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Electrocatalytic behavior of cobalt phthalocyanine complexes immobilized on glassy carbon electrode towards the reduction of dicrotophos pesticide

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Dedicated to Professor Tebello Nyokong on the occasion of her 60th birthday

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ABSTRACT: Electrocatalytic properties of cobalt phthalocyanine (CoPc), cobalt tetra-carboxy phthalocyanine (CoTCPc) and cobalt octa-carboxy (CoOCPc), towards the detection of dicrotophos have been studied. Catalytic behavior towards the reduction of dicrotophos was found to be dependent on the pH, as well as the substitution on the phthalocyanine ring. Strong electron withdrawing groups on the phthalocyanine ring yielded best catalysis as evidenced by the enhancement of the reduction peak current, (~5 fold) compared to the bare glassy carbon electrode. The analysis gave a good detection limit of 1.25×10^{-7} M, and good linearity for the studied concentration range. A high Tafel slope value was obtained, indicating a strong interaction between dicrotophos and the cobalt phthalocyanine complex.

KEYWORDS: cobalt phthalocyanine, dicrotophos, pesticides, cyclic voltammetry.

INTRODUCTION

Metallophthalocyanines (MPc) have been used as catalysts in a vast number of reactions such as the detection of molecules in biological systems and of environmental importance [1–10]. MPcs act as electron transfer mediators and in the process may or may not interact with the analyte in question. Analytes such as thiols, oxygen and nitric oxide have been reported to coordinate with the metal centre of the MPc complex, during catalysis [11]. Such reactions are described as inner-sphere reactions. For outer sphere reactions, there is no interaction between the central metal and analyte.

In recent years the use of pesticides and insecticides has improved agricultural productivity however they leave residues that exceed legal limits and are detrimental to human health. The mode of action of these pesticides in vertebrates and insects is based on inhibition of the activity of acetylcholinesterase (AChE) enzyme in the hydrolysis of the neurotransmitter acetylcholine, which is responsible for the transmission of nervous impulses. Thus there has been extensive work done towards the development of biosensors based on AChE for the detection of pesticides [12–17].

The use of AChE in the detection of pesticides is based on the measurement of the decreased enzyme activity after exposure of the enzyme, either in the free form or immobilized on an appropriate support, due to an inhibitor (*e.g.* a pesticide). This only provides information about the total anticholinesterase toxicity of a given sample without the possibility of selectively detecting and quantifying different pesticides [18–20]. In an effort to improve sensitivity and stability, MPc complexes have been immobilized together with enzymes for pesticide detection [21–23], however the lack of long-term stability of the biosensor remains a problem. Attempts to detect dicrotophos in particular, with acetylcholinesterase failed whilst the method worked for other organophosphates [24].

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