FABRICATION OF DISPOSABLE ELECTROPHORESIS MICROCHIPS BASED ON USING OF COLORED TONER

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ABSTRACT

This work describes the use of colored toner to produce disposable microchips electrophoresis (ME) devices. Colored ME devices were fabricated in polyester-toner (PT) using a color LaserJet printer. PT devices were printed in black, yellow, magenta, and cyan. The toner composition and effect of printing process (thickness and roughness of the toner layer) were evaluated and compared with PT devices produced by a monochromatic laser printer. The analytical performance of colored PT devices was investigated with a capacitively coupled contactless conductivity detector (C^4D) to monitor separations of a mixture containing inorganic ions.

KEYWORDS: Electrochemical detection, Microchip electrophoresis, Microfabrication.

INTRODUCTION

Due to their impressive potential to fabricate microfluidic devices at very low cost, toner-based techniques have received considerable attention in the last years [1-3]. Polyester-toner (PT) electrophoresis devices have been fabricated by a direct-printing process [1] using just a computer, a laser printer, a laminator, and a paper driller. PT devices have exibilithed a great potential to be coupled with electrochemical, mass spectrotrometry and fluorescence detectors for analytical and bioanalytical applications [4]. Besides their low cost and instrumental simplicity, PT device has presented some disadvantages. When compared to to the most popular substrate materials such PDMS and and glass substrates, PT microchips have shown lower separation efficiency and electroosmotic flow (EOF) as well as poor injection-to-injection repeatability [2]. The low EOF on PT has been successfully explored to promote the sequential separation of DNA fragments using the same polymeric matrix [5]. To overcome the problems mentioned, we investigated the use of a colored laser printer to produce PT device instead a monochromatic laser printer.

EXPERIMENTAL

Colored PT devices were fabricated by a direct-printing process [4] using a color LaserJet printer (model HP CP1515n, Hewlett Packard) with 1200-dpi resolution. PT microchannels were printed in CMYK standards (cyan, magenta, yellow and key-black) with 250-µm wide and 10-µm deep. The injection and separation channels were 10 and 50 mm long, respectively. A double-T injector with 200-µm gap was used for all experiments (Figure 1). For evaluating the analytical performance, PT devices were coupled with a C^4D system to monitor separations of a mixture containing alkaline-metal cations (K^+, Na^+ and Li^+). Microchannels were initially filled with buffer solution by capillary action. Then, running buffer was added in all reservoirs and all channels were preconditioned during 5 min under application of voltage of 1.0 kV. Injection and separation voltages were generated using a high-voltage power supply (C40, EMCO, Sutter Creek. CA, USA). Electrokinetic sample injection was controlled by a program written in LabVIEW version 8.0. All experiments were performed at the room temperature. Contactless conductivity measurements were carried out by applying a sinusoidal wave of 400 kHz with 5 V_{pp} amplitude to the excitation electrode. The resulting signal was pickup at the receiver electrode, amplified and sent to the data acquisition interface (USB-6009 model, National Instruments, Austin-TX, USA). Detection electrodes were produced with adhesive copper tape with width of 1-mm (each). Copper tapes wwere cut and fixed on the top of PT device in an antiparalel orientation, as depicted in Figure 1.

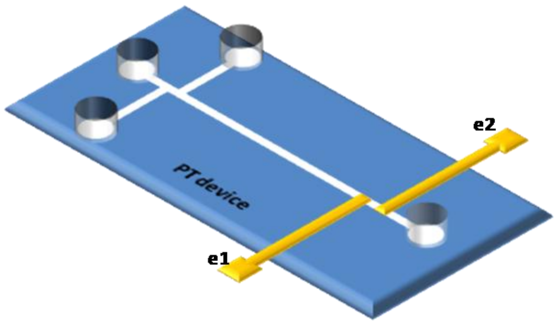

Figure 1. Example of a PT electrophoresis microchip fabricated using the color laser printer. The labels e0 and e1 represent the copper adhesive tape electrodes for contactless conductivity measurements.

