Pt Nanomaterial-based Artificial Enzyme System: Peroxidase mimicking and colorimetric biosensing

Camila Marchetti Maroneze[1,2] (PQ), Glauco P. dos Santos[1,2] (PG), Vitoria B. de Morais[1,2] (IC), Luiz P. da Costa[3] (PQ), Lauro Tatsuo Kubota[1,2]* (PQ)

[1] Institute of Chemistry, State University of Campinas (UNICAMP), P.O. Box 6154, 13083-970 Campinas, SP, Brazil
[2] National Institute of Science and Technology of Bioanalytics, UNICAMP, 13084-971 Campinas, SP, Brazil
[3] Post-graduate Program in Industrial Biotechnology - Tiradentes University, Aracaju, Brazil
E-mail address of corresponding author: kubota@iqm.unicamp.br

Keywords: Pt nanoparticles, Ionic Liquids, H_2O_2, Glucose

Abstract

Functional silica with Pt nanoparticles showing peroxidase-like catalytic activity was applied in colorimetric sensing.

Introduction

The development of functional nanomaterials with enzyme-like catalytic activity has been one of the several areas benefited by the successful merging of nanotechnology and biology[1,2]. Medical diagnostics can be highlighted as a field where these artificial systems have found important practical application, acting in processes that originally make use of natural enzymes, especially horseradish peroxidase (HRP).This work describes the synthesis and application of a hybrid material based on Pt nanoparticles (NPs) supported on porous silica functionalized with an ionic liquid-like alkoxysilane. The proposed system displays peroxidase-like catalytic activity which allowed its application in the colorimetric determination of H_2O_2. A bioassay for determination of glucose was carried out as a proof of concept to demonstrate the potentiality of the developed platform for biosensing applications.

Results and Discussions

The catalytic porous platform was characterized by several techniques including elemental analysis (CHN), N_2 physisorption and transmission electron microscopy (TEM). The amount of imidazolium functional groups chemically bonded to the silica was 0.5 mmol g^{-1}. The specific surface area of the SiO_2/Imi/Pt material was 246 m²/g, with an isotherm profile typical of mesoporous materials. The average particle size of the Pt is approximately 2.5 nm, with the nanostructures well dispersed into the porous structure. The catalytic properties of the SiO_2/Imi/Pt porous platform and the ability of Pt nanoparticles of mimicking the HRP activity were evaluated toward the H_2O_2-mediated oxidation of TMB (HRP chromogenic substrate) and can be observed in Figure 1. The nanostructured-based artificial system (SiO_2/Imi/Pt) exhibited a linear behavior towards the colorimetric detection of H_2O_2 within a concentration range (0.001-1M) 10 times higher than enzyme-based SiO_2/Imi/HRP (0.1-0.1M).

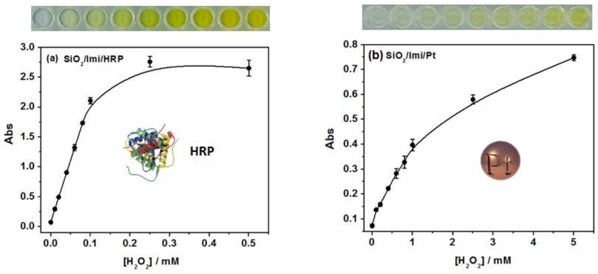

Figure 1. Absorbances for solutions with increasing concentrations of H_2O_2 in the presence of TMB chromogenic substrate. **(a)** refer to the natural enzyme HRP immobilized on the SiO_2/Imi sample and and **(b)** to the artificial system based on the SiO_2/Imi/Pt nanomaterial.

The immobilization of glucose oxidase on the SiO_2/Imi/Pt material was also performed and a bioassay for the determination of glucose was successfully carried out. Upon addition of glucose and TMB, a cascade reaction initiates with the oxidation of glucose, followed by the formation of H_2O_2 and the subsequent H_2O_2-mediated catalytic oxidation of the TMB on the surface of the metallic Pt nanostructures.

Conclusions

The enzyme-like catalytic properties of the SiO2/Imi/Pt as well as its ability to immobilize and keep active biological entities on the porous structure indicate that this hybrid porous platform is potentially useful for the development of colorimetric sensing devices for H_2O_2 as well as derived biosensors.

Acknowledgments

This work was supported by FAPESP, CNPq and the National Institute of Science and Technology in Bioanalytics (INCTBio). We also acknowledge LNNano/CNPEM for the TEM measurements.

[1] Lin, Y., Ren, J., Qu, X., *Acc. Chem. Res.*, 2014c, 47 (4), 1097-1105.
[2] Wei, H., Wang, E., *Chem. Soc. Rev.*, 2013, 42 (14), 6060-6093.