Development of electrochemical and electromechanical aptasensors for bioprocess monitoring

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Introduction

On-line detection and monitoring of analytes in bioprocesses are essential to facilitate a successful bioprocess. Biosensors are affinity-based sensors, which use biological components for the detection of analytes. Most biosensors utilize immobilized antibodies for specific detection. Aptamers present a promising alternative as biological recognition elements in biosensors. Main advantages of aptamers compared to antibodies are the wide range of detectable analytes, the stability of functionalization and the fast and low-cost synthesis. Within our project we develop both electrochemical and electromechanical aptamer-based biosensors for the detection of pharmaceutical target proteins and contaminants. The aim of our future work is the integration of an aptamer-based biosensor for on-line monitoring in cell cultivation processes.

Aptamer immobilization

Aptamers can be easily functionalized and therefore enable several immobilization techniques. By adding thiol-groups, immobilization on gold can be achieved. One application is the immobilization on gold coated screen printed electrodes (SPE) (see fig. 1). Thus, aptamer functionalized SPEs can be used as electrochemical biosensors. The latter require small sample volumes and have the potential to be used in a lab-on-a-chip.

Impedimetric aptasensor for detection of Escherichia Coli

Herein, an aptamer [1] selected to specifically target *Escherichia coli* Crook’s strain was employed to demonstrate the possibility to electrochemically detect the binding of *E. coli* cells directly from a sample suspension without any pre-treatment.

The biosensor is based on the principle that the binding event decreases the electron transfer between electrode and ferri-/ferrocyanide in solution, which is measured as an increase of impedance (see fig. 3).

Electrochemical & electromechanical biosensors

Biosensors require a transducing mechanism, which converts the binding of the target by the biorecognition element into a measurable signal. Both electrochemical and electromechanical elements are widely used as transducers.

While electrochemical biosensors often use the increase of impedance as the detection method, most electromechanical biosensors use piezoelectric materials like in a quartz crystal microbalance (QCM) (see fig. 2).

Integration of SPE into 3D printed flow cells

High-resolution 3D printing enables the integration of SPE aptasensors into a microfluidic flow chamber as depicted in fig. 6 (chamber volume 10 μL, total volume 90 μL). To overcome the usually low mixing in microfluidic devices, a micromixer is included for rapid mixing and to ensure the appropriate ratio of binding buffer and sample. Automatable calibration and sample throughput are achieved by programmable syringe pumps (see fig. 6).

Currently, the work focuses on the implementation of an Immunoglobulin G aptasensor, which is supposed to be integrated in the monitoring of cell cultivation process.

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