Enzymatic Sensor of Biogenic Amines with Optical Oxygen Transducer

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The biogenic amines (BA) are formed by the decarboxylation of amino acids. Because of their impact on human health, they have been used as markers for assessing the freshness and quality of a wide variety of protein-containing products such as fish, meat, wine and beer where BA accumulate in the process of food spoilage and high concentration of BA is put into context with formation of cancer. In contrast to sensors with electrical transducers, optical sensors of BA might be integral components of a sealed package and a content of biogenic amines might be measured noninvasively.

We studied biosensor for BA with an optical oxygen transducer that contained a diamine oxidase from pea and ruthenium complex. Both active components were incorporated in chemically stable polymer to form sensitive films thickness of 100 - 200 μm. The sensor is based on the measurement of oxygen consumption due to oxidation of BA catalyzed by enzyme diamine oxidase. Ruthenium complex serves as an optical transducer. Its fluorescence is quenched proportionally with oxygen concentration. The sensor is composed from a lens coated with sensitive film and a bundle of optical fibers connected to a light source and detector. The fluorescence lifetime is determined by the measurement of light intensities at four points after the cessation of the excitation.

The sensitivities of putrescine (model BA) determinations, measured under saturation with air were between 3.40 and 4.37 $\mu s.L.mmol^{-1}$ in repetitive experiments conducted over a period of one year. With increasing oxygen saturation DO (dissolved oxygen) from 10 % to 100 % the biosensor sensitivity decreased ten times and its dynamic range increased one order.

With aim to optimize a composition and manufacturing of the biosensor we developed a mathematical model of processes inside the sensing film that revealed qualitative relations among sensor analytical responses, characteristics of the sensitive layer and substrate concentrations (DO and putrescine) in a measured solution. The developed mathematical model revealed qualitative dependencies of the biosensor behavior (sensitivity, response time and dynamic range) on the (i) thickness of the sensitive layer, (ii) concentrations of substrates in the solution, (iii) enzyme activity in the layer and (iv) layer permeability for the substrates.