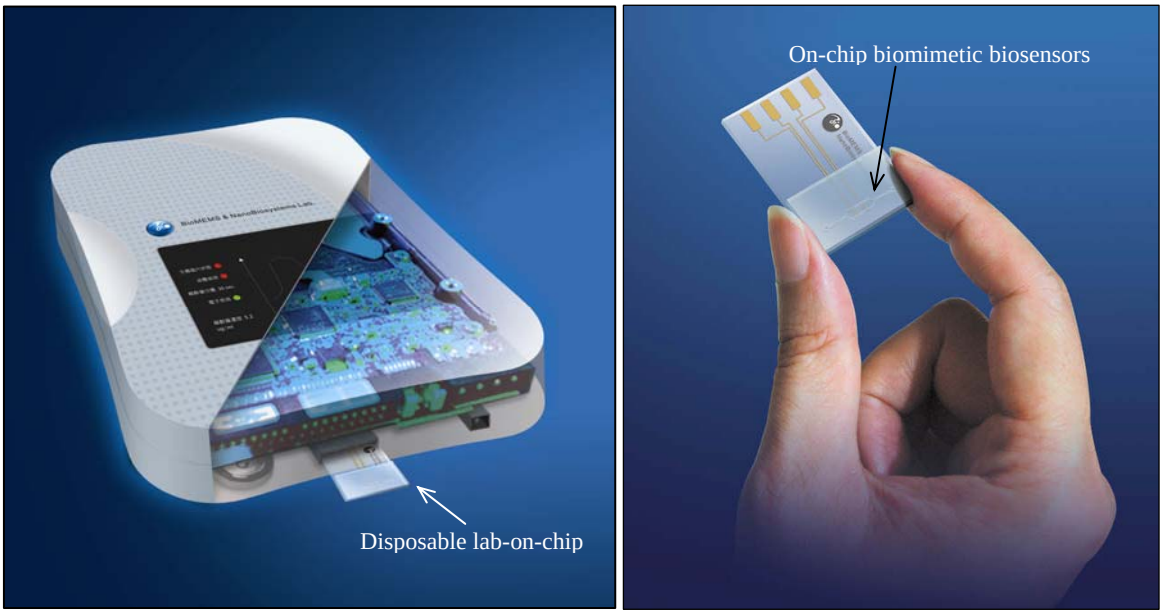
Handheld analyzer, disposable lab-on-chip, electrical detection, anesthetic propofol.

INTRODUCTION

Propofol (2,6-di-isopropylphenol) is an intravenous anesthetic, widely used in induction of anesthesia, total intravenous anesthesia and sedation of intensive care unit patients. Although the blood concentration can be detected by high-performance liquid chromatography and/or gas chromatography [1], these methods are time-consuming and not ease of access. In order to achieve effective blood concentration and avoid adverse effect produced by excessive or insufficient propofol, clinically we need a more convenient access to monitor the blood concentration. We have previously developed and characterized optical propofol biochips based on color reagents reaction in methanol-based propofol samples [2]. In this abstract, we develop and characterize handheld analyzer with disposable lab-on-chips for electrical detection of propofol in human serum. The developed biosensors are based on plastic antibody technology, which can capture analyte with high specificity. In addition, color reagents and label tags are not required while using the electrical detection with plastic antibody technology.

DESIGN AND FABRICATION

Figure 1 shows a schematic drawing of novel handheld analyzer with disposable lab-on-chips. The proposed handheld platform consists of embedded systems, touch screen, sensing circuit, battery, electronic interface, and disposable microfluidic biochip with on-chip biomimetic biosensors.



(a) (b)

Figure 1. Schematic illustration of the proposed handheld analyzer with disposable lab-on-chips and on-chip biosensors for electrical detection of propofol in human serum for clinical diagnostics.

The developed biomimetic biosensor, which provides high specific binding to the analyte, is used for separation and sensing of analyte propofol, shown in Figure 2. According to the equivalent circuit of the biosensors, the analyte concentration can be measured by the detection of surface capacitor change, which is related to the captured analyte.

The fabrication process of molecularly-imprinted conducting polymer (MICP) electrodes involves three steps, including combination, electropolymerization, and extraction. After the electropolymerization of the conducting polymer electrodes, the imprinted sites were formed by releasing template molecules from the electrodes. Figure 3 shows the picture of the developed novel handheld analyzer with disposable lab-on-chips. The right inset picture is the fabricated plastic microfluidic chip with on-chip biosensors. The chip was inserted to the handheld platform. The propofol sample was dropped at the inlet of the plastic biochip and then was sucked into the chip by capillary force.

