Progressive Cellular Architecture for Vapor Collection and Chromatographic Separation

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Summary: This work presents the progressive cellular architecture for vapor collection and chromatographic separation, which achieves a wide range of analysis using low energy consumption. The progressive cellular architecture uses multiple heterogeneous gas chromatography cells, each including a preconcentrator and separation column designed for a specific volatility range. High energy efficiency is achieved because of the partial separation provided during sampling, and because each chemical is separated by the most suitable column. A preliminary 3-cell system has been successfully demonstrated for sampling and separation of 9 chemicals in the volatility range between methanol and decane using only minimal column heating. The results show significantly superior separation resolution and lower energy consumption than conventional architectures.

1 Motivation and Concept

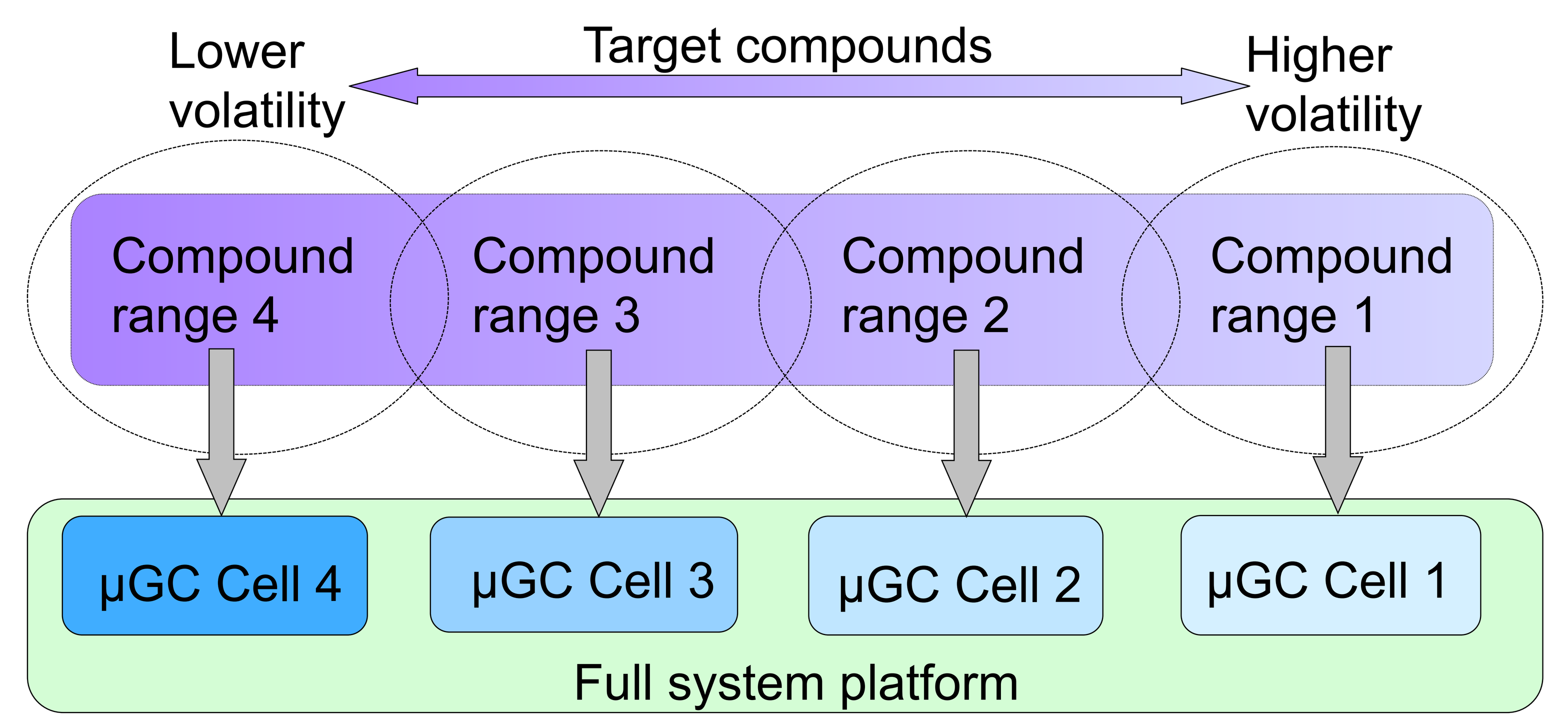
The progressive cellular architecture provides a wide range of chemical analysis using low energy consumption

