PORTABLE DEVICE FOR PESTICIDE TOXICITY ANALYSIS

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ABSTRACT

Fast detection of pesticide toxicity in field conditions is not fully solved yet. The new device for field measurement of organophosporous pesticides toxicity is described. The detection is based on the inhibition of acetylcholinesterase. The enzyme acetylcholinesterase is immobilized on a miniature electrochemical detector made by thick film technology forming together a biosensor. The dimensions of biosensor are 7,35 x 25,4 mm. The biosensor is placed in flow chamber which assures the reproducible hydrodynamic conditions near of active surface of the sensor. The analyzed sample is detected in the flow of supporting buffer.

The biosensor detects the integral sample toxicity. 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 preconcentration of sample is possible. The detection limit varies in wide range depending on the toxicity of pesticide.

1 INTRODUCTION

Fast detection of pesticide toxicity in field conditions is very important in many aspects, such as:

- longtime influence of low concentrations on human´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, 1000 Kč is a 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.

The new device for the field measurement of organophosporous pesticides toxicity is described and first results are presented. The low costs and time-undemanding analysis are the biggest advantages of the device. The price of one analysis is about 300 Kč. The results of the analysis are at disposal in 30 minutes. The device can ensure an effective prescreening of samples in field or in the laboratory. The full classic analysis will be done only for positive results.

2 TOXIC ACTIVITY MECHANISM

Toxic activity of organophosphorous pesticides is due to Action Potential transfer damage via cholinergic synapsis [1], [2].

When the inhibitor (pesticide) penetrates into the nerve, the enzyme function is reduced. The amount of released acetylcholine (ACH) is continuously increasing in the synaptic gap. The ACH ties up to a receptor. In this case the action potential can be increased without any initial impulse in presynaptic part. And there are more Action Potentials in the output forming the answer to one Action Potential in presynaptic part as shows Fig. 1. The noncoordinated Action Potentials is result, which can invoke cramps or even death. The mentioned function is very simplified and schematic. The aim is to make some intuitive imagination of toxic-activity mechanism.

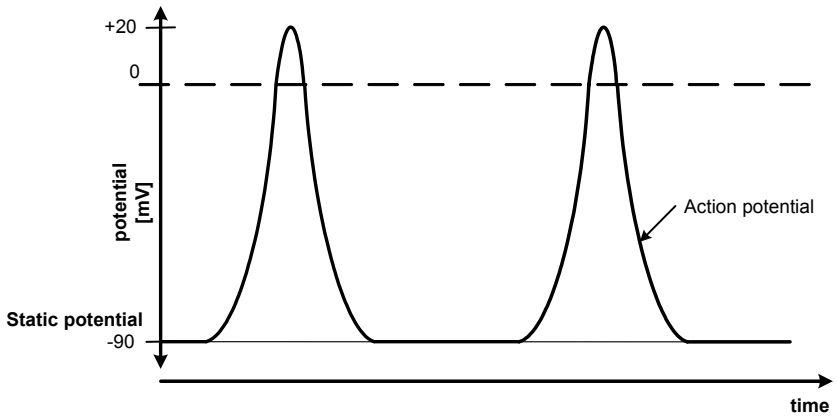

Fig. 1: *Action potential seeking for inhibition*

3 ARTIFICIAL SYNAPSE

Fig. 2 shows the artificial synapse principle, which is analogical to the biologic synapse in simplified shape. The capillary is used for putting an input solution of acetylthiocholine (ATCH – analogical to ACH) , which simulates the presynaptic part. The solution with ACH washes the mechanical membrane with immobilized acetylcholinesterase (ACHE) the ACH to choline and acetic acid. The product (choline) flows back into the solution and flows to the electrode. It can be detected there. The choline is not electroactive. When the input substrate is ATCH, which is the substrate with ACHE too, the new product (thiocholine) is electroactive and can be detected by an electrode.

