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3D-printing: An approach to fabricating a generator-collector system electrochemical microfluidic device

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Highlights

Reconfigurable and easy-to-assemble 3D-printed microfluidic device. Cotton threads provide capillary-driven action and flow control.

Resumo/Abstract

The microfluidics approach offers interesting features to analytical devices, including low consumption of chemicals and samples and the possibility of integrating multiple analysis steps in the same platform. This possibility of combining the sample preparation steps in the same platform is an interesting feature that makes microfluidic devices potentially applicable for point-of-need (PON) analyses, which are highly desirable in several fields. Herein, we proposed a new, low-cost, versatile, and reconfigurable design for assembling the electrochemical microfluidic device, fully developed using 3D-printing technology and cotton thread as a capillary driven. The inlet and outlet reservoirs and microfluidic channel were printed from a masked stereolithography printer using photopolymer acrylate resin (Clear resin and ABS-like resin, Elegoo, China). All electrodes (reference, auxiliary, and working (generator and collector)) were printed as ring design by fused deposition modeling printer using PLA/CB filament, Figure 1A. The microfluidic device was assembled by coupling the electrodes, microfluidic channel, and reservoirs using a "*stud-and-tube*" inspired connection system. Afterward, cotton thread was introduced into the microfluidic channel, and a cotton piece was fitted on the outlet to control flow. The inlet reservoir was continuously filled with the carrier solution during the analysis. 4 µL of the sample solutions were injected through a sample hole located on the top of the channel. All the parameters, such as sample injection volume, injection/detection distance, and electrode position, were optimized using a ferry/ferrocyanide redox probe. The generator-collector signal was monitored using hexaammineruthenium (III), where the probe was first reduced at the initial electrode (red line) and then collected at the subsequent electrode (blue line). Figure 1B presents the transient signals recorded for the generator-collector array. As shown in Figure 1C, the generation efficiency averaged around 20% across all concentrations, indicating that it is not dependent on concentration under these conditions. On the other hand, the efficiency of the collection was concentration-dependent, increasing with higher concentrations. These results suggest that the low-cost and simple microfluidic device fabricated from 3D-printed can be applied for total analysis since it is possible to make sample preparations in the same platform. It also suggests the applicability of studying electrochemical reaction mechanisms.

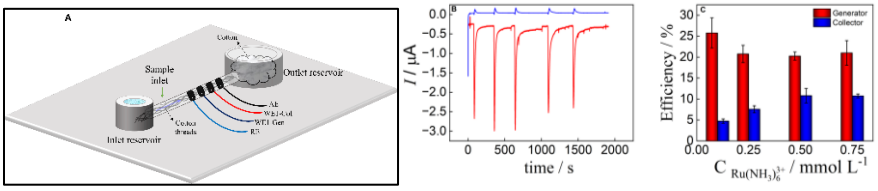

Figure 1. **A)** Schematic represantion of the system. **B)** Transient current signals for injections of 4 µL of 0.75 mmol L^{-1} $[Fe(CN)_6]^{4-}$ in 0.5 mol L^{-1} KCl. **C)** Conversion and collection efficiency. E_{gen} = -0.65V and E_{col} = +0.3V

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