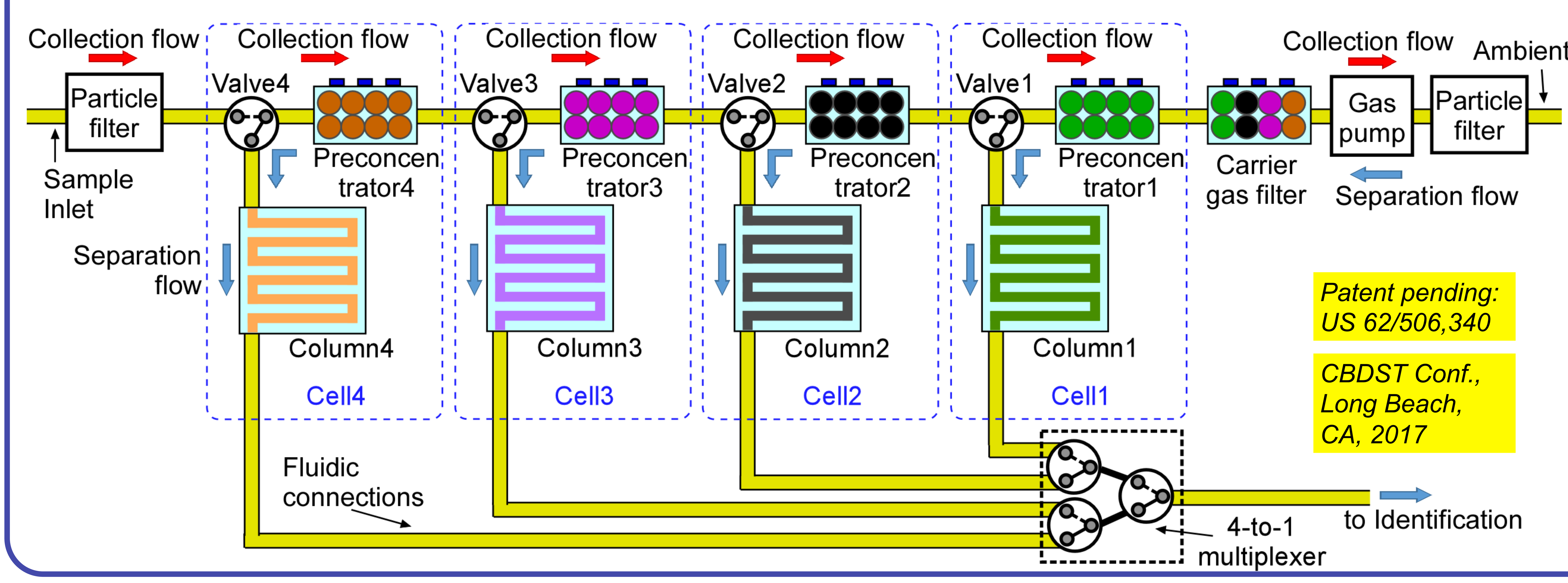
- Multiple heterogeneous gas chromatography cells, each including a preconcentrator and separation column designed for a specific volatility range
- Partial separation achieved during sampling; each chemical separated in the most suitable column – minimizes the column heating and pumping requirements

Background: in traditional gas chromatography (GC)

- All target analytes are separated by the same separation column
- However, compounds with high and low volatilities place contradictory requirements

Compound volatility	High	Low
Stationary phase requirement	Thick film, retentive	Thin film, less retentive
Column temperature requirement	Low temperature	High temperature