RESULTS AND DISCUSSION

Basically, the main difference between the toner from monochromatic and color laser printer is related to the chemical composition. It is well known that toner from monochromatic printers is composed of iron oxide and a polymeric mixture. Oppositely, the composition of the color toner is based on a mixture of polymer with silica. The difference in terms of the toner composition directly affects the EOF magnitude. The EOF values recorded for for colored chips (*ca.* 4×10^{-4} $cm^2V^{-1}s^{-1}$) were *ca.* 20% higher than those obtained with monochromatic chips.

Besides the chemical composition, the colored toner layer has exhibited lower thickness and roughness, when compared to the toner from monochromatic laser printers. The channel depth produced by both monochromatic and color laser printers has been estimated to be 7 ± 1 µm and 4 ± 1 µm, respectively. On the other hand, the toner surface roughness values were calculated to be around 1.20 ± 0.50 µm and 0.24 ± 0.05 µm for monochromatic and color printers, respectively. Figure 2 depicts the channel profile for PT devices printed in black, magenta, cyan, and yellow.

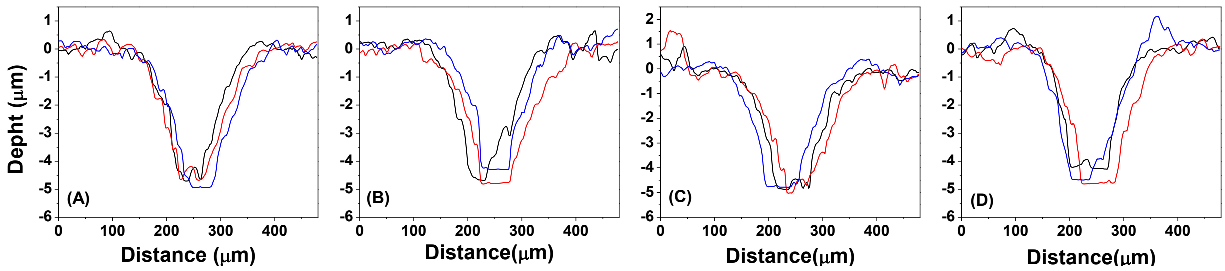

Figure 2. Profilometric measurements of the PT channels printed with a color laser printer. Labels A, B, C and D indicate the yellow, cyan, magenta, and black devices, respectively.

Figure 3 depicts electropherograms the separation of inorganic cations in all colored PT devices. It can be seen that all cations were successfully separated within 40s with a good baseline resolution. Separation efficiencies for all cations ranged from 14,000 to 52,000 plates/m in all colors investigated. Black toner devices have provided the lowest EOF and separation efficiency when compared to other colored PT devices. These effects have been associated to the toner chemical composition as well as the uniformity of the printed channel.

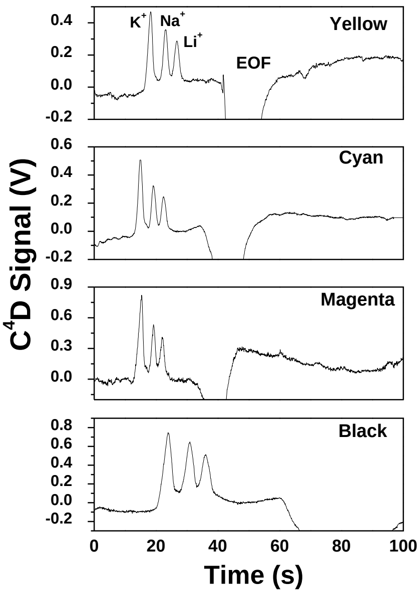

Figure 3. Examples electropherograms recorded in all colored PT device. Electrokinetic transport: 10-s injection at 1.0 kV; separation at 200 V/cm. The values for the total and effective length of the separation channel were 5.0 and 4.3 cm, respectively.

CONCLUSIONS

Overall, it has been shown that the analytical performance of PT electrophoresis microchips can be improved by using a colored laser printer in the fabrication process. Colored ME devices present differences in terms of toner chemical composition. In addition, when compared to the toner layer from monochromatic laser printers, colored toner layers are smother and thinner. All these effects have contributed to enhance the analytical parameters of electrophoretic separations on PT devices. Among all colors, yellow toner has provided better defined channels. Future studies will focus on the analysis of more inorganic cations even as the validation of an analytical methodology for quantitative analysis.

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