Microfluidic Devices on Polymer Substrates for Bioanalytical Applications

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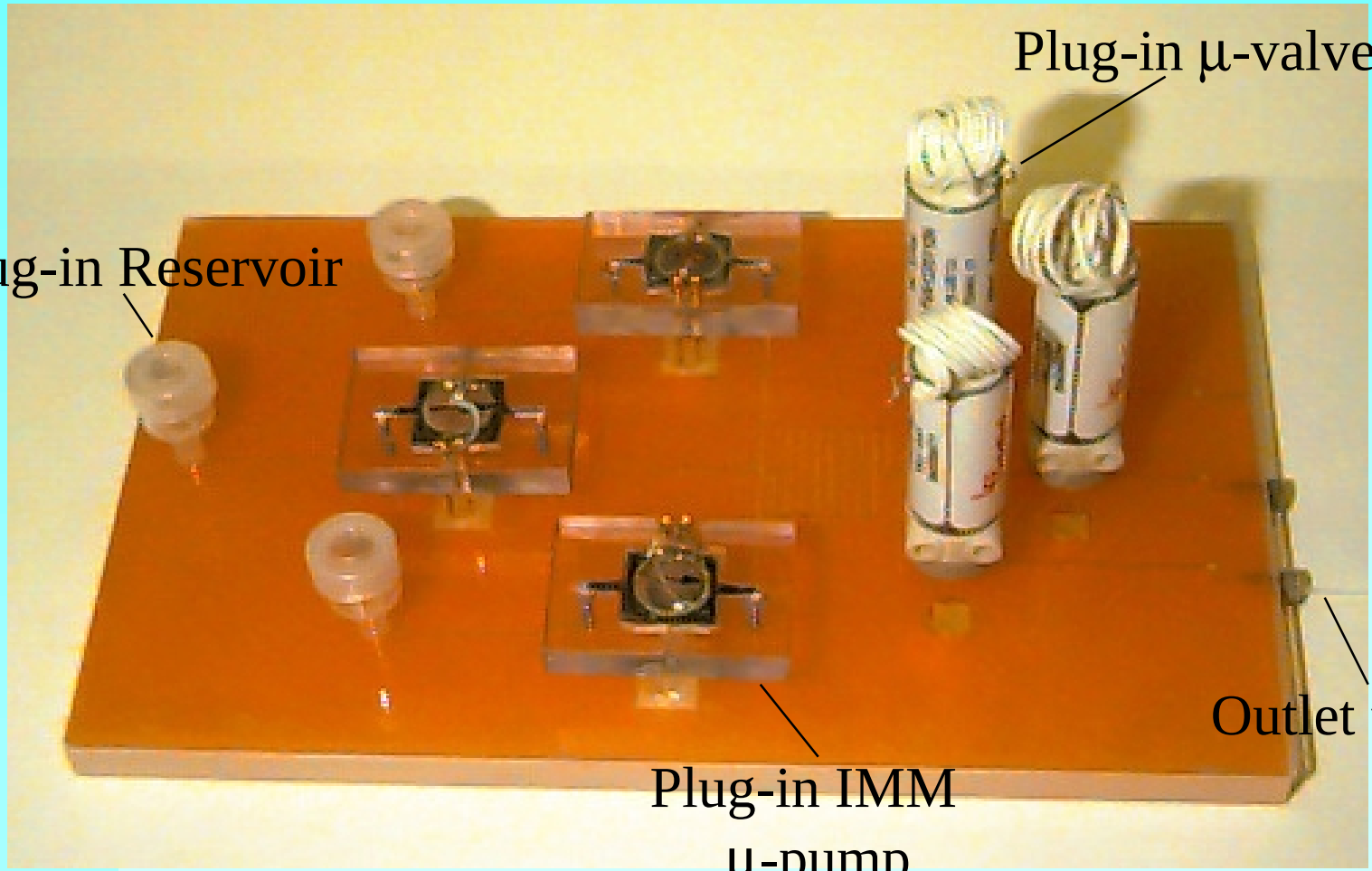
Overview

- Designed and fabricated microfluidic motherboard. Demonstrated connectors for “Plug-and Play” modules.
- Designed and fabricated dual-stage microdialysis devices using laser-micromachining technology. Successfully demonstrated desalting and fractionation of biological samples using these devices with electrospray ionization mass spectrometer (ESI-MS).
- Designed and fabricated capillary isoelectric focusing (CIEF) devices. Demonstrated the separation of proteins samples using CIEF devices
- The results indicate substantial potential for construction of highly compact and rugged devices enabling field applications of ESI-MS

