ORIGINAL SCIENTIFIC PAPER

CROATICA CHEMICA ACTA

Croat. Chem. Acta **2018**, *91*(4), 567–575
Published online: January 21, 2019
DOI: 10.5562/cca3424

HKD 1926

Non–enzymatic Amperometric Sensor for H_2O_2 Based on $MnCO_3$ Thin Film Electrodes

Sasho Stojkovikj,[1,*] Metodija Najdoski,[1] Birhan Sefer,[1,2] Valentin Mirčeski[1]

[1] Institute of Chemistry, Faculty of Natural Sciences and Mathematics, Ss. Cyril and Methodius University, Arhimedova 3, PO Box 162, 1000 Skopje, Republic of Macedonia

[2] Institute for Surface Science and Corrosion, Department of Materials Science and Engineering, Friedrich-Alexander-University of Erlangen-Nuremberg, D-91058 Erlangen, Germany

* Corresponding author's e-mail address: sashostojkovikj@gmail.com

RECEIVED: September 24, 2018 ✶ REVISED: December 22, 2018 ✶ ACCEPTED: January 11, 2019

Abstract: The present study describes development of a non–enzymatic amperometric sensor for detection of H_2O_2 based on $MnCO_3$ thin film electrodes. The film was deposited on electroconductive FTO coated glass substrates using simple chemical bath deposition method. The phase composition of the thin film was confirmed by X-ray diffraction analysis. The electrochemical properties and the sensor sensitivity towards H_2O_2 were examined using cyclic voltammetry and chronoamperometry in 0.1 M phosphate buffer solution with pH = 7.5. It was revealed that the sensing mechanism is based on electrocatalytic oxidation of H_2O_2, involving Mn species as redox mediators. According to the results, the best sensor response towards H_2O_2 was found at E = +0.25 V, with detection limit and sensor sensitivity of 10.0 μM and 2.64 μA cm^{-2} mM^{-1} (for the range of 0.09–1.8 mM), respectively, associated with R^2 = 0.999.

Keywords: amperometric sensors, hydrogen peroxide, manganese(II) carbonate thin films, electrocatalysis.

INTRODUCTION

THIS research contributes to the application of manganese(II) carbonate ($MnCO_3$), which already demonstrated interesting behaviour when used for preparing electrochromic materials,[1] as a precursor for synthesizing perovskites applied in high temperature solid oxide fuel cells,[2] and especially as an electrode material in supercapacitors.[3–7] The possibility of controlled deposition of uniform $MnCO_3$ thin films on FTO-coated substrates,[1] makes this material eligible to be studied as a working electrode in electrochemical systems for hydrogen peroxide (H_2O_2) sensor applications. H_2O_2 is an important substance that finds a wide use in various fields. Its oxidizing properties enable application in chemical and petro-chemical industry as a strong oxidizer, bleaching agent, disinfectant and propellant. [8–14] H_2O_2 is also used in medicine, pharmacy, cosmetics, food and beverage industry.[10,13–16] Apart from industrial applications, H_2O_2 is also important for the living cells.[17] It is well established that H_2O_2 is formed as a product in the mitochondria due to enzymatic reactions that involve free radicals.[17,18] Moreover, the increased mitochondrial production of H_2O_2 causes cytotoxic effects[11,13,18,19] through activation of several classes essential signalling proteins that compromise the cell reproduction, causing diseases such as cancer, diabetes, cardiovascular and neurodegenerative disorders.[17,20,21] The presence of H_2O_2 in the cells is significantly detrimental and commonly responsible for proliferation, apoptosis and/or necrosis of the cells, which depends on the cytosolic steady state concentration.[18,20] From this point of view, an accurate and precise quantification of H_2O_2 is substantially important. Hence, an enormous research strive is in progress in order to develop simple, efficient and reliable methods for detection and quantification of H_2O_2 at relatively low concentrations in biological fluids.[17] There are numerous methods for detection and quantification of H_2O_2. These include redox titrations,[22] chemiluminescence,[23–26] fluorescence and fluorimetry,[27–29] spectrophotometry,[30–32] chromatography[33] and electrochemistry.[13,34] The electrochemical sensors are based on sensing either reduction or oxidation