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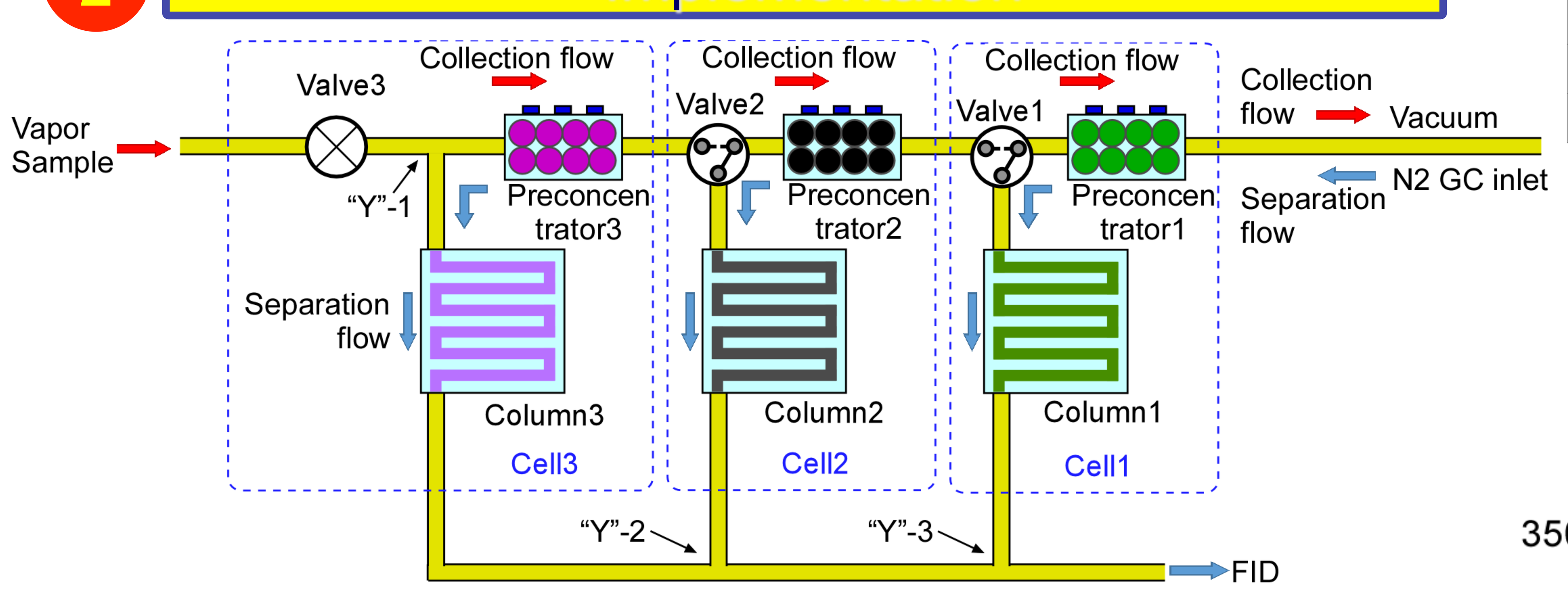
Technical approach:

- Each cell uses a different combination of preconcentrator and separation column for a specific volatility range
- During vapor collection
  - All preconcentrators form a serial connection
  - Each preconcentrator only collects a targeted subset of vapor species
  - *De facto* partial separation achieved during collection
- During separation
  - Each column optimized for its targeted subset of vapor species
  - Separation progressed from cell to cell (first in Cell 1 and last in Cell 4)

