Investigation of metal sulfides electrochemical properties for application in non-enzymatic glucose sensors

Point-of-care diagnosis has become an inevitable part of health monitoring for people suffering from diabetes. The most commonly used devices for this purpose are test kits. Their working principle relies on the electrochemical measurement of glucose level in blood from a pricked finger. However, such measurement is inconvenient, invasive and provides only discrete information about glucose concentration. Intensive studies have been carried out on continuous monitoring in other body fluids (e.g., interstitial fluid or sweat) to overcome these drawbacks. Moreover, enzyme-based working electrodes have been substituted by inorganic- or carbon-based ones to enhance sensor stability and operating time. Nonetheless, the lack of comprehensive research on non-enzymatic detection mechanisms hinders the development of such electrodes for real applications. This project aims to find the correlation between material electrochemical properties and its performance in glucose sensors. As a research subject, metal sulfides (MS_x, M: Fe, Cu, Ni; x: <1, 2>) are chosen due to the reported high sensitivity values for electrodes based on these compounds. Special attention will be devoted to determining electronic structure and conductivity based on *ab initio* calculations and experimental data. Moreover, studies on deposition techniques of nanomaterials will enable the proposal of a facile and reproducible method for the manufacturing of modified screen-printed electrodes (SPE/MS_x).

Planned research tasks involve synthesizing metal sulfides with a defined composition (FeS_2, CuS, and NiS), morphology, and particle size. Computational studies involving *ab initio* calculations will aid in gaining fundamental knowledge about the electronic structure and electrical properties of aimed materials. The structure of the synthesized MS_x will be analyzed by means of X-ray Diffraction (XRD) and Raman spectroscopy. Investigation of the morphology will be carried out using scanning electron microscopy (SEM) and high-resolution transmission electron microscopy (HR-TEM). Emphasis will be placed on surface properties characterization, including specific surface area determination (BET method), zeta potential, as well as hydrodynamic diameter measurements by electrophoretic (ELS), and dynamic light scattering (DLS) techniques. The surface elemental composition will be studied with X-ray photoelectron spectroscopy (XPS). Comprehensive characterization of optical and electrical properties will play a significant role in the implementation of the project. Information about the electronic band structure (UV-ViS spectroscopy) and semiconductor characteristics (electrochemical impedance spectroscopy, EIS) will be provided. Special attention will be devoted to developing a facile deposition method ensuring uniform and dense coverage of particles on the SPE surface. Investigated will be electrophoretic deposition (EPD) and Langmuir-Blodgett (LB) techniques. A crucial aspect of the project will be evaluating the voltammetry performance of metal sulfides towards glucose and chosen interfering species. The final step will involve research on chemical stability with particular emphasis on the possible oxidation of metal sulfides due to electrochemical interactions with bioactive molecules.

This multidisciplinary project integrates knowledge from the fields of chemical engineering, materials science, and electrochemistry. Obtained results will provide a better understanding of the correlation between electronic structure and metal sulfide performance during glucose detection in the presence of other electroactive species. A significant impact on the development of non-enzymatic sensors is expected due to planned research on an effective working electrode modification technique. Moreover, detailed analysis of optical and electrical properties of the selected group of compounds will contribute significantly to other fields, including nanotechnology, photoelectrochemistry, optoelectronics, energy storage and conversion.