Pesticide Telemetry Using Potentiostat

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Abstract. Even if the pesticides can cause different diseases, there are few methods to detect their influence and presence within the food products. However, it has been found a way to detect these harmful substances. The use of a potentiostat within a telemetry system can represent the solution to this problem. The potentiostat is an electronic device which can control a three electrode cell and run electroanalytical experiments. This paper aims to present methods and components of a telemetry system. It represents an experimental demonstrative model for immunobiosensor, composed of carbon nanomaterials/magnetic and antibodies serving for detecting the carbamate pesticides in horticultural products. In addition, a way of exploiting the properties of nanomaterials which could provide great platforms for the electronic/optic signals generator required for the development of a new generation of bio-detection devices will be presented.

Keywords: Pesticide · Telemetry · Potentiostat · Immunobiosensors

1 Introduction

Fruits and vegetables represent one of the most contaminated sources of food with pesticides that all of the people consume daily. Using pesticides represents a good method for eliminating plants diseases and most of the pests. Even so, the abuse of pesticides leads to endangering the health of those who consume the horticultural products. Moreover, these substances present low solubility and their decomposition takes a long time. This is why they are called persistent organic pollutants and their secondary effects can determine serious environmental and health diseases [1].

The scientific works which successfully implemented the electrochemical devices for detecting the pesticide residues come in the help of the population. The goal of these devices is to detect and monitor these solutions by using only few resources, sensitive and more practical instruments [2]. In laboratories, the electrochemical techniques are used to study the thermodynamics and kinetics processes of electrons and ions transfer in order to deduct the absorption phenomena that occurs on the electrode's surface and the possible reaction mechanisms in organic chemistry and biochemistry.

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In most of the voltammetric methods, an electrochemical cell consists of three electrodes [3]:

1. A working electrode at which the electrochemical reaction appears at the electron's transfer;
2. A reference electrode which is characterized by a constant potential in time;
3. An auxiliary electrode, where a counter reaction to the working electrode takes place in order to balance the total load all over the system.

These being said, when a voltage potential is applied to the working electrode interacting with a pesticide probe, the working electrode is getting oxidized or reduced, resulting in a concentration change on the electrode's surface. As consequence, this process causes the transfer towards the electrode and the appearance of an electric current. This current is recorded on a curve called voltammogram and it is directly proportional to the applied potential. Due to its dependency on the analyte's concentration, voltammetric methods can be applied for analytical purposes [4].

A biosensor represents an analytical device that turns a biological response into a quantifiable and processable signal. The composition of a typical biosensor used for pesticide detection consists of a bio-receptor, an electrochemical interface (electrode) to which the bioreceptor is connected and also an electronic system developed to turn the biological response of the electrode into a processable and measurable signal, as presented in Fig. 1. The steps of the analysis process are the following: when the working electrode gets in contact with a pesticide solution, an interaction between the bio receptor and pesticide solution appears. The basic tools necessary for an electrochemistry experiment are an electrochemical cell and a voltamperometric analyzer, which consists of a potentiostat connected to a computer [5].

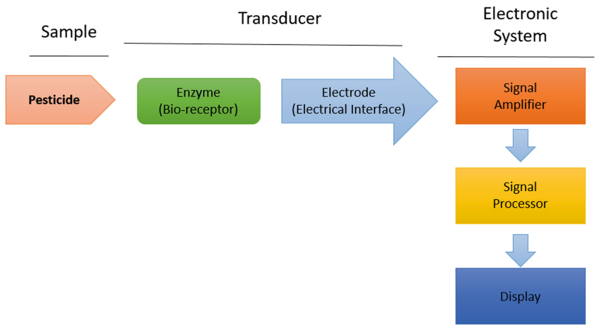

Fig. 1. Major components of a typical biosensor for pesticide detection

The rest of the paper is structured as follows: Sect. 2 presents the related work, Sect. 3 shows the methods of using the potentiostat for the telemetry system, while Sect. 4 presents the measurement results. Finally, Sect. 5 concludes the paper.

