TITLE: Development of electrochemical biosensors for point-of-care application

Summary: In the frame of this project, we aim to develop and study electrochemical biosensors for sensitive and selective point-of-care detection of important analytes such as viruses, antigens, antibodies, and DNAs/RNAs. The work will encompass the bottom-up approach, including (a) selection, pre-treatment, and preparation of suitable supporting electrode(s), (b) modification of supporting electrodes with various inorganic and organic materials to facilitate binding of the biorecognition elements and/or to provide improved sensitivity and selectivity, (d) development and selection of suitable biosensing schemes and their integration onto the electrode system, (e) optimization of electrochemical methodologies to obtain enhanced sensitivity and/or selectivity, (f) testing the biosensor performance in a simulated or real sample.

Research techniques used: The candidate will acquire theoretical and practical insights into electrochemical techniques, such as amperometry, (stripping) voltammetry, potentiometry, electrochemical impedance spectroscopy, etc. Various electrode materials will be examined, such as carbon-based materials (e.g., glassy carbon, carbon paste, carbon fiber, screen-printed carbon), gold, platinum, etc. Selected supporting electrodes will be treated chemically, electrochemically, and by utilizing other approaches, e.g., plasma treatment, laser ablation. Numerous electrode modification strategies will be employed, such as drop-casting, dip-coating, spin-coating, chemical and electrochemical modification (polymerization). The prepared sensing surfaces will be examined using laser ablation hyphenated with inductively coupled plasma elemental mass spectrometry, atomic force microscopy, scanning electron microscopy, interferometry, electrochemical and spectroscopic methods. The candidate will also obtain specific knowledge in work/handling with biological samples and reagents, microvolume samples, and trace analysis.

The reason why the topic is innovative: Various molecular and serological techniques are used to monitor viral infections. Currently, real-time analysis by RT-PCR is at the forefront. However, the PCR-based methods require a thermocycling step, limiting their practical point-of-care diagnostic applicability. On the other hand, isothermal amplification-based strategies such as RT-LAMP, CRISPR, SHERLOCK, and others have been recognized as powerful alternatives. These and related immunological approaches, e.g., ELISA and LFIA, are based on fluorescent and colorimetric detection and the use of components such as fluorescent dyes, magnesium pyrophosphate, enzymes, antibodies, viral spike proteins, etc. Very recent situations highlight an enormous need for powerful sensing systems that can enable the transition from centralized laboratory testing to point-of-care or bedside analysis. In this respect, electrochemistry offers unique opportunities due to countless geometries and sizes of supporting electrodes, numerous possibilities for electrode materials and further modifications, and simplified data acquisition devices. For example, electrochemical methods can detect viral RNA by tracking the redox probe activity, change in conductivity, or pH variations of the sample solution due to the isothermal amplification process. Additionally, they can also be utilized to detect antigens or antibodies produced by the human immune system in response to viral infection.

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