Centrifugal microfluidic platform with real-time electrochemical detection

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Lab-on-a-chip (LOC) technology has in the last few decades matured to be very promising in the field of diagnostics or prognostics. Many advantages come with miniaturizing conventional diagnostics methods such as the sample volume, low consumption of expensive chemicals and faster sample to analysis time. One of the key aspects of this technology is the prospect of simple-to use platforms with all-inclusive potential, reducing contamination and human errors. With label-free sensing technology, such as electrochemical techniques, minimum sample preparation is needed and therefore has the potential of successful integration with LOC platforms, facilitating micro-total analysis systems (μTAS) [1].

Here a centrifugally driven LOC platform with integrated real-time electrochemical detection is presented. The main advantage of centrifugal microfluidics is the pump-free setup, where the centrifugal force acts as the driving force for liquid handling, which enables a simpler setup and eventually a portable device [2]. The setup consists of a spinning stage on which a combined polymer platform is attached. The platform includes a clean-room fabricated quartz disc with a three electrode set up with interdigitated gold electrodes for electrochemical detection. To allow electrical connection a commercially available swivel is attached on top, connecting the spinning disc with the potentiostat, as illustrated in Figure 1.

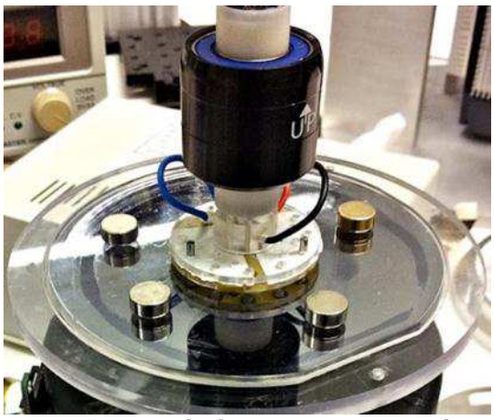

Figure 1. Setup with the spinning stage and a swivel attached on top. The gold electrodes are fabricated on quartz crystal and have a polymer microfluidic system supplying the electrodes with the sample. The magnets are used for clamping.

A PMMA disc with embedded microfluidics is attached by adhesive tape on top of the electrodes enabling microfluidic handing and manipulation. The microfluidics consists of three chambers containing; base-line buffer, sample and washing buffer. The liquids are contained by capillary burst valves, which are designed to burst at different spinning frequencies [3]. The three chambers lead to the detection point where the electrodes are positioned. For the electrochemical measurements to be reliable, the electrodes need to be covered with liquid at all times, which means that the three solutions have to replace each other without trapping air in between. To do this, a narrow channel (1 mm) reduces the diffusion between the different liquids and leads the liquid from the three chambers past the electrodes. The channel bends back towards the middle of the disc, ending abruptly above the electrodes, and leading the rest of the liquid to a waste chamber. This design enables the liquid from the first chamber to stay in place above the electrode until the second liquid replaces the first (similar with the second and third liquid) by pushing the liquid towards the periphery of the disc with the centrifugal force. The liquid handling design and procedure is shown in Figure 2.

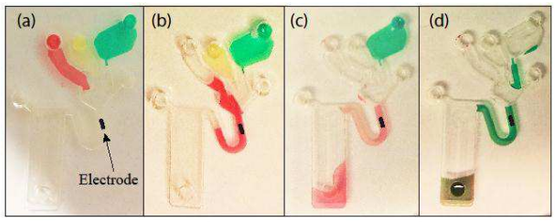

Figure 2. The centrifugally driven microfluidic system, where each chamber bursts consecutively and replaces each other on top of the electrode.

The results of the electrochemical measurements while spinning of the discs are shown in Figure 3, where a cyclic voltammogram of 10 mM potassium ferri/ferro cyanide in PBS is illustrated with a potential window between -0.7 V and 0.7V and a scan rate of 50 mV/s. The peaks represent the reduction and oxidation reactions and their potential corresponds to the values known from literature. The noise is determined to be periodic to the spinning rate by FFT analyses.

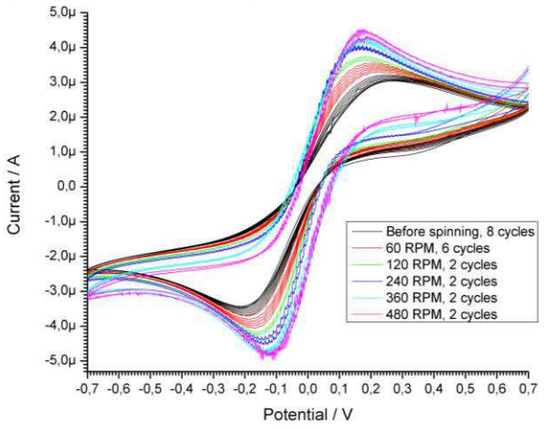

Figure 3. Real-time cyclic voltammogram of potassium ferri/ferro cyanide on gold electrodes while spinning of the disc.

[1] T. H. Kim et al., "Fully integrated centrifugal microfluidic platform for electrochemical biomarker detection" Proceedings of Micro-Total analysis systems, 2011, Seattle, USA.

[2] R. Gorkin et al., "Centrifugal microfluidics for biomedical applications," Lab Chip, **10**, 1758 (2010).

[3] A. L. Brogger et al., "Centrifugally driven microfluidic disc for detection of chromosomal translocations," Lab Chip, **12**, 4628 (2012)