2 Implementation



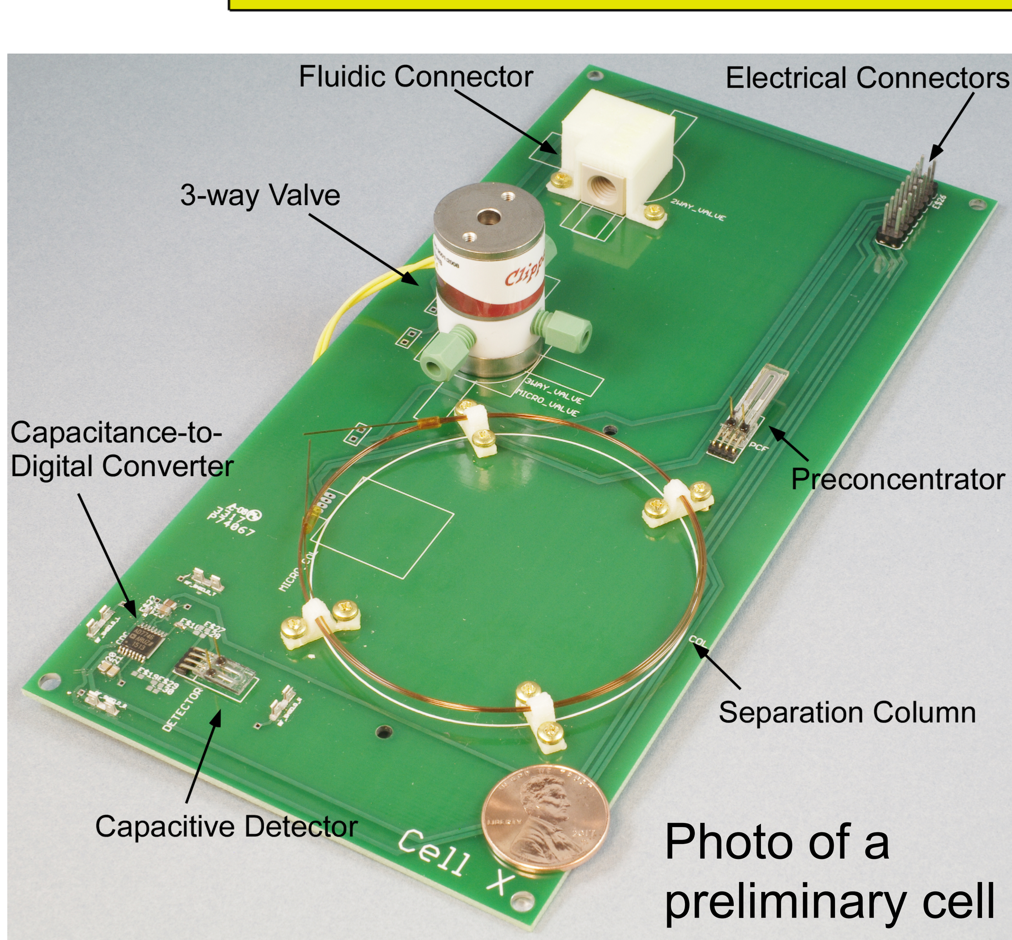
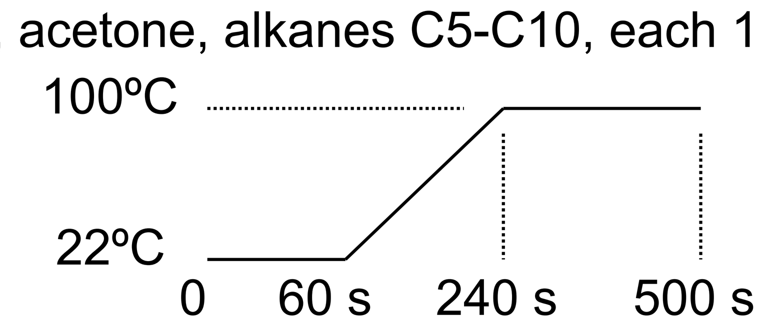