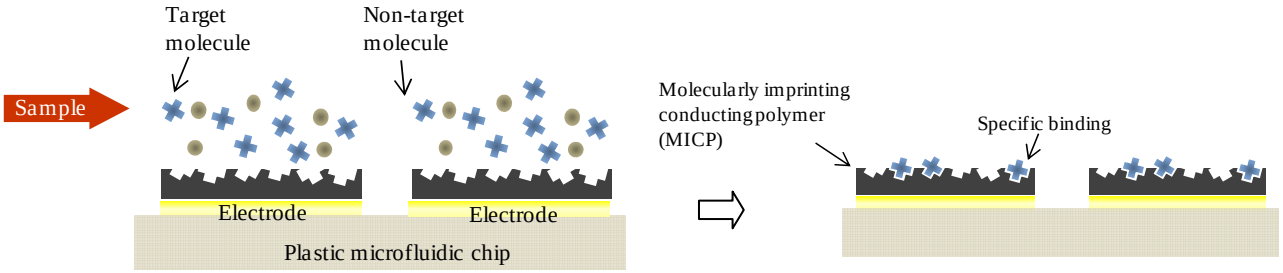


Figure 2. *Working principle of biomimetic moleculary-imprinted conducting polymer biosensors.*

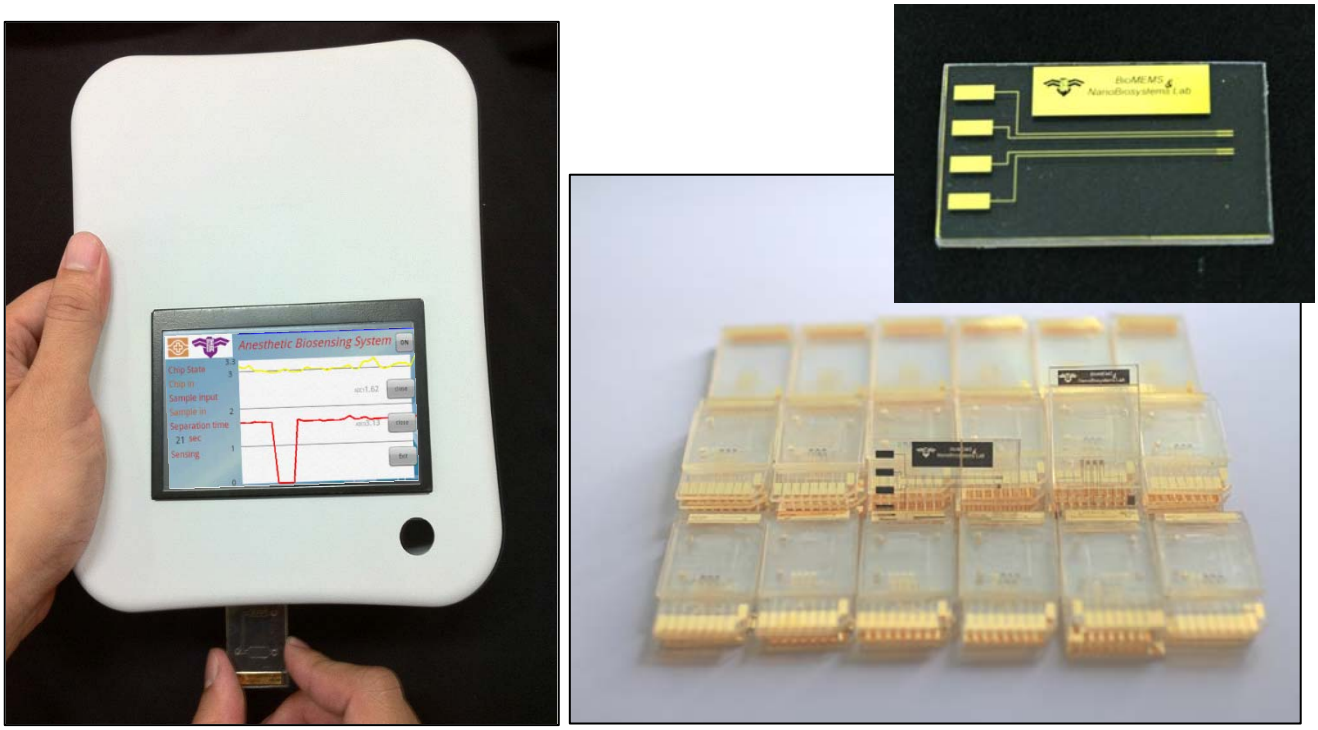


Figure 3. Photographs of the developed handheld ARM-based analyzer with disposable lab-on-chips and on-chip molecularly-imprinted conducting polymer biosensors.