Microfluidic Motherboard



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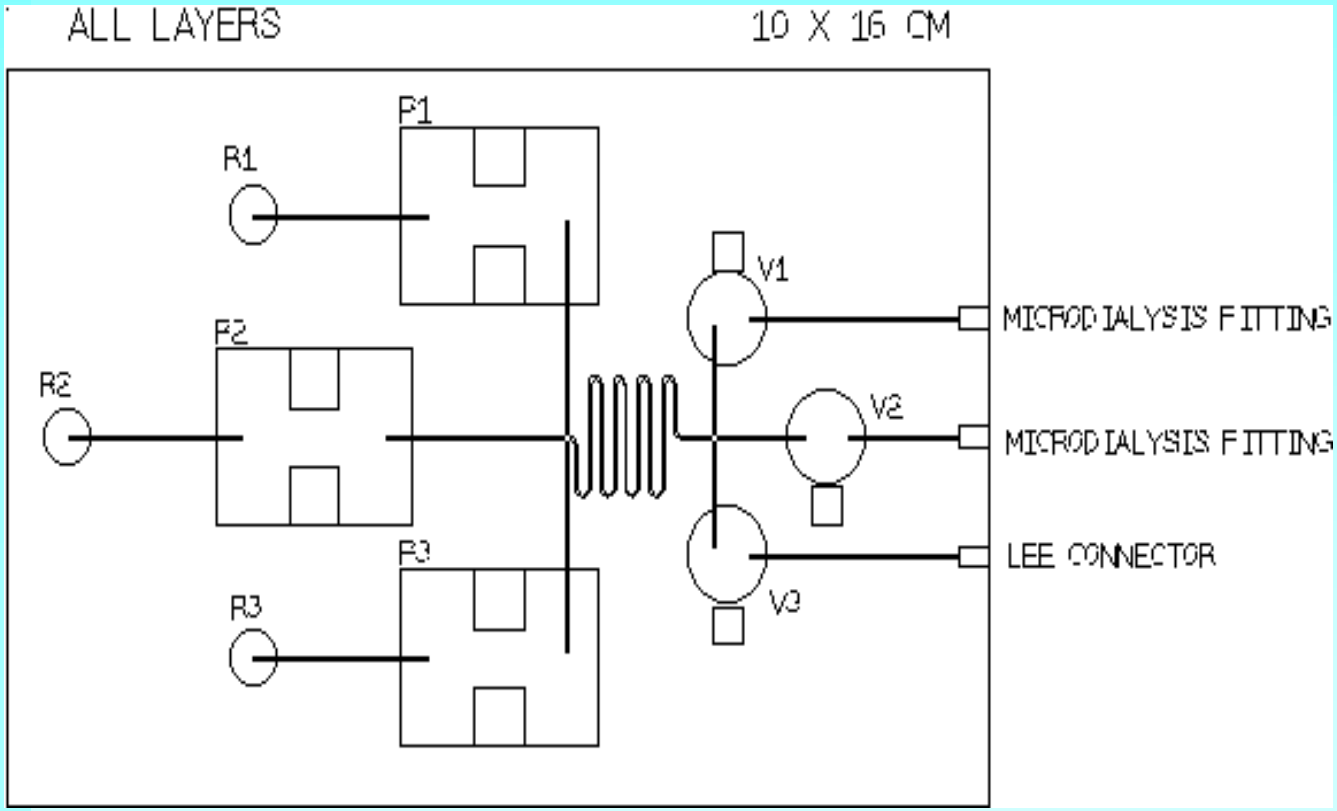
Microchannels in Microfliuidic Motherboard

