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Comparative Study of Pesticides Analysis Using Enzyme Inhibition Sensor and Gas Chromatography Methods

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Abstract

Pesticides are widely used in paddy field to control pests, diseases, weeds and other rice pathogens in minimizing a serious loss in rice production. The presence of pesticide residues and metabolites in rice, water, soil, currently represents a major environmental pollutant issues. It sometime will cause insect pest outbreaks in paddy field. An electrochemical enzyme inhibition sensor using screen-printed carbon working electrode with onboard carbon counter and silver–silver chloride pseudo-reference electrode for insecticides detection is described in this paper (Figure 1). The detection is based on the inhibition of insecticides used in paddy field towards acetyl-cholinesterase enzyme (AChE) with the presence of Acetylthiocholine Iodide (ATCh) substrate on the sensor surface. The mixtures of AChE enzyme (0.02 UmL^{-1}), electron mediator, TCNQ (1mM) and polypyrrole matrix (75 mM) were electro-polymerized on the sensor surface with a constant potential of 1.0V for 20 minutes. The sensor was soaked for 5 minutes with insecticides standard or sample containing insecticides before the electrochemical measurement was taken by adding Acetylthiocholine Iodide substrate in KCl (0.08M, pH 7.5) which acts as the enzyme mediator /substrate system. The current measurement was conducted using chronoamperometry at 100mV vs. on board screen-printed Ag-AgCl pseudo- reference electrode. Comparative analysis of spiked water samples with 0.1ppm pesticides and real samples (paddy) also were conducted using enzyme inhibition sensor and gas chromatography methods. From the data analysis, it showed very comparable results with R^2 = 0.96 in the correlation plot for paddy samples samples. This makes the developed sensor a potential tool for the rapid, simple and sensitive detection of insecticides residues in agriculture industry.

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Keywords: Gold nanoparticles; enzyme inhibition sensor; screen-printed carbon electrode; insecticides; rapid detection; rice industry.

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1. Introduction

Pesticides are widely used in paddy field to control pests, diseases, weeds and other plan pathogens in minimizing a serious loss in rice production. Insecticides such as Organophosphates, Organochlorine and Carbamate insecticides is been used for pest and disease management. Many of these insecticides show a strong persistence in the soil and water environment and also in fatty tissue as they tend to bioaccumulate (Lucía Pareja *et al*., 2011). Moreover, due to their physicochemical properties, pesticides can leach from agricultural fields to ground and surface waters being a potential risk for ecosystems as well as for drinking water quality. Currently, many methods are available for pesticide detection such as gas chromatography (GC) and high performance liquid chromatography (HPLC) coupled with mass spectrometry (MS). These methods are very sensitive and reliable but present strong drawbacks such as complex and time consuming treatments of the samples. Moreover, they can only be performed by highly trained technicians and are not convenient for on-site or on in-field detection. Biosensors are potentially useful as they detected pesticides quickly and suitable for on-site detection. Biosensors have been developed for the detection of pesticides using integrated enzymes, antibodies, cell and DNA-based biosensors (Lucía Pareja *et al*., 2011). This paper will focuses on enzymatic determination of pesticides which based on inhibition of the activity of selected enzymes such as acetylcholinesterase, acid phosphatase, ascorbate oxidase, acetolactate synthase and aldehyde dehydrogenase. Gold nano-particle coated with AChE enzyme was used as a sensor platform (Figure 1). AChE has proven to demonstrate inhibition of insecticides in terms of its mechanistic and kinetic activities (Arun Prakash et al., 2009).

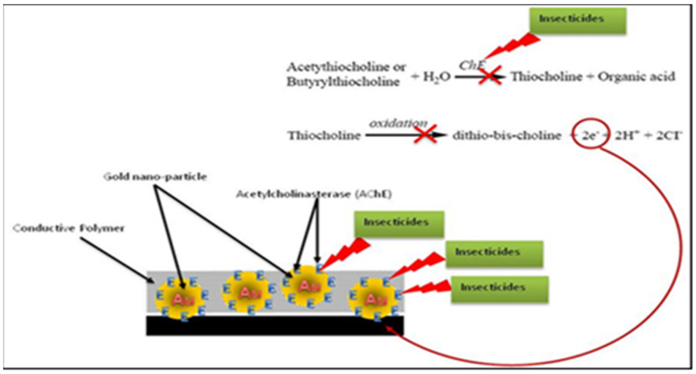

Fig. 1: Schematic diagram of the enzymatic reaction on the carbon working electrode coated with AChE

2. Material and Methods

2.1. Source of chemicals

Insecticides (Buprofezin, Chlorpyrifos, Carbofuran, Imidacloprid, Fipronil, Cypermethrin, Etofenprox , Dimethoate, Acephate, Malathion, Acetylthiocholine substrate (ATCh), Acetylcholinesterase enzyme (AChE –221U/mg), pyrrole, sodium hydroxide (NaOH), sodium acetate and hydroxylamine hydrochloride (HAH) used in the present study were obtained from Sigma-Aldrich (Malaysia). Potassium