Abstract

Hydrogen peroxide is one of the most important reactive oxygen species and plays a significant role in numerous biological and chemical processes. In the human body, it participates in biosynthesis processes, cellular signaling, and immune defense mechanisms. However, excessive accumulation of hydrogen peroxide and its elevated concentration in exhaled breath have been associated with impaired physiological function and may serve as potential biomarkers of various diseases, including asthma and lung cancer. Therefore, the accurate determination of gaseous hydrogen peroxide is of considerable importance for modern medical diagnostics and environmental monitoring.

This Ph.D. dissertation focuses on the development of new electrochemical methods for the detection of gaseous hydrogen peroxide and the investigation of factors influencing the analytical performance of the proposed sensing systems. The research involved the elucidation of electrode processes associated with the electrochemical reduction of hydrogen peroxide in the presence of copper(II) ions acting as an electrocatalyst, evaluation of the applicability of screen-printed electrodes and surface modification strategies, as well as investigation of the influence of the supporting electrolyte composition on the analytical properties of the developed sensors. A key element of the work was also the development of a measuring system based on the three-phase boundary concept and the implementation of advanced electrochemical techniques to further improve sensitivity and analytical performance.

The conducted research led to the development of new strategies for the determination of gaseous hydrogen peroxide, offering high sensitivity, good repeatability, and the capability for real-time measurements. The findings presented in this dissertation contributed to a better understanding of the mechanisms of electrochemical hydrogen peroxide reduction and provided new approaches that may be applied in the design of highly sensitive gas sensors.