Micropumps capable of flow rates of 100-300 µL/min

Microchannels: 300 µm wide, 150 µm deep

Straight sections and serpentine channel



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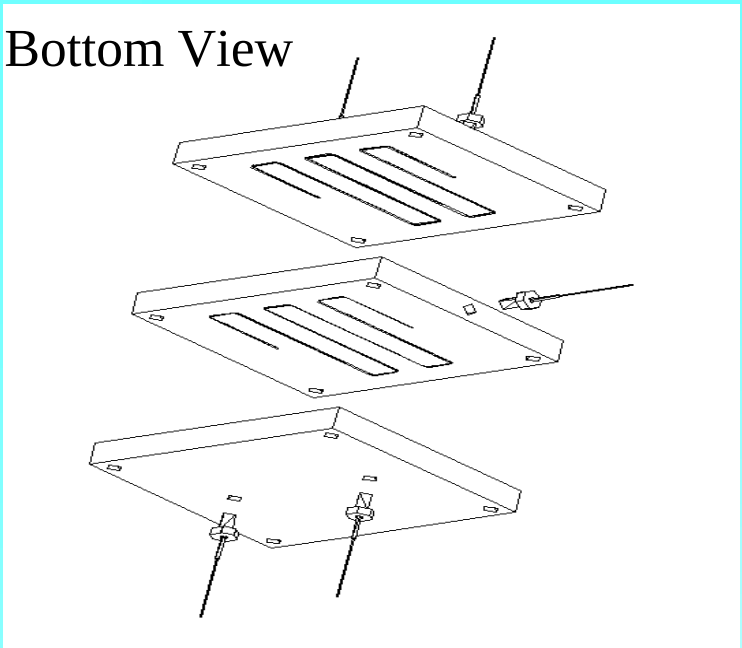
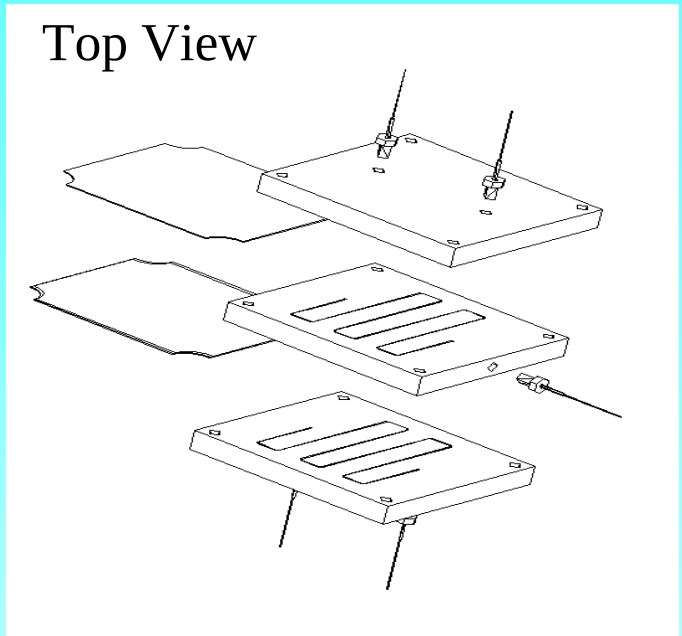
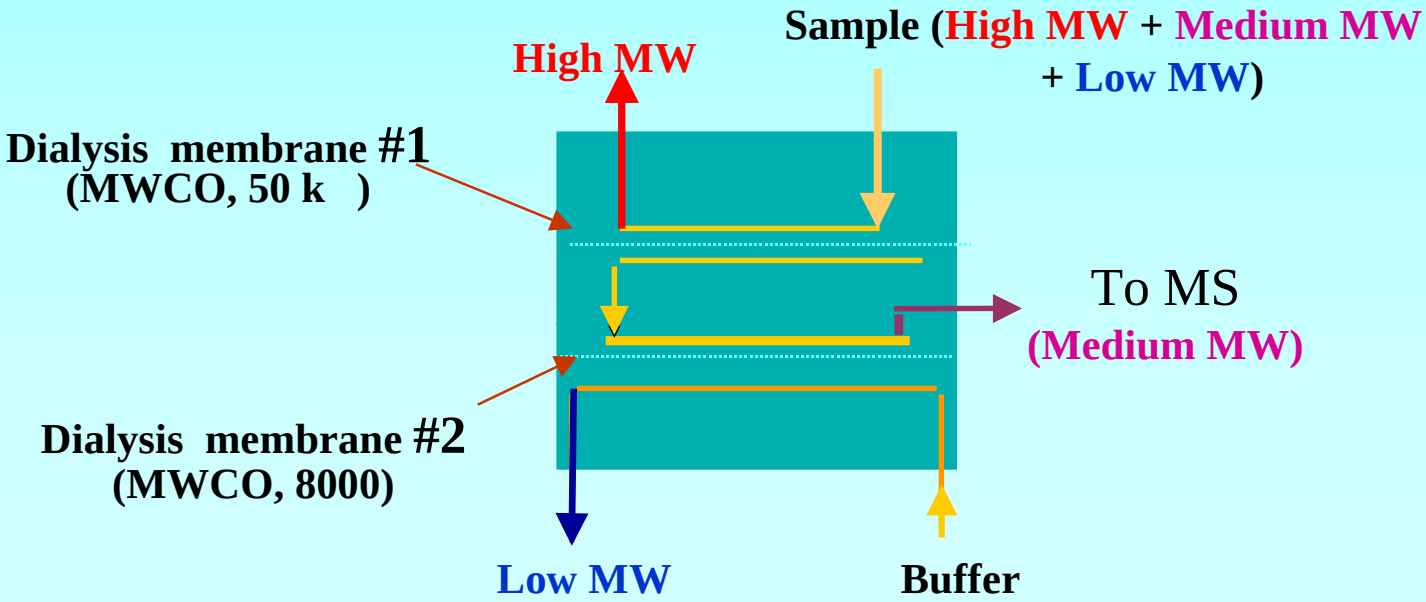
Microfabricated Dual-Stage µ-dialysis Device







