Electrodes modified with carbon nanotubes and enzymes

Name Surname: Adrianna Złoczewska

Supervisor: Prof. dr hab. Marcin Opałło

Auxiliary supervisor: Dr Martin Jönsson-Niedziółka

Abstract

Different ways of electrode modification with non-functionalised and functionalised carbon nanotubes (CNTs) and enzymes are presented in this thesis. The study is mostly focused on the preparation and electrochemical characterisation of the bioelectrodes for O_2 reduction. Bilirubin oxidase without a mediator or laccase with a mediator such as 2, 2'-azinobis(3-ethylbenzothiazoline-6-sulfonate) or syringaldazine were chosen to catalyse O_2 electroreduction. CNTs give a huge increase in the electrode active area as well as enable and/or enhance electron transfer between the electrode substrate and the enzyme. The best biocathode - the one which gives the highest reduction current density - is obtained for a breathing system with functionalised CNTs and BOx. In a breathing system the electrode substrate is a semipermeable membrane and is exposed form one side to gas, and from the other side to an electrolyte. This construction allows to avoid problems with diffusion of O_2 in electrolyte limiting the current and convection of the electrolyte which typically have a large influence on the obtained current of O_2 reduction.

Different attempts to obtain biobatteries, biofuel cells (BFCs) and biosensors with the above mentioned biocathodes are described. The biobatteries are prepared by using a Zn wire as an anode. The anodes modified with vertically aligned CNTs or carbon nanoparticles (CNPs) are used in ascorbic acid (AA) oxidation. This modification enables to apply these electrodes in BFCs with the breathing biocathode acting as self-powered sensors for AA. Moreover it is shown that the CNP-BFC in connection with a Prussian blue display acts as a truly self-powered sensor which can be used for the quantitative analysis of AA in a real sample. A photo-BFCs and a self-powered sensor for glucose with titania nanotubes are also constructed and studied.

A small part of this thesis describes the way of growing CNTs in a defined place on a specially designed chip. The local heating method is used for the growth.