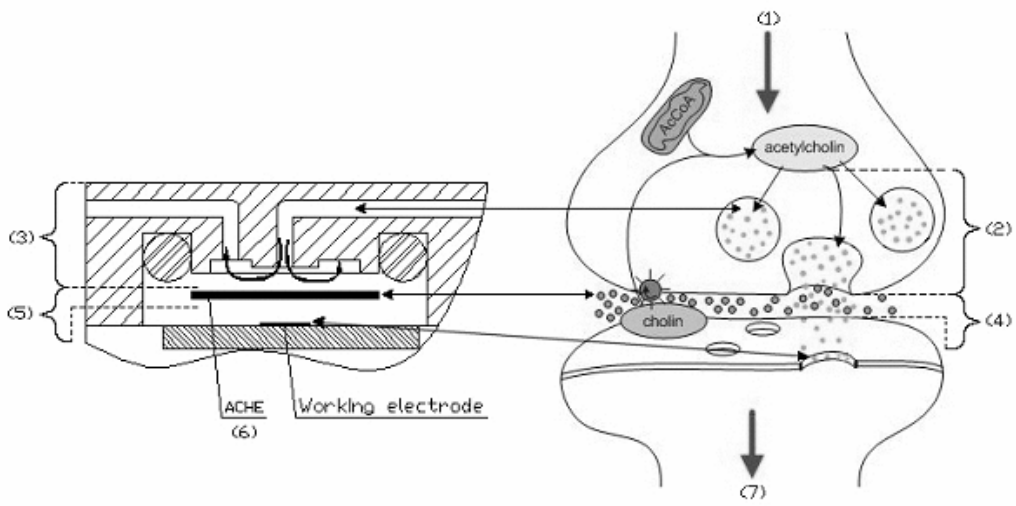

Fig. 2: *Artificial synapse structure (explanation in text)*

Fig. 2 presents: (1) - Input electrical exiciting (Action Potencial), (2) - ACH is transported through vesicula from presynaptic end to synaptic gap, (3) - ACH is transported through hydro-dynamic flow, (4) - synaptic gap with ACHE, (5) - ACHE is immobilized in gap between electrode and input of ACH, (6) - immobilized ACHE, (7) - output electrical exiciting (Action Potencial).

4 MICROFLOW UNIT

Artificial Synapse is a very effective detector of pesticides. That is why it was integrated into the device, which was developed as the research project ANTOPE in cooperation with BUT, Krejčí Engineering and BVT Technologies a.s. Fig. 3 shows a laboratory sample of the microflow unit with stand.

Fig. 3: *Microflow unit with stand*

This module is the core of the whole system and was patented recently (CZ287676) 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.

These are the most important units and accessories, which are included in the system:

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

4.1 SYSTEM DESCRIPTION

In the Fig. 4**,** 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.

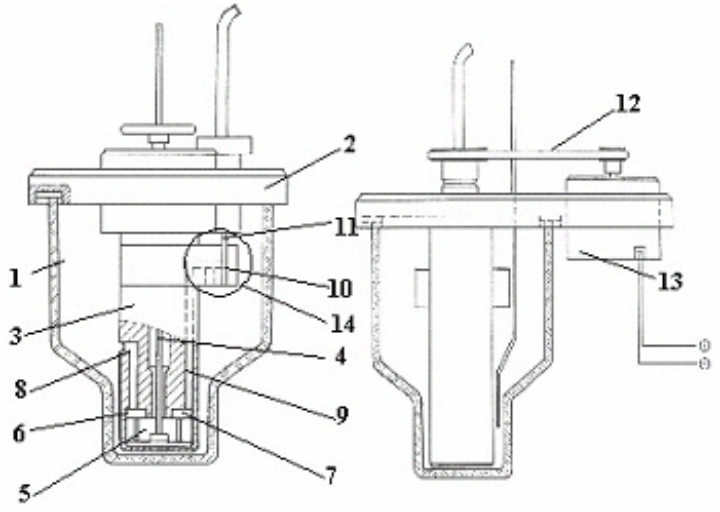

Fig. 4: *Electrochemical vessel structure*

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 for 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. 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.

Electrode cell (10) is designed for the integrated three-electrode amperometric sensor (11) (type AC1 produced by BVT Technologies a.s.). Driving shaft (4) is connected by means of an elastic belt (12) to the external motor (13).

4.1.1 FUNCTION

When the sample electrolyte solution is filled into the electrochemical vessel and the external motor is switched on with the help of the rotor pump immersed in the sample liquid, 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 it's 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 on Biosensor analyzer unit.

The entire vessel can be placed in a thermostat bath to keep the temperature constant. The microflow insert can also be independently used (without the electrochemical vessel) in the field conditions, in the water sources by direct insertion of the insert into the medium.

5 CONCLUSION

The possibility to determine the pesticide toxicity by biosensor is presented. This method is well known for a long time. 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 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.

The intensive testing measurements are being carried on with various types of pesticides in various concentrations at present time. The detection limit enables to determine the values of pesticide residuum.

ACKNOWLEDGEMENTS

This research has been supported by Czech Ministry of Industry registred by FD-K2/53 as Reseach and development program ANTOPE - Analyser of Pesticide Toxicity.

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