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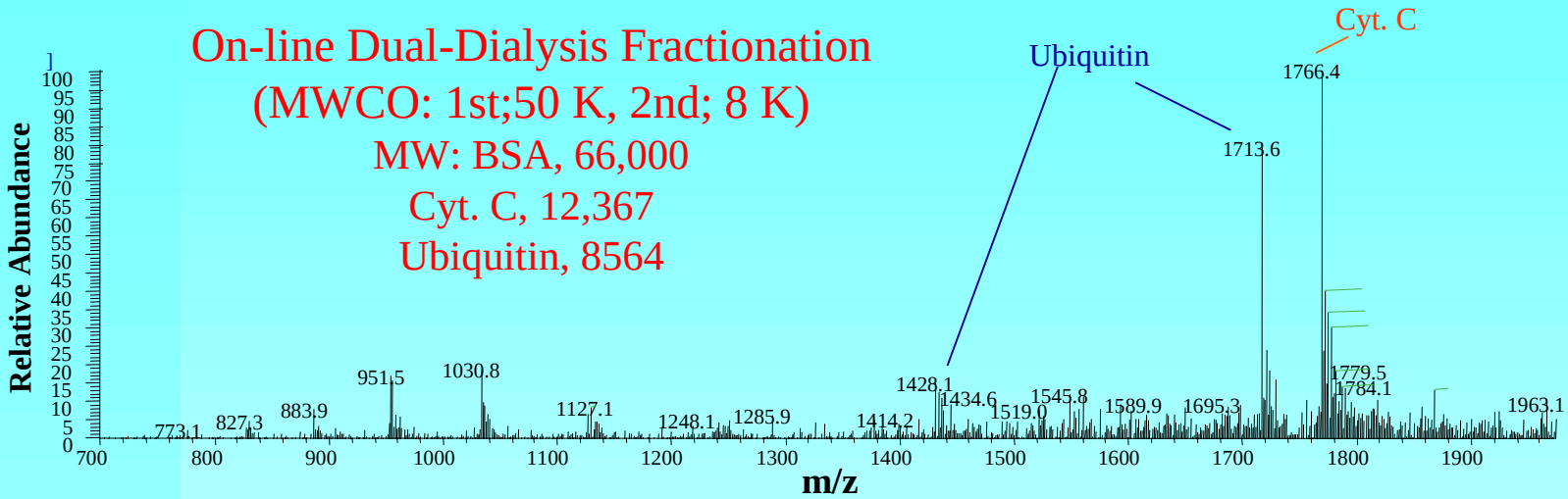
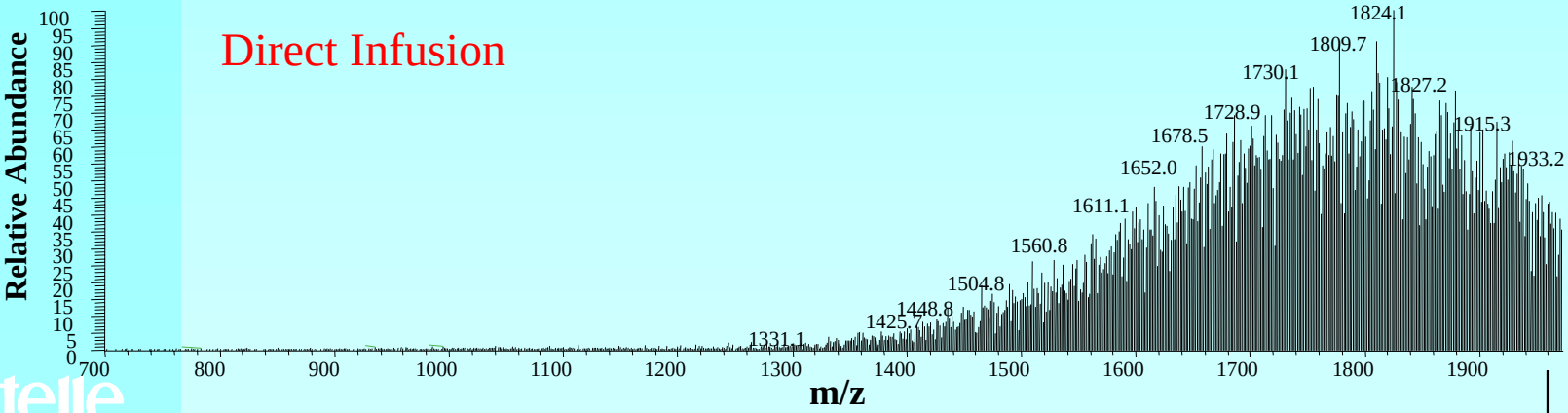
ESI-MS Spectrum of a Protein Mixture

30μM Bovine Serum Albumin (BSA), 8 μM cytochrome C, 2.4μM Ubiquitin in 0.01 M PBS

On-line Dual-Dialysis Fractionation
(MWCO: 1st;50 K, 2nd; 8 K)
MW: BSA, 66,000
Cyt. C, 12,367
Ubiquitin, 8564



Direct Infusion



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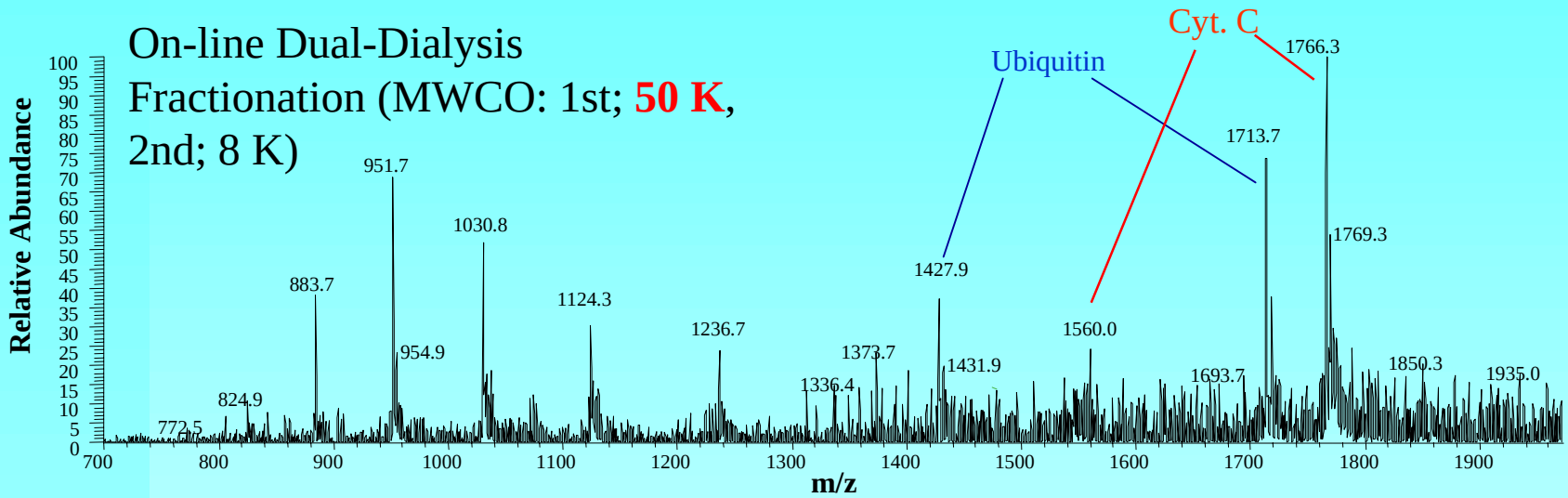

