Microfluidic Platform for Phase Separation of Aqueous Solutions

A microfluidic system capable of accomplishing refrigeration induced phase separation of aqueous-acetonitrile solutions.

Georgia Tech inventors have created a microfluidic system capable of accomplishing refrigeration induced phase separation of aqueous-acetonitrile solutions. The system has integrated fluidic connections for sample introduction and removal of the resulting phases. The device is unique due to the solutions of acetonitrile and water, being fully miscible in one another at room temperature, separate into two distinct phases upon refrigeration. This phenomenon has been demonstrated across a broad range of process parameters, with phase separation occurring at or below temperatures of -1.3°C. The presence of dissolved solutes and limited concentrations of other liquid solvents has been shown to have negligible impact on the separation, permitting this phenomenon to be used as an alternative liquid phase extraction technique for the isolation of dissolved analytes in addition to purification of aqueous or acetonitrile solutions.

Summary Bullets

- **Efficient workflow-** sample removal and analysis can be performed without manual oversight
- **Smaller sample size-** less sample volume required alleviating dilution of low concentration solutions that is common in alternative sample preparation workflows
- **Faster process-** thermoelectric cooling can induce separation in a matter of seconds with precision and tunability

Solution Advantages

- **Efficient workflow-** sample removal and analysis can be performed without manual oversight
- **Smaller sample size-** less sample volume required alleviating dilution of low concentration solutions that is common in alternative sample preparation workflows
- **Faster process-** thermoelectric cooling can induce separation in a matter of seconds with precision and tunability
- **Lower cost-** increased throughput of sample analysis without the need for expensive equipment and supplies as a single control module is needed with interchangeable microfluidic separation chambers
- **Microfluidic -** minimizes dilution during sample handling, reduces time scale for phase separation thus increasing throughput of sample analysis

- **Compact System -** portable control module allows for system to be used as a point of sample device to provide immediate and on-demand sample preparation and preservation
- **Multiple modes of operation –** phase separation can be performed in both batch or continuous flow modes extending utility to a broad range of existing analytical workflows

Potential Commercial Applications

- Enrichment/ desalination of acetonitrile-aqueous solutions
- Purification of protein laden HPLC effluents via acetonitrile
- Inline sample prep for mass spectrometry analysis:
    - Biologics
    - Pharma
    - Forensics
    - Food safety
    - Geology

Background and More Information

Though the phenomenon of aqueous-acetonitrile phase separation at subzero temperatures is documented and several applications of this technique have been made, there is currently no device capable of inducing this phenomenon in a rapid, on-demand manner with precise and tunable control of the resulting phases in an inline fluidic platform. The specificity of inline sample preparation is crucial for the automation of complicated analytical workflows, freeing operators from intermittent and time consuming manual sample preparation and handling steps. The microfluidic design with integrated thermoelectric cooling enables rapid cooling compared to conventional refrigeration techniques, taking only seconds compared to hours. Many analytical samples are also limited in volume with sample handling resulting in sample loss and dilution; the microfluidic platform can be easily integrated with existing workflows to alleviate manual sample manipulation while maintaining the ability to detect analytes in low concentrations.

Inventors

- Austin Lance Culberson
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IP Status

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Publications

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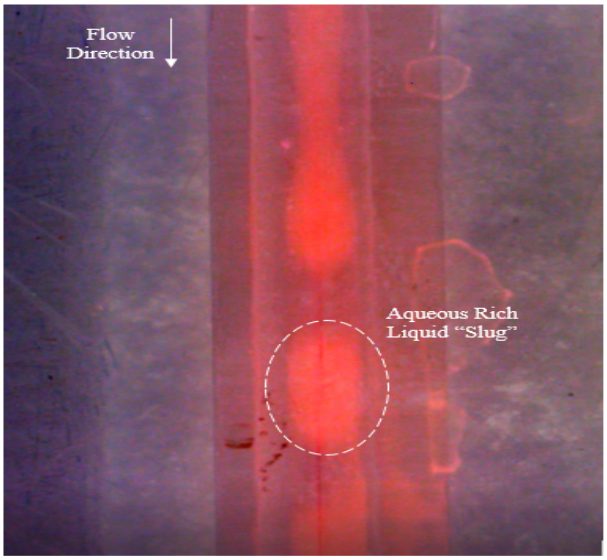
Images

Continuous Flow Proof of Concept:



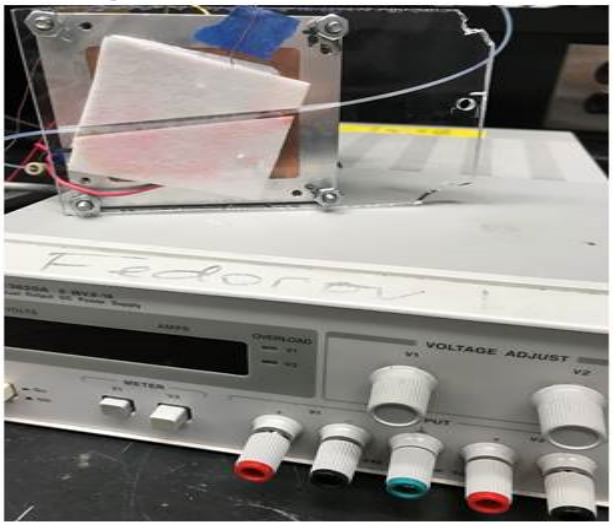
Homogenous solution of ACN-DI above temperature for initiation of phase separation

Two phase mixture of ACN rich liquid surrounding slugs of aqueous rich liquid (seen here in red) at temperature below that needed for phase separation

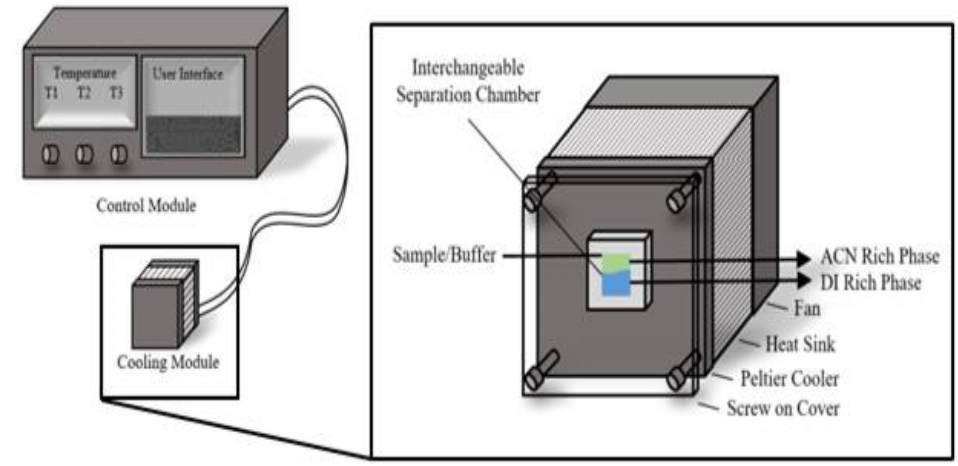
Batch Mode Proof of Concept:

Homogenous solution of ACN-DI separates in <1 min following → initiation of cooling into lower aqueous rich and upper ACN rich phases

Current System:



Envisioned System:



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