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Use of a Pen-Shaped Capillary Gel Electrophoresis Cartridge for Cost-Effective DNA Fragment Analysis

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Most laboratories currently utilize slab-[gel electrophoresis systems](#) for DNA and protein analysis. However, both polyacrylamide gel electrophoresis (PAGE) and agarose slab-gel electrophoresis methods are time-consuming and labor-intensive and therefore need to be improved in terms of resolving power, throughput, and cost per analysis. [Capillary gel electrophoresis](#) (CGE) has been recognized as a high-performance and automated approach that addresses the shortcomings of slab-gel electrophoresis by offering fast separations with high sensitivity, excellent resolution, ruggedness, and ease of operation.¹



Figure 1 – Qsep100 dna-CE genetic analyzer.

Without a doubt, CGE with laser-induced fluorescence (LIF) is one of the most powerful analytical tools for rapid, high-sensitivity, and high-resolution dsDNA analysis and immunoassay analysis applications. However, CGE-based LIF systems are much more expensive than traditional slab-gel-based bioanalysis systems due to the complicated optical detection mechanism. CGE-based systems are thus out of the reach of all but a few well-funded laboratories, and seem to be a high-cost barrier to the expansion of DNA fragment analysis business/applications.

To overcome the above challenges, the Qsep100 dna-CE analyzer with pen-shaped gel cartridge has been developed (BiOptic, New Taipei City, Taiwan).² It provides ease of operation, fast separations with high detection sensitivity, 2–4 bp resolution, and low-cost per sample runs (\$0.1–\$0.2/sample run).

Single-channel capillary gel electrophoresis system



Figure 2 – Single-channel pen-shaped gel cartridge.

The Qsep100 dna-CE analyzer (*Figure 1*) utilizes super-bright LED-based fluorescence detection with a pen-shaped, disposable gel cartridge that incorporates a short fused-silica capillary in an injection-molded body with integrated running gel-buffer reservoir (*Figure 2*). An RFID chip as part of the pen-shaped gel cartridge tracks the number of runs, type of gel cartridge, S/N, and expiration date.

Samples are introduced into the gel-filled capillary cartridge by means of electrokinetic injection. As the lower electrode (the cathode) with its embedded capillary tubing is immersed into the sample well, the applied voltage electrokinetically injects the negatively charged sample components (DNA or sodium dodecyl sulfate [SDS]–protein complexes) inside the capillary tubing, which then migrates and separates upstream in the separation gel-buffer system filled capillary (*Figure 3*). The fluorescently tagged sample components are then detected at the detection zone (*Figures 3 and 4*) by LED-induced fluorescence. The modular design provides flexibility in single-channel-type capillary electrophoresis applications at a very low-cost per sample run.

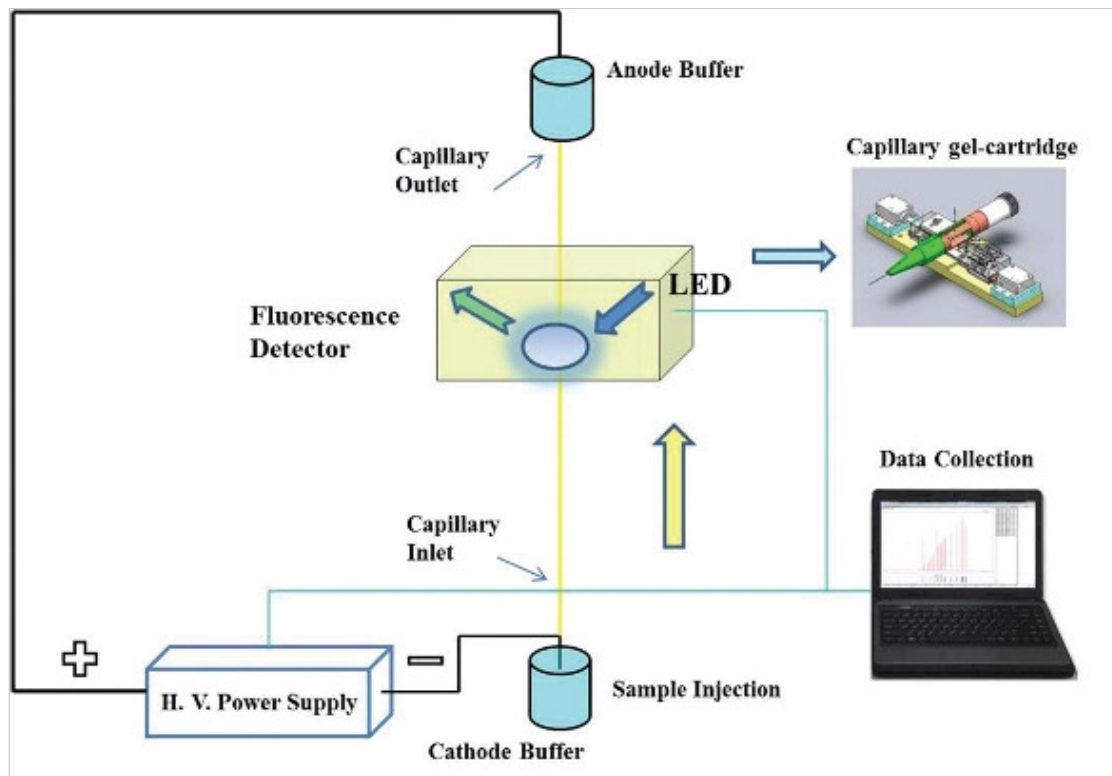


Figure 3 – Schematic of fluorescence CGE.