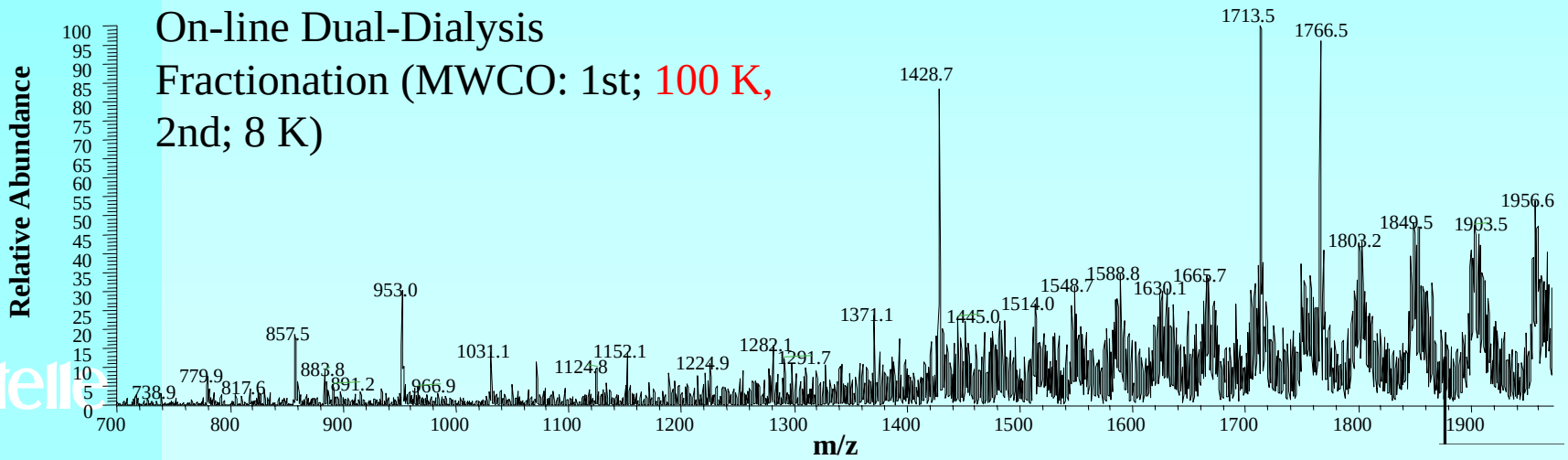

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Comparison of Original Dual-Dialysis Device and Microfabricated μ-Dual-Dialysis Device

