

MINIATURIZED THERMAL FIELD-FLOW FRACTIONATION SYSTEM

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ABSTRACT

TFFF systems are used for separation of biological and synthetic materials with different molecular weights as well as colloidal particles such as cells and proteins. Miniaturization of conventional macroscale TFFF systems is made possible through utilization of micromachining technologies. Miniaturization of the TFFF system has the advantages of reduced sample size, reduced power consumption, and decreased analysis time for equivalent results.

INTRODUCTION

TFFF is an elution separation technique similar to chromatography except the separation field is normal to the sample and carrier flow. TFFF utilizes thermal diffusion as the separation field instead of mediums found in chromatographic separations. A schematic of the TFFF system is shown in Figure 1. Separation of suspended particles are typically performed in a solvent carrier. Higher molecular weight particles react more to the thermal gradient and compact more tightly against the cold wall than do lower molecular weight particles. Because of the laminar velocity profile of the carrier, lower molecular weight samples will have a higher average velocity. The difference in average velocity results in the spatial and temporal separation along the TFFF channel.

The TFFF system possesses unique characteristics making it more suitable for some separations than conventional system. In TFFF speed and elution, as in chromatography, are combined with well developed theory and gentleness, as in centrifugation, to give

it a unique versatility in separations and analysis of both biological and synthetic materials. [1]

Figure 1. Schematic of a thermal field-flow fractionation (TFFF) channel.

In order for a separation in a TFFF channel to occur, there must be a difference in molecular weight of the components, a sample selective perturbation of the samples toward one wall, and a laminar velocity profile that results in a different average velocity of each constituent of a given sample. [1]

The resolution of two samples is inversely proportional to the channel width. As a result, for a given separation, the resolution time is shorter, or, for a given time the resolution is higher for a smaller channel. [1] Micromachining techniques are available to reduce this channel width to dimensions that macromachining techniques are not capable of.

METHODS

The μ -TFFF system was fabricated on a silicon wafer. A silicon dioxide (SiO_2) mask was thermally grown and patterned to define input/output points. The ports were then anisotropically etched through the silicon wafer in KOH. The SiO_2 was then used as the

mask for the boron diffused heaters. A negative photosensitive polymer (SU-8) was spun on to a thickness of $25\mu\text{m}$ onto the wafer and patterned to

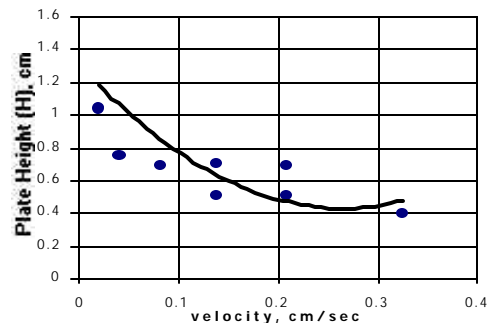


Figure 2. Plate height for unretained sample. The carrier was DI water, the sample was $0.1\mu\text{L}$ 100% acetone.

A glass microscope slide was affixed to the top of the SU-8 to complete the channel. After completing the fabrication of the μ -TFFF separation channel, the complete system was assembled (e.g. fluid interconnects, power supply, flow meters, and detector) and tested.

Using the μ -TFFF device fabricated as described in this paper, the total plate height was determined as a function of flow rate for an unretained sample. DI water was used as the carrier and pure acetone was used as the sample. The flow rates used were 2.34, 1.5, 1.0, 0.6, and 0.3 mL/hr. An acetone sample, $0.1\mu\text{L}$, was injected into the input port at time zero for each flow rate. A detector measured the absorbency with respect to DI water.

RESULTS

Channel height has been reduced from $127\mu\text{m}$ (macro-TFFF system) to $50\mu\text{m}$ (μ -TFFF). A power of only 10 W was required to maintain a 20°C temperature drop across the channel where the hot wall was at 47°C . This drop is more than ten times lower than that reported for a typical macro-scale TFFF channel.

Plate height was determined as a function of average carrier velocity (Figure 2) and compared with results from the μ -EFFF system [2] and TFFF theoretical results. The μ -TFFF plate height characteristics follow the curves that are found in the μ -EFFF [2] channel as well as the theoretical curve for the TFFF system.

CONCLUSION

A micromachined thermal field-flow fractionation device has been successfully fabricated and tested. Common micromachining fabrication techniques were implemented with good control of the channel geometry and reduced the channel width beyond that which conventional macro-machining processes capable of. The integrated heater power consumption was decreased by about 10 over common conventional TFFF systems. The μ -TFFF system exhibited plate height attributes similar to those from the μ -EFFF system, macro-TFFF system, and theory.

REFERENCES

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