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PORTABLE DEVICE FOR PESTICIDE TOXICITY ANALYSIS FOR MEASUREMENT IN FIELD CONDITIONS

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Abstract − The new portable microfluidic device for field measurement is presented. It consists of two loop pumps. The first loop asssures the mixing of solution. The 95 % of solution circulates through the first loop. The second loop consists of capillary which creates the hydrodynamic resistance and the chamber with biosensor. The Artificial Synapsis (AS) [1] is integrated in the chamber, which detects the integral organophosphorous pesticide toxicity. The 5% of solution circulates through AS. Both parts are integrated in a compact device with size of 200 x 100 x 100 mm.

The signal from biosensor is evaluated by Bioanalyzer electronic unit. It is destinated for detection of traces of pesticides in washout from leaves for direct measurment in rivers, ponds, vaste waters and drinking water sources. The electronic unit contains the unique software for data aquisition and biosensor signal analysis. The whole device consists of two basic units and several accessories. The article describes structure and function of this device.

Keywords: portable device, pesticide toxicity analysis

1. INTRODUCTION

Fast detection of pesticide toxicity in field conditions is very important in many aspects such as:
- longtime influence of low concentrations on man´s health,
- influence on environment,
- pesticide storage,
- move in food chain,
- intoxication of high concentrations and their fast detection,
- speed of an analysis and possibility to make a test in field conditions,
- price of one test.

All of the above mentioned points are not fully solved yet. The price of one test is too high, 33 Euro is the minimum. The test must be performed in a laboratory. That is why the time between taking the sample in field and its analysis is too long (1 to 5 days). The probability of finding a possitive sample is low, because the number of samples and their tests is very small. In 1999 about 400 tests were done according to the notice in south-moravian region. Only 10 decisions were possitive, the control is very inefficient mainly from economical point of view.

The low costs and time-undemanding analysis are the biggest advantages of the new device for the field measurement of organophosporous pesticides toxicity. The price of one analysis is less then 10 Euro. The results of the analysis are at disposal in 30 minutes. The device can ensure an effective prescreening of samples in the field or in the laboratory. The full classic analysis will be done only for positive results.

2. THE PORTABLE DEVICE DESCRIPTION

2.1. Microflow unit

The AS is a very effective detector of pesticides. That is why it was integrated into the device, which is being developed in the frame of the research project ANTOPE in cooperation with the Brno University of Technology, Krejčí Engineering and BVT Technologies a.s. Fig. 1 shows a laboratory sample of the microflow unit with stand.

Fig. 1. Microflow unit with stand

This module is the heart of the whole system and has been patented recently [2] by the company. The microfluidic capillary arrangement allows precise and constant flow of the liquid onto the active surface of the Electrochemical sensor/Biosensor. This means there exists a high level of repeatability and sensitivity in the measurements carried out when using the system. The module has an integrated chamber in which the sensor can be placed or replaced easily.

2.2 System description

In the Fig. 2, a conventional electrochemical vessel (1) is covered by a modified lid (2), which carries the body of the microflow insert (3). The driving shaft (4), located in the centre of the microflow insert, is connected to the pump rotor (5) and immersed in the electrolyte/sample fluid.

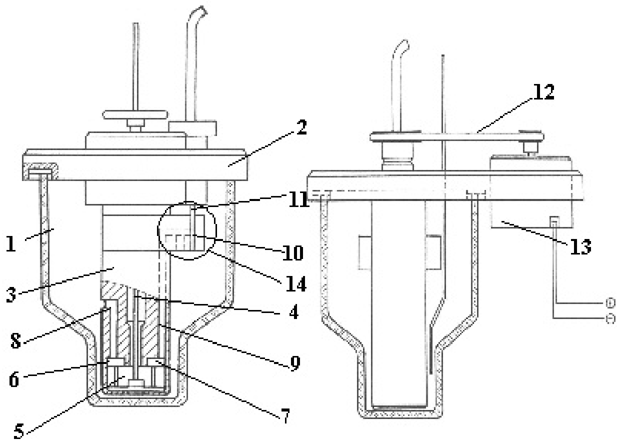

Fig. 2. Electrochemical vessel structure

The two chambers located above the rotor fulfil two different functions: The first chamber (6) is connected via channel (8) to the bulk of the electrolyte/sample solution inside the electrochemical vessel. The portion of the liquid being pumped through this passageway provides sufficient stirring of the solution inside the electrolyte vessel. The second chamber (7) helps to guide the fluid coming from the rotor into the capillary (9) and into the electrode cell (10). The key function of the narrow capillary is to stabilise the flow of the liquid before it enters into the electrode cell.