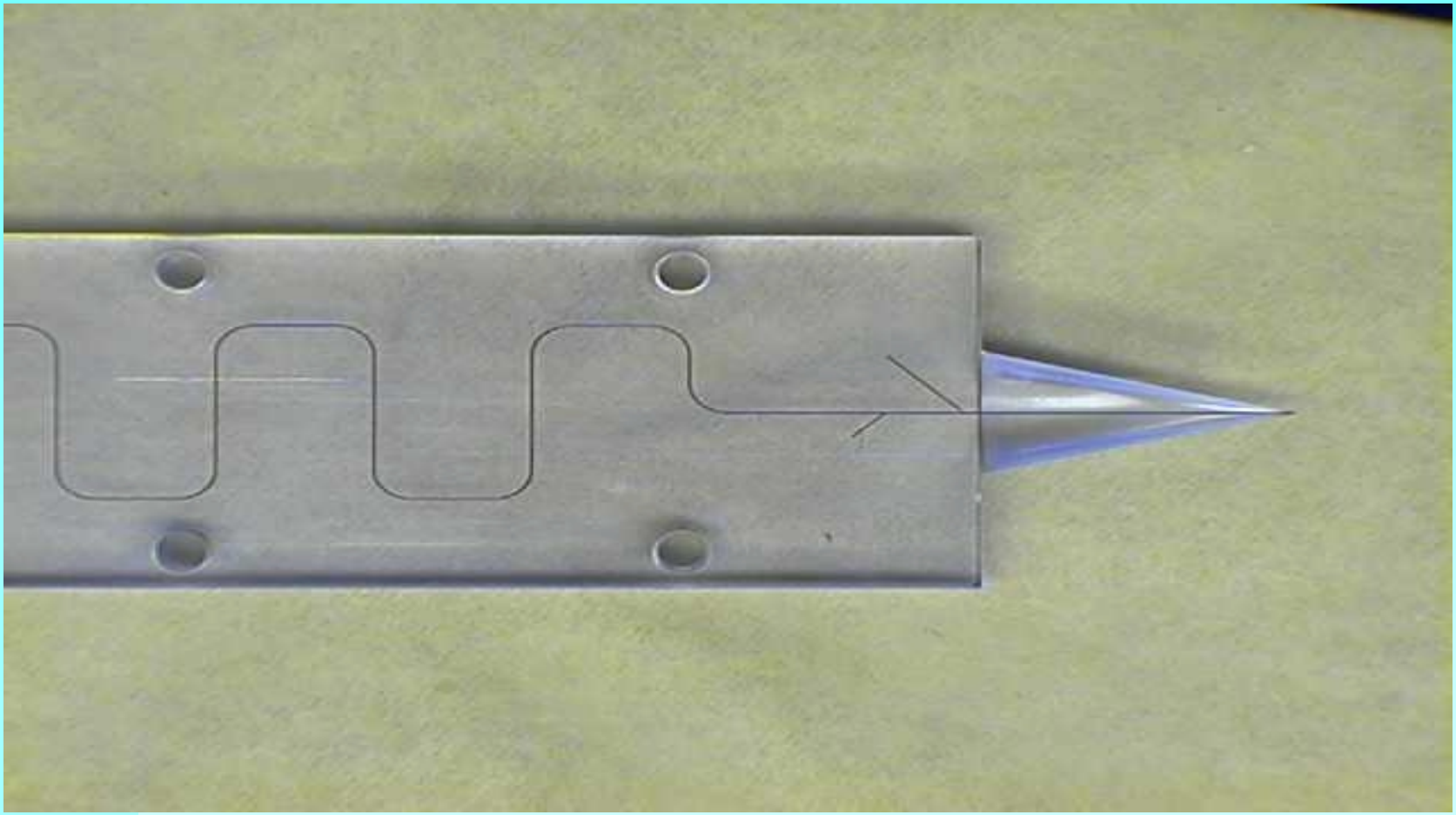
Dual-Dialysis Device

- Dead volume 30 μL
  10 ul tubing + 20 uL dual-dialysis Device
- 30 min/sample (5 ul/min)
- Sample consumed, 150 μL

μ-Dual-Dialysis Device

- Dead volume, 2 μL Integrated dual-dialysis device, eliminating connection tubing
- 2 min/sample: 1 μ L/min, combined with FI
- Sample consumed, 1 μL