2 Related Work

In [6], a portable biosensor is used in order to detect the pesticide concentration. This biosensor makes use of screen-printed electrodes and it has the ability to determine the concentration of organophosphorus and carbamate pesticides. Developed in a laboratory, the biosensor uses a screen-printed electrode with 10 mU of immobilized AChE (Acetylcholinesterase) coupled to a potentiostat and a portable computer. The whole system has been evaluated and validated to be used for determining the neurotoxic pesticides in water samples and horticultural products.

In [7] an experimental solution for a potential point-of-use platform for multivariate analyses by presenting homemade potentiostat and smartphone is documented. This system combines high-performance detection with great simplicity, low-cost, portability, autonomy (6 h), and wireless communication device. The features presented proved efficiency in different assays by allowing the real-time accomplishment of the entire analytical measurement at remote places. The system is composed of a point-of-use platform used for detection of the electroanalytical in function of the diverse analyses and a portable, self-sustainable and free cabled platform system composed of a potentiostat and smartphone.

3 Potentiostat Measurement Methodology and Immunosensors

A potentiostat is an electronic device able to handle the voltage potential difference between a working and a reference electrode [8]. The reference electrode maintains a constant voltage with the reference to the electrode potential of hydrogen. However, when a current passes through the reference electrode, the electrode gets polarized, meaning that the potential varies with the current. To avoid this and to maintain a constant potential, the respective current should not pass through the reference electrode. This means that the potentiostat should be presented with a high input resistance of the order of GOhms to TOhms. Another method for the above problem is to implement a counter electrode [9], as presented in Fig. 2. In this case, a current must be forced to pass between the working and counter electrode.

Immunosensors can be defined as sensors that act on the principle that the response of a biological species exposed to contaminants will produce antibodies which can be measured [10]. They are based on the immunochemical reactions so that the antigen (Ag) is bounded to a specific antibody (Ab). For every antigen, determination corresponds the production of a particular (Ab), its purification and isolation. To increase the sensitivity of the immunosensors, the enzyme labels are coupled to (Ab) and (Ag) resulting in more chemical steps. It is worth mentioning that the immunosensors consist of two processes. The first process is called the molecular recognition process which determines the specific (Ag-Ab) binding reaction on the surface of the receptor while the second process is called the signal-transfer process which responds to the changes in an electrochemical parameter of the receptor. These changes are caused by the specific binding between (Ag-Ab) [2]. As resources, nanomaterials have already

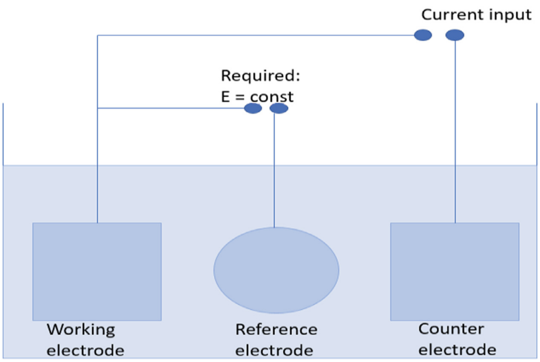

Fig. 2. Principle of a potential-controllable electrochemical cell

demonstrated their utilities for bio sensing applications in many technological domains. Nano-objects amazed with their increased performances in the sensitivity domain and accurate detections. One advantage of the nanomaterials is the high specific surface which enables the immobilization of an enhanced amount of bio receptor units. Nevertheless, a constant challenge reffers to the immobilization strategy or easier, the distinction which is used to conjugate intimately the bio-specific entity onto nanomaterials. Thus, immobilizing the pesticide sample represents one of the main factors in developing a reliable biosensor [11].

4 Measurement Results

In this section, the implementation of an experimental prototype model of imuno-biosensor used for detecting carbamate pesticides in horticultural products is presented. In Fig. 3 is presented the schematic of the potentiostat.