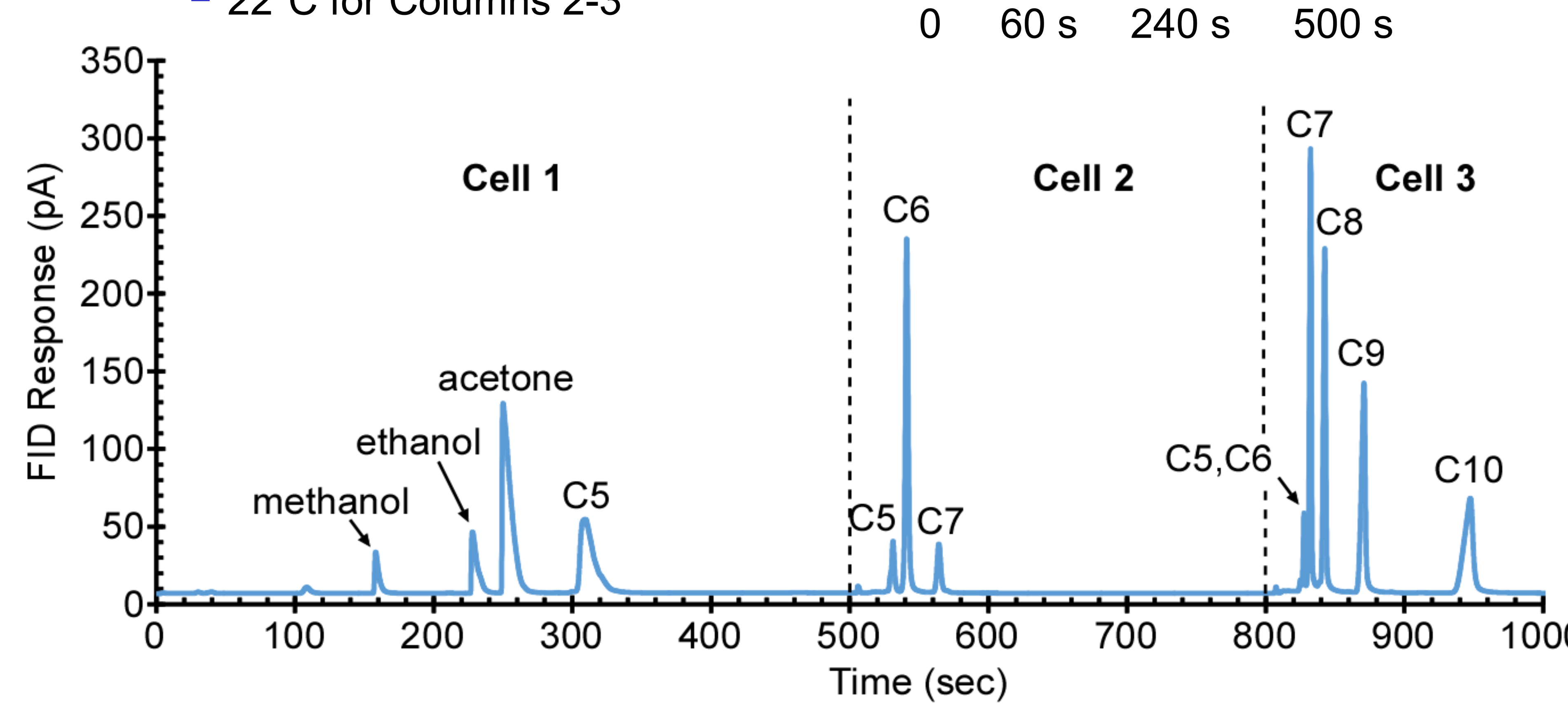
Photo of a preliminary cell

Cell	Precon. sorbent	Separation column	Targeted range
1	Carboxen 1000	1 m x 250 μm ID x 8 μm divinylbenzene	C1-C5
2	Carbopack B	1 m x 250 μm ID x 1 μm OV-1	C5-C7
3	Carbograph 2	1 m x 250 μm ID x 0.1 μm OV-1	C7-C10

Testing conditions

- Vapor collection: 1.13 sccm, 20 minutes
- Vapor sample: methanol, ethanol, acetone, alkanes C5-C10, each 1 ppm
- Separation flow: N_2, 0.6 sccm
- Separation temperature:
  - Programmed for Column 1
  - 22ºC for Columns 2-3





Takeaway: *The concept of progressive cellular architecture concept has been successfully demonstrated. Future work includes building a complete system with all microfabricated components and improving the overall system performance in various aspects.*

Patent: Y.B. Gianchandani, Y. Qin, "Progressive Cellular Architecture for Microfabricated Gas Chromatograph," US 62/506,340, patent pending
Publication: Y. Qin, Y.B. Gianchandani, "Progressive Cellular Architecture in Gas Chromatograph for Broad Vapor Sensing," *Chemical and Biological Defense Science & Technology (CBD S&T) Conference,* Long Beach, CA, Nov. 2017.

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