CIEF Microchip with a Sharp Electrospray Emitter Tip



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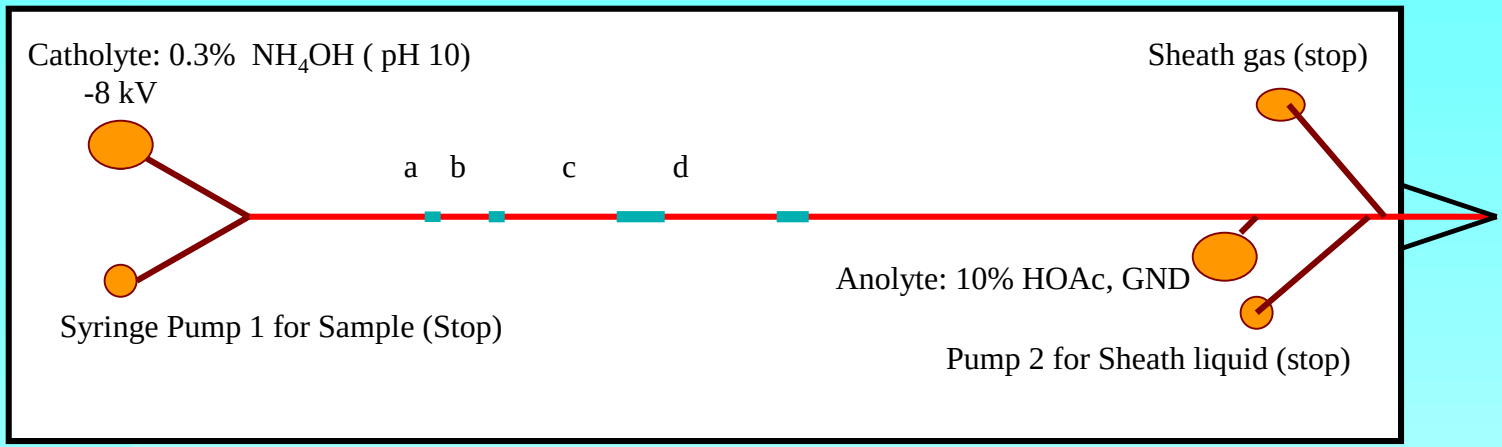
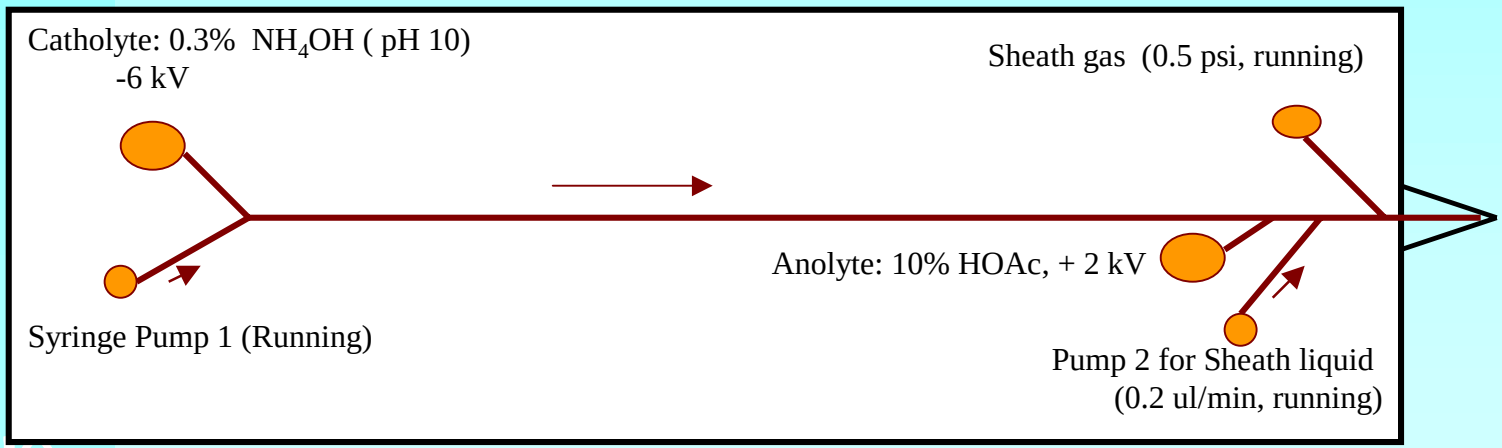
Two Step in Isoelectric Focusing Separation of Proteins



(A) Focusing Step



(B) Mobilization Step

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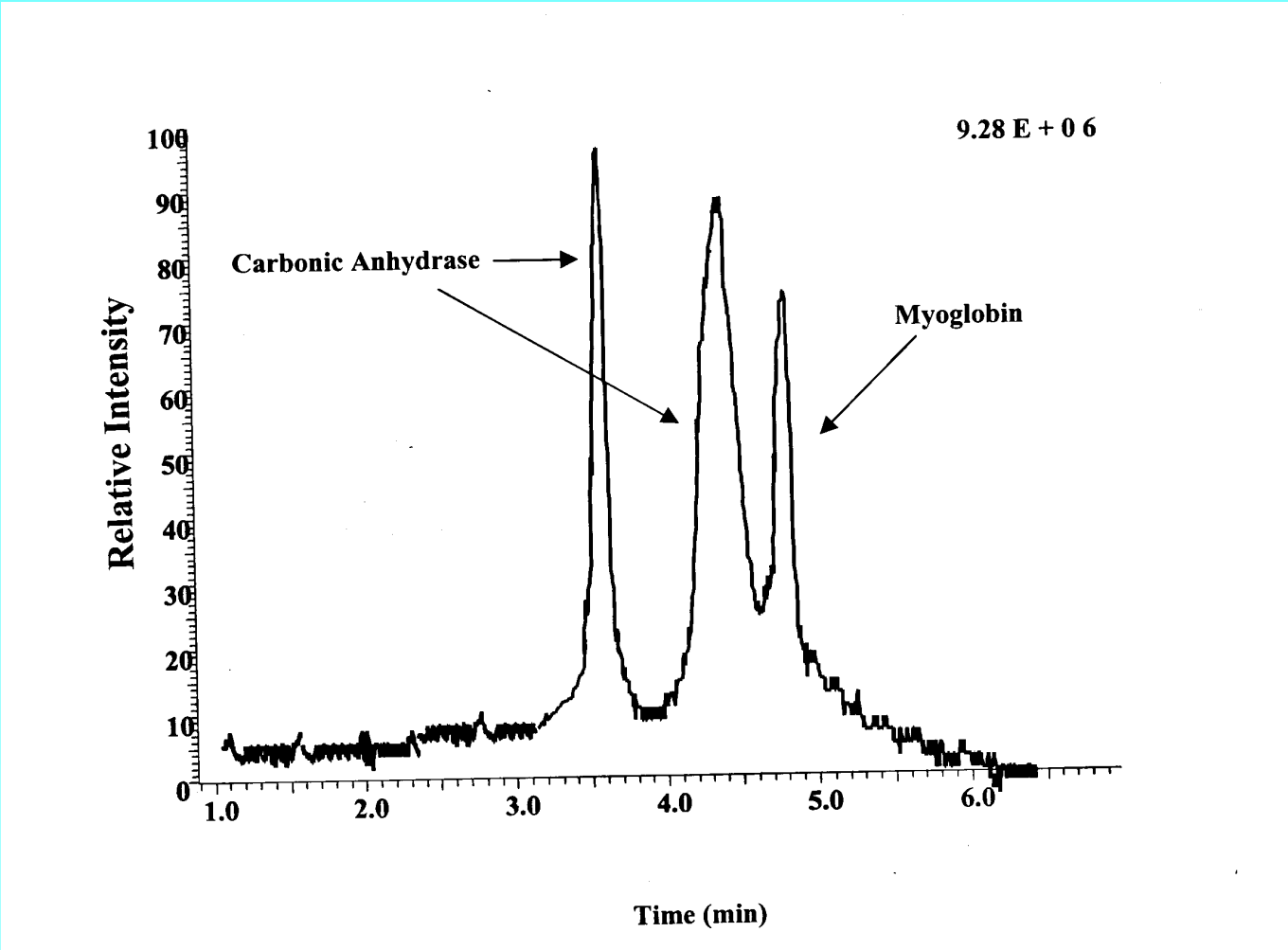
CIEF/ESI-MS Separation Profile on CIEF Microchip for Protein Mixture



