DIGITALLY-MODULATED LIGHT SOURCE UTILIZING A LOW-COST LCD PROJECTOR FOR HIGH THROUGHPUT CAPILLARY ELECTROPHORESIS DETECTION

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ABSTRACT

This paper presents a novel detection scheme for high throughput capillary electrophoresis (CE) applications which utilizes a low-cost LCD projector as the light source. Instead of switching a number of conventional filter sets for multi-wavelength detection purpose, a commercial LCD (liquid crystal device) projector is used to digitally modulate the projecting wavelength from the projector. An ultraviolet-visible-near infrared (UV-Vis-NIR) spectrometer is adopted to detect the emitted fluorescence synchronously with the switching light excluding spatial filter sets. A mixed sample composed of three fluorescent dyes and a labeled single-stranded DNA sample were successfully separated and detected using this proposed system.

KEYWORDS: high throughput, capillary electrophoresis, LCD projector, spectrometer

INTRODUCTION

In general, a typical CE system is operated using a spatial-filtered single wavelength scheme for single fluorescent detection such that the throughput is limited. Therefore, a number of detection schemes including pairs of aligned optical waveguides and a pulse multi-lines excitation configuration have been proposed for achieving multi-wavelength detection to increase the throughput [1, 2]. However, the reported methods relied on either a complex fabrication process or a delicate and expensive optical system. This paper proposed a simple and novel method to demonstrate multi-wavelength detection utilizing a computer controlled LCD projector and a spectrometer. High throughput CE detection can be achieved without using conventional filtering lens.

EXPERIMENTAL

Figure 1 shows the wavelength spectra of the filtered primary RGB (red, green, and blue) lights form a commercial LCD projector (HB-27, Aurora, Taiwan). The mercury lamp in the projector is a typical light source which can be digitally filtered for exiting the corresponding fluorescence. More importantly, the excitation lights can be switched and modulated very fast (less than 5 ms) without using any moving part. Figure 2 shows the experimental setup for the proposed detection system. The emitted fluorescence from the samples is then collected using an UV-Vis-NIR spec-

trometer (HR4000, Ocean Optics, USA) through a multimode optic fiber without any spatial filter. Fluorescence dyes of Atto 647N (λAbs.max: 644 nm, λEm.max: 669 nm), Rhodamine B (λAbs.max: 572 nm, λEm.max: 590 nm), and FITC (λAbs.max: 490 nm, λEm.max: 514 nm) were used to evaluate the performance of the proposed system. Prior to the practical CE application, the optimal detection wavelength of each fluorescent dye was firstly determined by selecting the highest SN (signal-to-noise) ratio while detecting the fluorescence (Fig. 3).

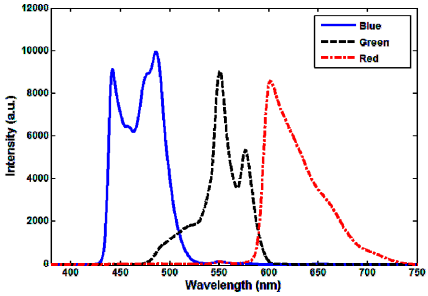

Figure 1. Emission spectra of the primary RGB colors from a commercial LCD projector.

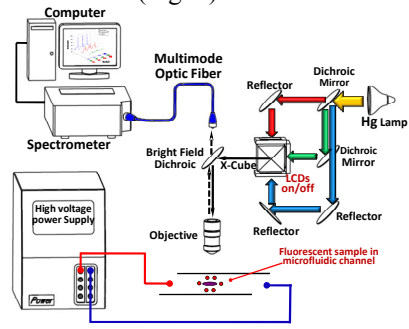

Figure 2. A schematic present the experimental setup for the proposed digitally-modulated CE detection system.

RESULTS AND DISCUSSION

A mixed fluorescent sample composed of these three fluorescence dyes was successfully separated and detected using the digitally-modulated detection scheme (Fig. 4). The result shows the fluorescent dyes can be successfully detected in a single run by sequentially modulating the excitation wavelengths from the LCD projector. Moreover, a mixed light (visually in purple color) composed of red and blue primary lights was used to simultaneously excite a mixed sample composed two fluorescent dyes (Atto 647N and FITC). Figure 5 shows that the mixed sample was successfully detected with this proposed system without switching the light color during operation. Biosample of a FITC-labeled ssDNA was used to demonstrate the bio-detection application of the proposed system (Fig. 6). The measured detection limit for the proposed system is 4×10^{-6}M for detecting FITC fluorescence, which is capable for detecting most PCR-amplified samples. Detecting a mixed DNA sample and further improving the detection limit are now still under going.

CONCLUSIONS

This study proposed a simple method to digitally filter the excitation light for fluorescence sample detection using a low-cost commercial LCD projector. Mixed fluorescence samples and FITC-labeled ssDNA were successfully detected by synchronously modulating the excitation wavelength without using a conventional spatial filter set. The proposed method has shown its potential for achieving a high throughput CE system in a simple and low-cost way.

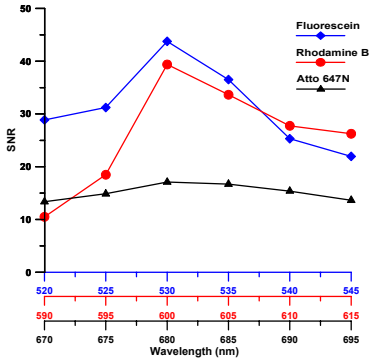

Figure 3. Measured relative signal SNR for detecting fluorescence dyes of Fluorescein (5×10^{-5} M), Rhodamine B (5×10^{-5} M), and Atto 647N (10^{-4} M), respectively.

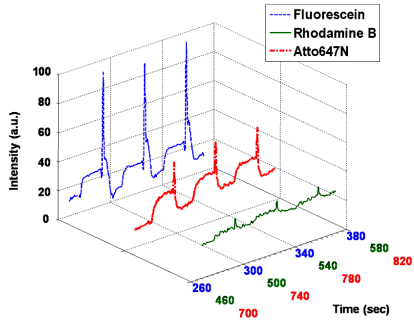

Figure 4. The electropherogram for detecting a mixed sample composed of Fluorescein (2.8×10^{-5} M), Rhodamine B (5.7×10^{-5} M) and Atto 647N (2.8×10^{-5} M) in a single test run.

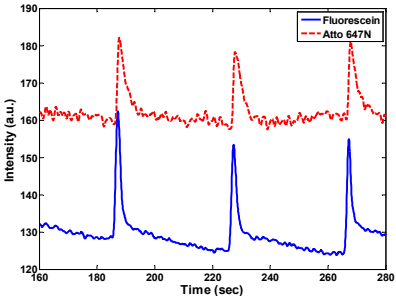

Figure 5. A mixed sample composed of Fluorescein (5×10^{-5} M) and Atto 647N (5×10^{-5} M) was detected using a visually purple light as the excitation light.

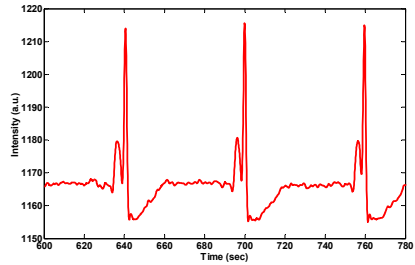

Figure 6. The electropherogram shows that a FITC-labeled single-stranded DNA was successfully detected using this proposed system.

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