Multiplexed electrochemical detection of p-Coumaric acid on a lab-on-a-disc platform

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We report the simultaneous electrochemical detection of p-Coumaric acid (pCA) in 8-separate chambers integrated with interdigitated gold microelectrodes (IMEs) on a lab-on-a-disc platform.

pCA is naturally occurring hydroxycinnamic acid with many physiological actions, including potent antioxidant, antimicrobial, anxiolytic, analgesic, antimutagenic, sedative, and immunoregulatory activities. In the past few years, the interest for pCA has increased significantly in chemical, food, health, cosmetic, and pharmaceutical industries due to its wide range of applications[1]. Currently, the main quantitative techniques for pCA detection are high-performance liquid chromatography (HPLC)[2], thin-layer chromatography (TLC)[3] and spectrophotometry[4] which are quite expensive, tedious and time consuming. On the contrary, electrochemical detection is an inexpensive alternative which is fast, portable, easy-to-use and sensitive. Being inspired by this fact, we successfully designed an electrochemical detection based lab-on-a-disc platform capable of quantifying pCA from 8 different samples at the same time.

In the current study, an array of 8-IMEs were patterned on PMMA substrate via e-beam evaporation (20nm Cr adhesion layer/200nm Au) through a laser machined steel shadow mask. The whole disc assembly is composed of 6 layers, where 3 precisely cut pressure sensitive adhesive layers (140µm thick) were interspread between 3 layers of CO_2 laser ablated PMMA (1.5 mm thick) substrates as shown in Figure 1. In order to interface the electrodes with a potentiostat for electrochemical measurements a printed circuit board (PCB) was micro-milled from single-sided copper clad circuit board and mounted over the whole disc assembly after integrating with 5 mm long gold coated spring loaded contact pins. The PCB was connected to the potentiostat via 8-channel swivel integrated on to the platform using 3D printed holder to obtain simultaneous electrochemical measurements using an array of electrodes on the disc while spinning (Figure 2).

As shown in Figure 3, the simultaneous cyclic voltammograms (CVs) were obtained from 8 different sets of electrodes on the same disc (intra disc) and found to be symmetric w.r.t the anodic and cathodic peak currents, and the peak potential separation (ΔEp) is reproducible for all the electrodes (110 (±5) mV). The peak current (21 (±2) µA) and ΔEp (110 (±10) mV) were also reproducible when the CVs were performed and compared among electrodes on different disc (inter disc). The high reproducibility of our IMEs make them promising candidates for effective and reliable electrochemical detection. To investigate the electrochemistry of pCA on interdigited gold electrodes, CV was performed with pCA solutions, where PBS (pH 7.4) was used as supporting electrolyte. pCA exhibited a well-defined oxidation peak during the potential scan towards the positive direction at approximately 0.6 V *vs.* Au Pseudo-reference. Furthermore, an increase in peak current was obtained with increase in concentration of pCA. The peak current is plotted as a function of concentration in Figure 4. These results obtained from our setup confirmed its potential to quantify pCA. The setup will be further optimized to quantify antioxidants from plant extracts, bacterial secretions, wines and beers by integrating centrifugal microfluidics for sample pretreatment, cell culturing and improved limit of detection.

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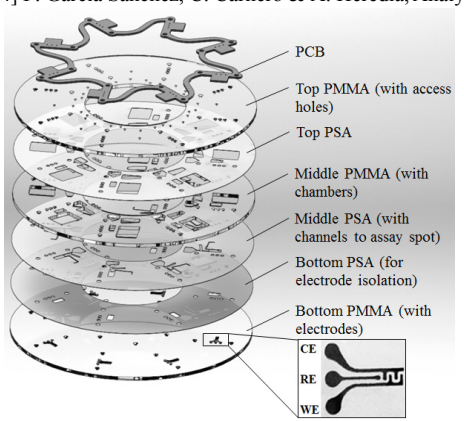

Figure 1. Exploded view of whole disc assembly: 3-adhesive layers are interspread between 3-PMMA substrates with PCB mounted at the top for interfacing electrodes embedded within the microfluidic disc with the potentiostat.

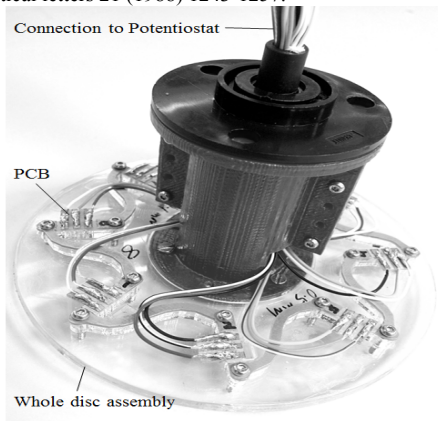

Figure 2. Image of the setup for the on-disc electrochemical measurements.

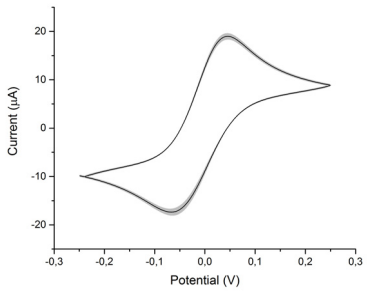

Figure 3. CVs recorded on an array of 8-electrodes on the disc in the presence of 10mM ferro/ferricyanide in PBS supporting electrolyte; scan rate 50mV/s (potential versus Au psedo-RE); The grey part shows the standard deviation of the mean, obtained from 8 sets of electrodes.

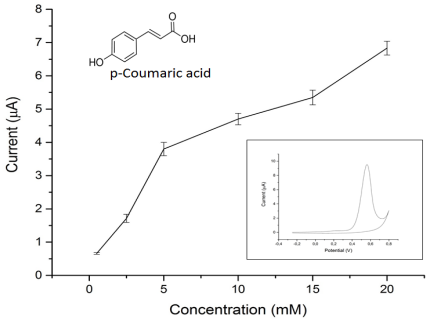

Figure 4. Peak current as a function of concentration for pCA acid in PBS (pH 7.4); error bar represents standard deviations of three independent measurements. Top inset: molecular structure of pCA; Bottom inset: oxidation peak for pCA at~0.6 V *vs.* Au Pseudo-RE.