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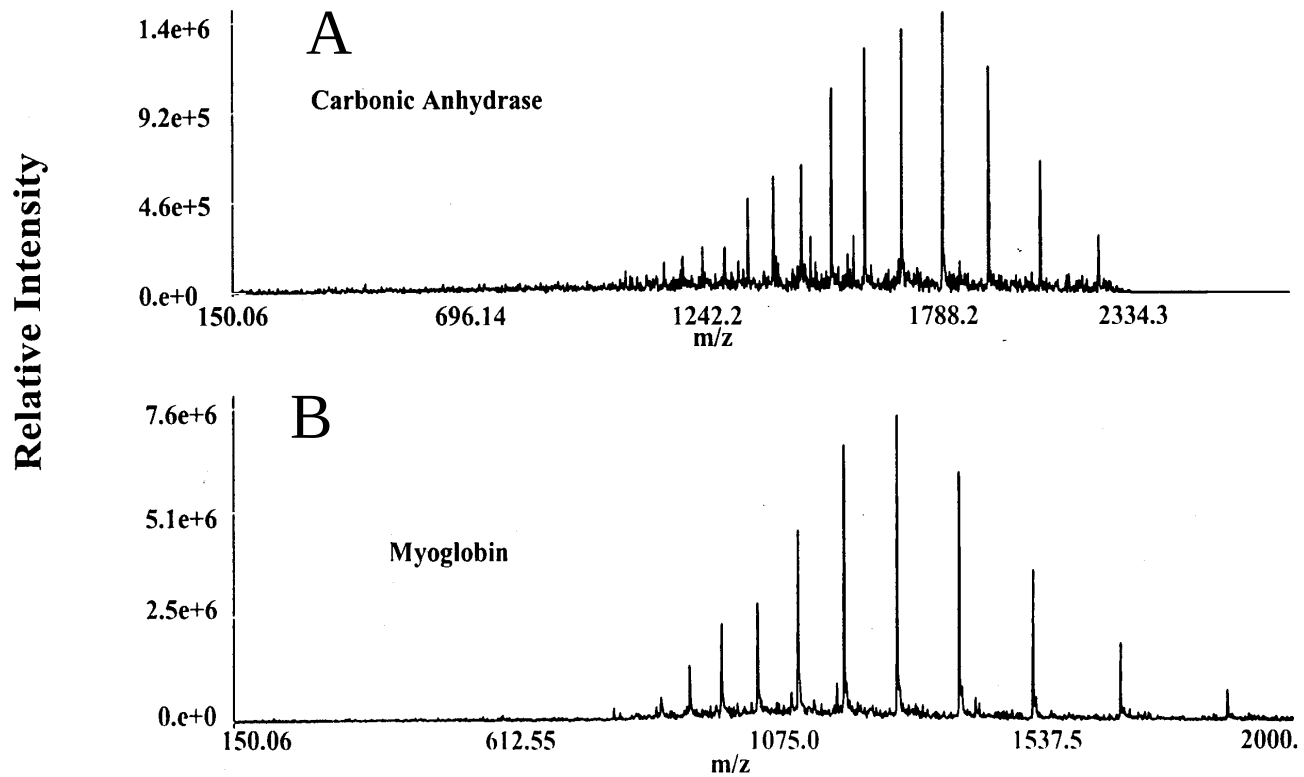
Positive ESI Mass Spectrum of Carbonic Anhydrase (A) and Myoglobin (B)



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Summary

- Laser microfabricated devices were constructed for rapid microdialysis cleanup and fractionation of biological samples for analysis by ESI-MS. Efficient desalting and fractionation were demonstrated for protein samples using ESI with an ion trap mass spectrometer.
- Microfabricated CIEF chip was constructed and preliminary results indicated the use of such device for protein concentration and separation without pre-coating.
- The microfabricated devices studied are readily fabricated on inexpensive polymer substrates, therefore, there is a great potential for large-scale production of inexpensive and disposable devices.

Acknowledgments

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