

A Flexible Glucose Electrochemical Sensor for Textile Integration

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Summary:

A printed electrochemical sensor based on Ag flexible ink is presented to determine chemical substances concentrations. The sensor consists of 3-electrodes structure with different thickness and distances. This design permits to measure by chronoamperometry different glucose concentrations and compare the responses obtained by the different geometries presented. The decrease of the current measured between the sensor electrodes provides enough information to identify the increase of the glucose concentration along the solutions.

Keywords: printing, textile, chemical, sensor, flexible

Background, Motivation and Objective

Electrochemical sensors have been centered the focus of numerous researchers who work on developing new opportunities to integrate sensors on flexible substrate [1], [2], [3]. The integration of electrochemical sensors over flexible substrates could lead to the appearance of new healthcare control applications.

One of the biomarkers which has attracted the interest of the researchers over the last years is the glucose. The importance to control the concentration in blood with direct measuring or indirect measuring (sweat) is very important to predict hypoglycemia or hyperglycemia from diabetic people. Flexible technologies have proved the possibility to integrate or built electrochemical sensor to measure the glucose concentration over textile or flexible substrates [1], [4]. Several of the electrochemical sensors developed use chemical treatments over the conductive materials to obtain sensitivity to chemical substances. These treatments could be chemical coatings or enzymatic treatments which are placed over the sensors to improve their functionality.

A flexible electrochemical sensor has been designed to detect different concentrations of glucose. The sensor has been built using commercially available silver ink (Ag) without additional chemical or enzymatic treatments.

Description of the New Method or System

The printed electrochemical sensor has been built following the 3-electrodes sensor design, where the longest electrode is the counter electrode (CE) the center electrode is the working

electrode (WE) and the right electrode is the reference electrode (RE). Three different geometries have been prepared to analyze the impact of the different sizes and distance of the electrodes. Figure 1 shows the printed electrochemical sensors.



Fig 1. Printed electrochemical sensor with 3 electrodes. From left to right the parameters for the electrodes changed are: 2mm of thickness and 1 mm distance ($d1t2$), 1mm thickness and 2mm distance ($d2t1$) and 1mm thickness distance ($d1t1$)

To print the sensor a flexible silver ink (FS0142), which is produced by ACI Materials company, is used. The ink is used with a *Voltera Nova* drop casting printing machine to manufacture each of the sensor over a flexible thin film (Fig 2). The printed sensor is connected to a Keithley Source Measurement unit SMU2636B (SMU) by pairs, CE and WE will be fed with a constant 400mV. Meanwhile, the current generated between WE and RE is measured.

To test the response of the sensor to a chemical substance, three glucose solutions are prepared. The glucose concentrations present in the solutions are 90, 180 and 900 mg/dL

Results

Sensor values are obtained performing a chronoamperometry with different glucose concentrations. Each measurement is performed during 30 seconds. After the initial 5 seconds, 10 μ L of solution is dropped.

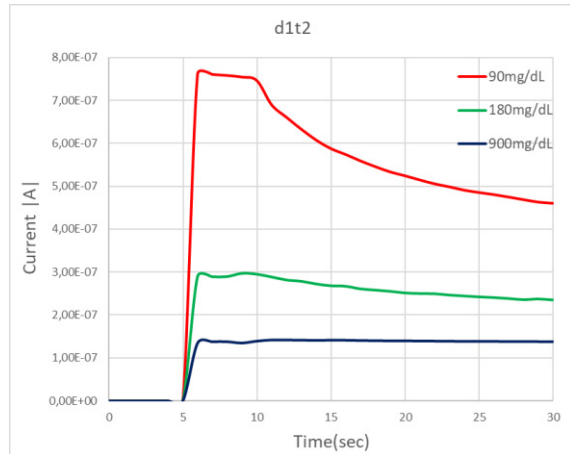


Fig 2. Chronoamperometry for the sensor 2mm thickness and 1mm distance.

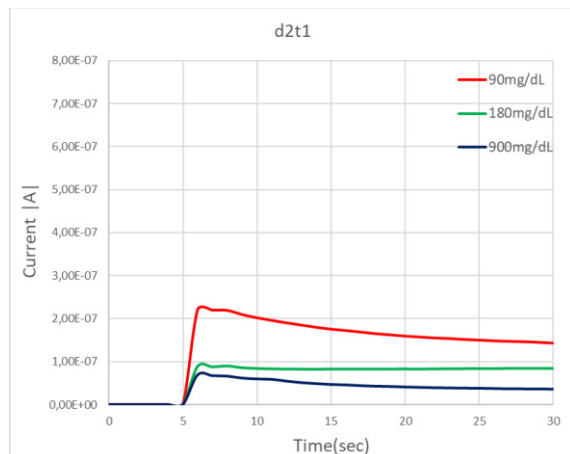


Fig 3. Chronoamperometry for the sensor 1mm thickness and 2mm distance.

It is observed in Figures 2, 3 and 4 how the lower concentration 90 mg/dL obtain the highest current measured. As the concentration increases, the current measured on the electrochemical flexible sensor decreases. The flexible sensor response for the 90 mg/dL also shows a higher instantaneous peak compared with the other solutions.

The printed sensor with both characteristics equal has a more stable and similar distributed data, meanwhile, the sensors with 2mm distance (Fig 2) or 2 mm thickness (Fig 3) shows a wider step from 90 mg/dL to 180 mg/dL.

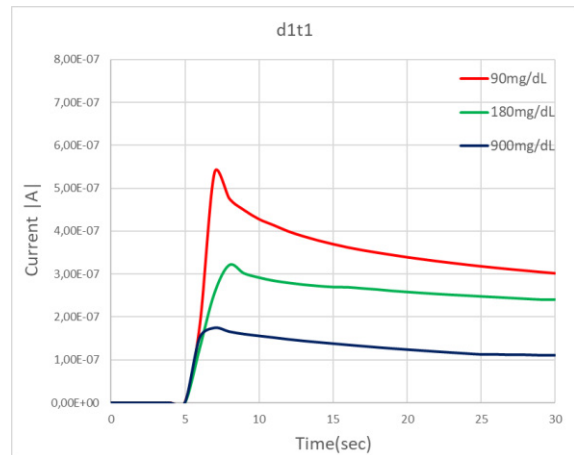


Fig 4. Chronoamperometry for the sensor 1mm thickness and 1mm distance.

Specially the sensor response observed in Fig 2 shows how the current value for 90 mg/dL is almost 2 times the current measured of 180 mg/dL and 4 times the current value of 900 mg/dL, which could be interesting for future applications and characterizations.

Overall, the printed flexible sensor presented demonstrate the ability to detect chemical substance concentration in solutions and also how the geometry could affect the behavior of the sensor. The flexible printed sensor could be integrated over textile or flexible substrate by direct drop printing or iron fixing to provide new possibilities of applications from textile substrates.

Acknowledgements

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