The overall design of the insert is such that only 1 to 5% of the liquid is flowing through chamber (7) and capillary (9), while about 95 to 99% of it is pumped through the chamber (6) and channel (8), ensuring intensive stirring of the solution.

Electrode cell (10) is designed for the integrated three-electrode amperometric sensor (11) (Type AC1 produced by BVT Technologies a.s.).

Following its passage past the sensor, the liquid is returned from the electrode cell directly into the bulk of the electrolyte/sample solution inside the vessel.

Driving shaft (4) is connected by means of an elastic belt (12) to the external motor (13). Other openings in the lid (2) are provided for sample additions, insertion of a thermometer and for other accessories.

2.3 Function

When the sample electrolyte solution is filled into the electrochemical vessel, the rotor pump immersed in the sample liquid and the external motor is switched on, the sample liquid is pumped into the two chambers above. While the chamber (6) allows a portion of this sample liquid to mix into the bulk contents of the vessel through the channel (8) to provide with sufficient stirring, the other portion of the sample liquid is pumped through chamber (7) and the capillary (9).

The capillary fulfils the function of stabilising the flow of liquid before it enters the electrode cell. Following its passage through the cell the liquid gets mixed into the bulk content. The sensor placed in the cell responds to the sample liquid and this response is recorded by Biosensor Analyzer unit.

The entire vessel can be placed in a thermostat bath to keep the temperature constant. The few other openings can be used for sample additions, thermometer insertion, accessory insertion etc.

The microflow insert can also be independently used (without the electrochemical vessel) in the field conditions for example in the water sources by direct insertion into the medium.

2.4 Units and accessories

Fig. 3 shows some units and accessories which are included in the whole system. These are the most important units and accessories:

- microflow unit with stand,
- biosensor analyzer unit,
- screen-printed sensor pack,
- Windows™ based analysis software "OFBio",
- connection cable,
- 9 V adapter,
- operating manual,
- pipettes,
- cartridges for preconcentration,
- carrying case.

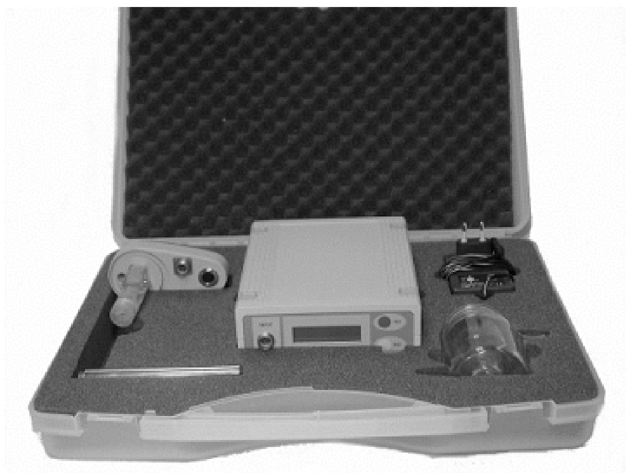

Fig. 3. Carrying case with units and accessories

2.5 Screen-printed sensor

The system is based on AC1 type screen-printed sensors (also manufactured by BVT Technologies a.s), Fig. 4. These sensors are produced by the screen printing technology. The benefits of using these sensors are:
- small size,
- low cost,
- easy handling and processing,
- wide range of electrode materials,
- easy immobilisation procedures etc.

Low cost ensures that the sensor is disposable, it can be replaced.

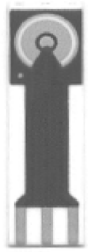

Fig. 4. Screen-printed TFT AC1 sensor

The sensor is formed on a corundum ceramic base by printing the working, reference and the auxiliary electrodes using Thick Film Technology (TFT). The sensor is provided with contact points connected to the electrode active parts by the silver conducting lines. Dielectric protection layer covers the whole sensor area except for active areas and the contact ends. A bio-chemically active substance can be put on the active part of the sensor to prepare a biosensor.

3. CONCLUSION

The possibility to determine the pesticide toxicity by biosensor is presented. This method is well known for a long time. The the new device for this determination is presented. The result made by AS is the first step [1]. The main aim is to find a correlation among the known methods to cover reliability and user friendly properties. The aim of this work is not to present this method as new, but to gather a new suggestions and to find new possible cooperation in this field.

The result of the biosensor analysis is the signal corresponding with biologic action of toxic substance. This information is more valuable than the knowledge of real concentrations of pesticides. On the other side without the knowledge of the existing data correlations with actual concentrations, the data about biologic action of toxic substances are worthless.

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[2] Patent CZ 287676.

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