EXPERIMENTAL RESULTS

In the experiments, propofol molecules were added into the human serum samples. The serum samples with known propofol concentrations were injected into the microfluidic biochips. Figure 4 shows the dynamic propofol binding results characterized by electrochemical impedance spectroscope. From the binding curve, the binding reached saturation at the 20th second. In the experiments, the developed biosensor started the measurement at the 21th second. Figure 5 shows the discharging curve for different propofol concentrations is measured between 0 μg/ml to 60 μg/ml. According to the measured discharging curve for MICP and non-molecularly imprinted conducting polymer (NICP) in Figure 5 and Figure 6a, the specific binding of the biosensor is up to 5500%. The discharging slopes were calculated as a calibration curve, shown in Figure 6b. The electronic anesthetic biosensors with MICP electrodes for rapid detection of propofol presented in this work showed good performance in separation and sensing of anesthetic propofol molecules.

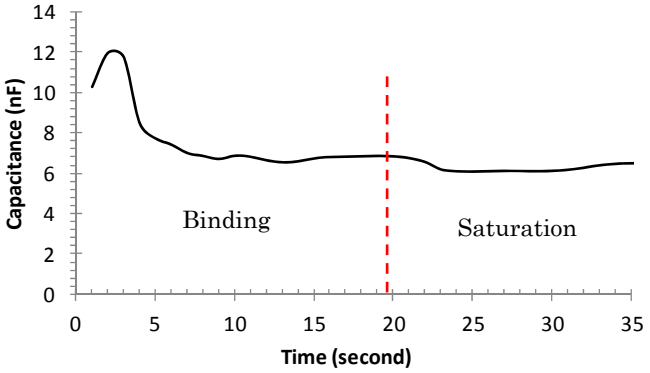


Figure 4. Dynamic capacitance measurements of molecularly-imprinted conducting polymer electrode during analyte binding by electrochemical impedance spectroscope.

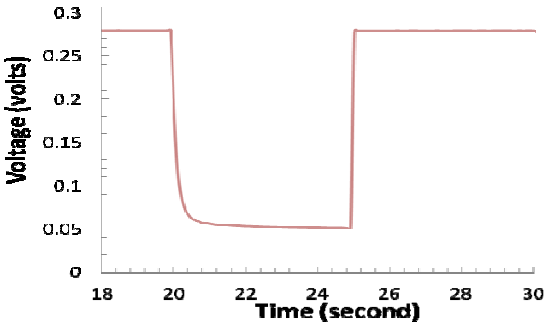
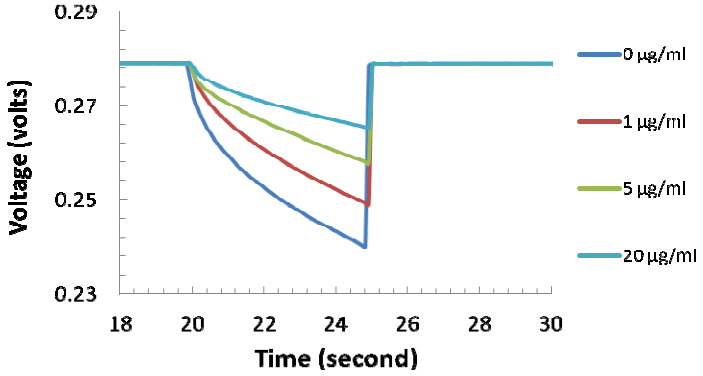
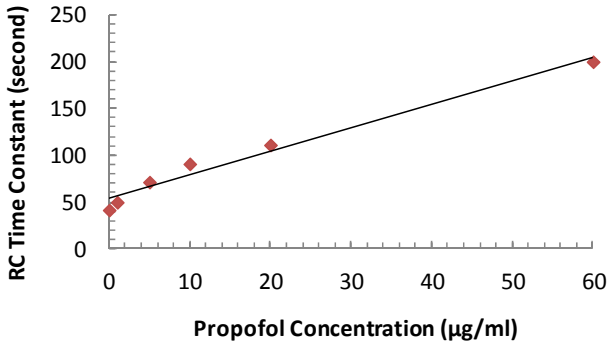


Figure 5. Dynamic voltage response from the non-imprinted conducting polymer (NICP) biosensors at different analyte propofol concentrations in human serum.



(a)



(b)

Figure 6. Measurement results at different analyte propofol concentrations in human serum: (a) dynamic voltage response from the molecularly imprinted conducting polymer (MICP) biosensors and (b) the calibration curve calculated from the dynamic voltage curve.

CONCLUSIONS

In summary, novel handheld analyzer with disposable lab-on-chips for clinical diagnostics has been developed and realized. The developed platforms with on-chip biomimetic biosensors have the advantages of compact size, ease of use, high sensitivity, high selectivity, and low cost.

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