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Multi-Walled Carbon Nanotubes Doped Poly (3,4 Ethylenedioxythiophene) Composites Based Electrochemical Nano-Biosensor for Organophosphate Detection

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Abstract : One of the most publicized and controversial issue in crop production is the use of agrichemicals- also known as pesticides. This is evident in many reports that Organophosphate (OP) insecticides, among the broad range of pesticides are mainly involved in acute and chronic poisoning cases. Therefore, detection of OPs is very necessary for health protection, food and environmental safety. In our study, a nanocomposite of poly (3,4 ethylenedioxythiophene) (PEDOT) and multi-walled carbon nanotubes (MWCNTs) has been deposited electrochemically onto the surface of fluorine doped tin oxide sheets (FTO) for the analysis of malathion OP. The -COOH functionalization of MWCNTs has been done for the covalent binding with amino groups of AChE enzyme. The use of PEDOT-MWCNT films exhibited an excellent conductivity, enables fast transfer kinetics and provided a favourable biocompatible microenvironment for AChE, for the significant malathion OP detection. The prepared PEDOT-MWCNT/FTO and AChE/PEDOT-MWCNT/FTO nano-biosensors were characterized by Fourier transform infrared spectrometry (FTIR), Field emission-scanning electron microscopy (FE-SEM) and electrochemical studies. Electrochemical studies were done using Cyclic Voltammetry (CV) or Differential Pulse Voltammetry (DPV) and Electrochemical Impedance Spectroscopy (EIS). Various optimization studies were done for different parameters including pH (7.5), AChE concentration (50 mU), substrate concentration (0.3 mM) and inhibition time (10 min). The detection limit for malathion OP was calculated to be 1 fM within the linear range 1 fM to 1 µM. The activity of inhibited AChE enzyme was restored to 98% of its original value by 2-pyridine aldoxime methiodide (2-PAM) (5 mM) treatment for 11 min. The oxime 2-PAM is able to remove malathion from the active site of AChE by means of trans-esterification reaction. The storage stability and reusability of the prepared nano-biosensor is observed to be 30 days and seven times, respectively. The application of the developed nano-biosensor has also been evaluated for spiked lettuce sample. Recoveries of malathion from the spiked lettuce sample ranged between 96-98%. The low detection limit obtained by the developed nano-biosensor made them reliable, sensitive and a low cost process.

Keywords : PEDOT-MWCNT, malathion, organophosphates, acetylcholinesterase, nano-biosensor, oxime (2-PAM)
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