Separation of biomolecules using paper microchip electrophoresis with integrated capacitively coupled contactless conductivity detection.

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Abstract

The integration of a contactless conductivity detector to monitor electrophoretic separations on paper devices is reported.

Introduction

Paper platform was an important tool for the separation of biomolecules in the 1950's decade contributing positively for the advances on electrophoresis systems[1]. In the last years, paper has been rediscovered for the development of microfluidic paper−based analytical devices (μPADs). Applications involving sensing, flow injection analysis and chromatographic devices are commonly found in literature[2]. Most recently, an electrophoretic separation of dyes was reported using colorimetric detection[3]. In this report, we describe for the first time the fabrication of paper microchip electrophoresis (pME) integrated with pencil electrodes for capacitively coupled contactless conductivity detection (C^4D). The feasibility of the proposed pME-C^4D device was demonstrated with the separation of biomolecules.

Results and Discussion

pME devices were fabricated in Whatman paper through CO_2 laser cutting in a cross geometry (Fig. 1a). Injection and separation channels were 2 cm and 5.5 cm, respectively. All channels were 1 mm wide. pME devices were thermally laminated (Fig. 1b) with a thermosensitive polyester film (pouch film) to provide the electrical insulation with pencil electrodes attached at their bottom surface (Fig. 1c). Pencil electrodes were hand-drawing on office paper sheets, as described elsewhere[4].

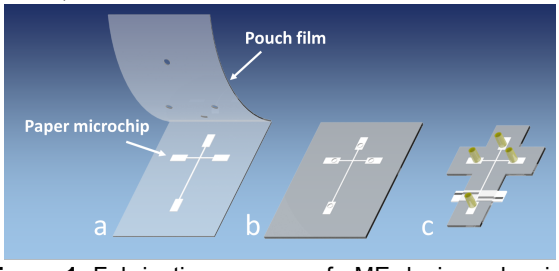

Figure 1. Fabrication process of pME devices showing the (a,b) lamination of laser-cut paper with perforated polyester films and (c) integration with electrodes for C^4D and solution reservoirs.

Sample injection was performed under floating mode applying the voltage of 2.3 kV at the injection channel for 50 s. Afterwards, separation was carried out under a voltage of 2.5 kV. Separations were monitored using a labmade C^4D system[5]. A mixture containing albumin (Alb) and creatinine (Cre) was prepared in running buffer composed of lactic acid (20 mM) and histidine (2 mM) at pH 3.1. A calibration curve was performed ranging the concentrations from 100 μM to 300 μM showing good linear correlations (R^2 > 0.879) for both analytes. Figure 2 displays the electropherograms recorded using the proposed device. Alb and Cre were separated within 120 s with baseline resolution and satisfactory repeatability.

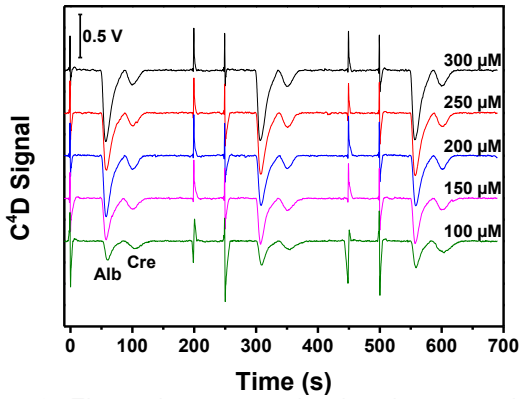

Figure 2. Electropherograms showing the separation of albumin (Alb) and creatinine (Cre) on pME-C^4D devices in different concentration levels. Detection parameters: 300-kHz-sinusoidal wave with excitation voltage of 1 V (peak-to-peak).

Conclusions

pME-C^4D devices have exhibited great capability to separate biomolecules with suitable repeatability for clinical assays. Based on the achieved results, the proposed device can be used for microalbuminuria diagnosis in biological fluids.

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