Dioxygen electroreduction on enzyme modified carbon ceramic electrodes

Abstract

Modification of carbon ceramic electrodes with enzymes catalyzing dioxygen reduction – laccase or bilirubin oxidase – is reported. Laccase is immobilized within sol–gel processed hydrophilic silicate film on electrodes surfaces with immobilized mediators – 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonate) or 3,5-dimethoxy-4-hydroxybenzaldehyde hydrazine (syringaldazine). These electrodes exhibit mediated bioelectrocatalytic reduction of dioxygen. Electrodes with adsorbed bilirubin oxidase exhibit efficient mediatorless bioelectrocatalysis of dioxygen electroreduction. The efficiency of electrocatalysis and permeability for gaseous dioxygen are increased for electrodes enriched with hydrophilic carbon nanoparticles. Presented electrodes are examined as biocathodes in zinc-dioxygen cells. Current-voltage characteristics of these cells are determined using chronopotentiometry.

Bioelectrocatalytic process is studied by scanning electrochemical microscopy. Special attention is paid to the possible leaching of mediator and the effect of the electrode potential on the formation of reaction products. New variant of the scanning electrochemical microscopy feedback mode measurements of enzymatic dioxygen reduction is proposed. This mode is applied to study the distribution of laccase within sol–gel processed silicate films and for the comparison of laccase and bilirubin oxidase activity. Special attention is paid to increased activity at the edge of the film. Scanning electrochemical microscopy is also used for imaging of lateral distribution of the electrical conductivity and dioxygen permeability of the carbon ceramic electrode enriched with carbon nanoparticles.