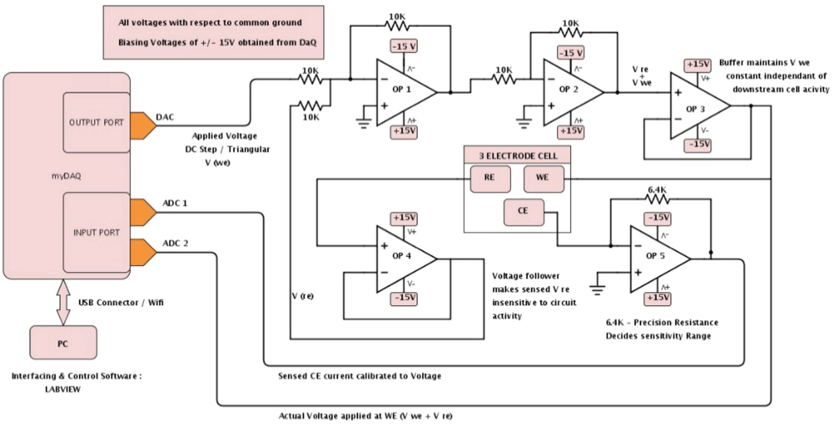

Fig. 3. The schematic diagram of the potentiostat

For measurements we used a NI myDAQ from National Instruments, which is a data acquisition device that has the ability to measure and analyze live signals, no matter the location or time. The potentiostat is connected on the ADC1, ADC2 inputs and DAC output of the myDAQ and the collected data can be easily visualized within the front panel interface of the LabVIEW environment [12], as presented in Fig. 4.

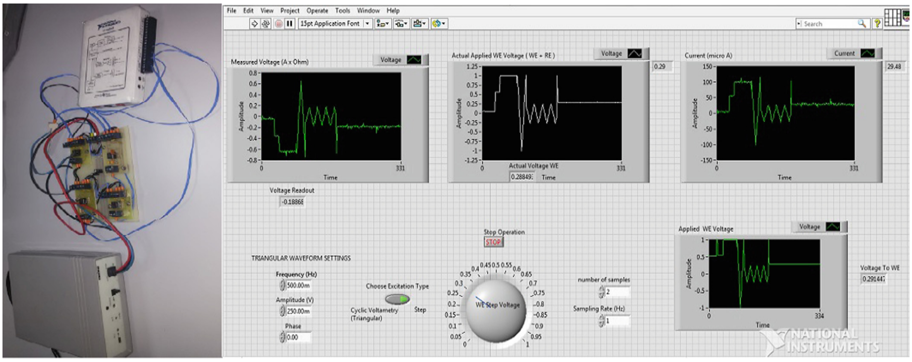

Fig. 4. Potentiostat - myDAQ connection and LabVIEW measurements front panel

The sensors connected to the potentiostat are a PAR Quantic Sensor which is used for the measurement of photosynthetic active radiation [13], a WET-2 sensor for measuring three vital soil properties: water content, electrical conductivity and temperature [14] and low cost and disposable Screen Printed Electrodes (SPE) [15].

Another set of sensors that can be used within CarbaDetect project are an SHT15 digital temperature and humidity sensor [16] – it is a unique capacitive sensor element that is used for measuring relative humidity while temperature is measured by a band-gap sensor and an ML8511 UV Sensor [17] which is equipped with an internal amplifier able to turn the photo-current into voltage depending on the UV intensity. Also, the graphical interface can be used for the manual input of some parameters like: pesticide type, antibody type, the protein, type of link, carbon type or magnetic link, fluorescent or not, ample label, concentration, dilution, the incubation time.

5 Conclusion

In this paper, we presented a solution for telemetry of pesticides using a potentiostat. The prototype is a compact analytic device designed for biomolecular recognition. We developed an experimental demonstrative model for imunobiosensor based on carbon nanomaterials/magnetic and antibodies for detection of carbamate pesticides in horticultural products. As compared to other existing systems, our solution is both cost-effective and easy to be implemented.

As future work, we envision to exploit the unique properties of nanomaterials (magnetic/carbonic) which could offer excellent platforms as electronic/optic signals generator necessary for the design of a new generation of bio detection devices. In addition to this, we aim to conduct various tests using different fruits and vegetables, under different conditions.

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