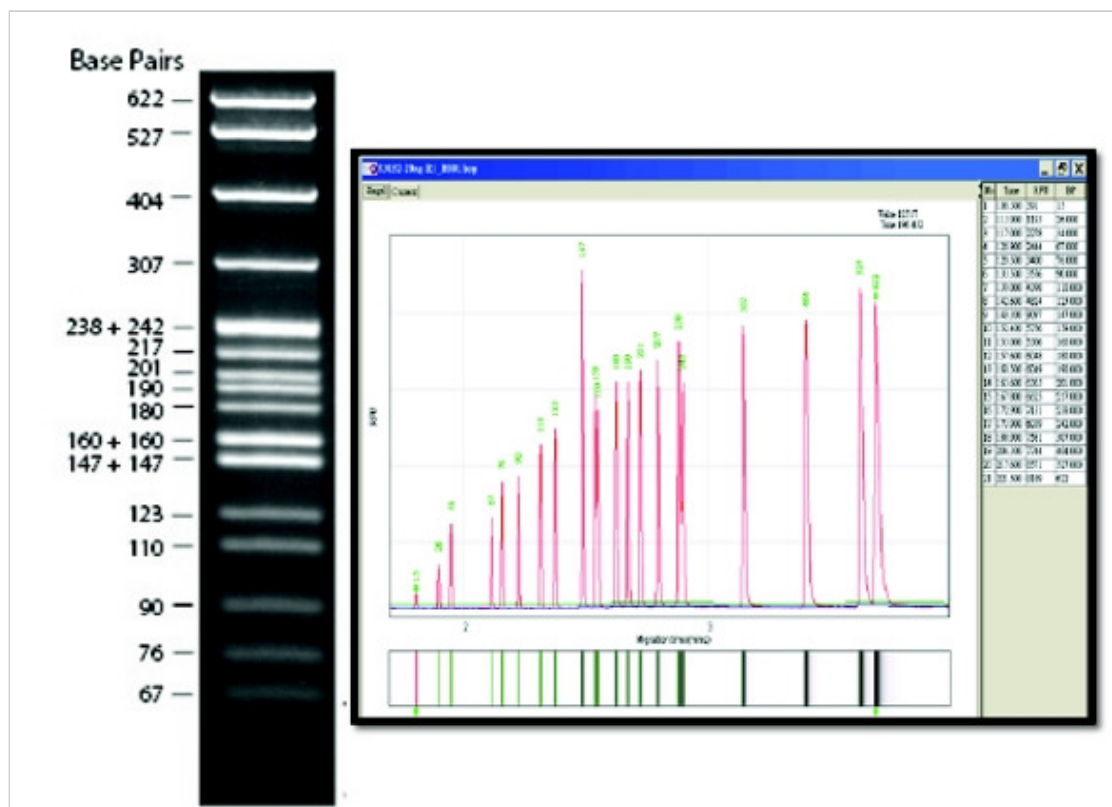


Figure 4 – pBR322 DNA–MspI digest visualized by ethidium bromide staining (1.8% agarose gel) is compared to a 4-min run of the Qsep100 dna-CE using the gel cartridge, which provides high-resolution separation of different sequences at 160 bp and 238 bp/242 bp (4 bp resolution). With high detection sensitivity and high resolution, the fragments of 15/26/34 bp were easily detected with the Qsep100 dna-CE system.

Results: Reproducibility study

The migration time reproducibility of the separation system was assessed by a 10- run repeatability study of a 100-bp DNA molecular mass marker (size range 100– 3000 bp). A final concentration of 25 ng/ μ L (**Biocenter Ltd.**, Szeged, Hungary) was used for this evaluation. Each injection was from the same well of the 96-well plate. The average RSD% of the migration times for the fragments ranging from 100 to 3000 bp were between 0.5118 and 0.7477%, i.e., they exhibited excellent reproducibility.

Conclusion

The compact (15" L \times 12" W \times 16" H) Qsep100 dna-CE system described here is capable of rapidly resolving DNA fragments in the range of 20 bp–10,000 bp with 2–4 bp resolution at <500 bp. The CGE system is able to perform both high-resolution and high-detection sensitivity DNA fragment analysis. The disposable pen-shaped gel-cartridge design, which provides low-cost solution (\$0.1–\$0.2 per sample run), is equal to or lower in cost than the manual slab-gel electrophoresis process.

References

1. Liu, M.S.; Amirkhani, V.D. DNA fragment analysis by an affordable multichannel capillary electrophoresis system. *Electrophoresis* **2003**, *24*, 93–5.
2. <http://www.bioptic.com.tw>.

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