Micro-Biosensor Devices for Biochemical Analysis Applications | Biological Engineering

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Full Abstract

Traditional techniques for identification and detection of specific targets are high cost, time consuming, and lack of portability. A biosensor can be defined as an analytical device consisting of a biological recognition element and a physicochemical transducer that converts the recognition even to measurable signals for analytes of interest. In this dissertation, we are developing a novel, versatile micro-biosensor system that integrates microfluidics (polymer-based devices or paper-based devices) and bio-sensing parts (optical sensor and electrochemical sensor) that converting biochemical signal to measurable pixels and electronic signals. This microfluidic integrated biosensor system has many advantages such as configurability (different combinations of parts for different applications), real-time detection, disposability, fast prototyping and affordability (volume could be as low as nanoliter), high throughput and multiplexing capability (multiple analytes);more importantly, the enhanced transport for controlling the flow conditions under microfluidic environment that will remarkably increase the biosensor performance (sensitivity and selectivity). The microfluidics-integrated biosensor with these features offers a powerful tool with the attractive ability to merge biological and mechanical components into the single detection platform that could be alternative to the traditional bulky equipment and instruments.

This dissertation proposes a novel microfluidics-integrated biosensor platform system that can be flexibly adapted to form individual micro-devices depending on particular applications. The first five technical chapters of this dissertation presents five examples of different emerging areas with this biosensor system including drug-cancer cell screening, point of care (POC) diagnostics, environmental monitoring, obesity healthcare, and biomarker identification and detection. These micro-devices-based biosensors have great potential to be further developed to emerging portable sensing devices especially useful for the users in resource limited settings and developing and undeveloped world.

In the last chapter of the dissertation, Raman spectroscopy was employed for analysis of extracellular vesicles (EVs) isolated from lymphocyte and trophoblast. The objective of this project was to differentiate EVs isolated from bovine placenta and peripheral blood mononuclear cells (PBMC) by Raman spectroscopy. The long-term goals are to apply this non-invasive, label-free method to distinguish EVs from the serum of pregnant and non-pregnant cows to assess gestational status and the potential for pregnancy complications, which could significantly benefit to animal reproduction.