Continuous/Intensified solvent extraction of biomolecules using hydrophobic ionic liquids

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Abstract

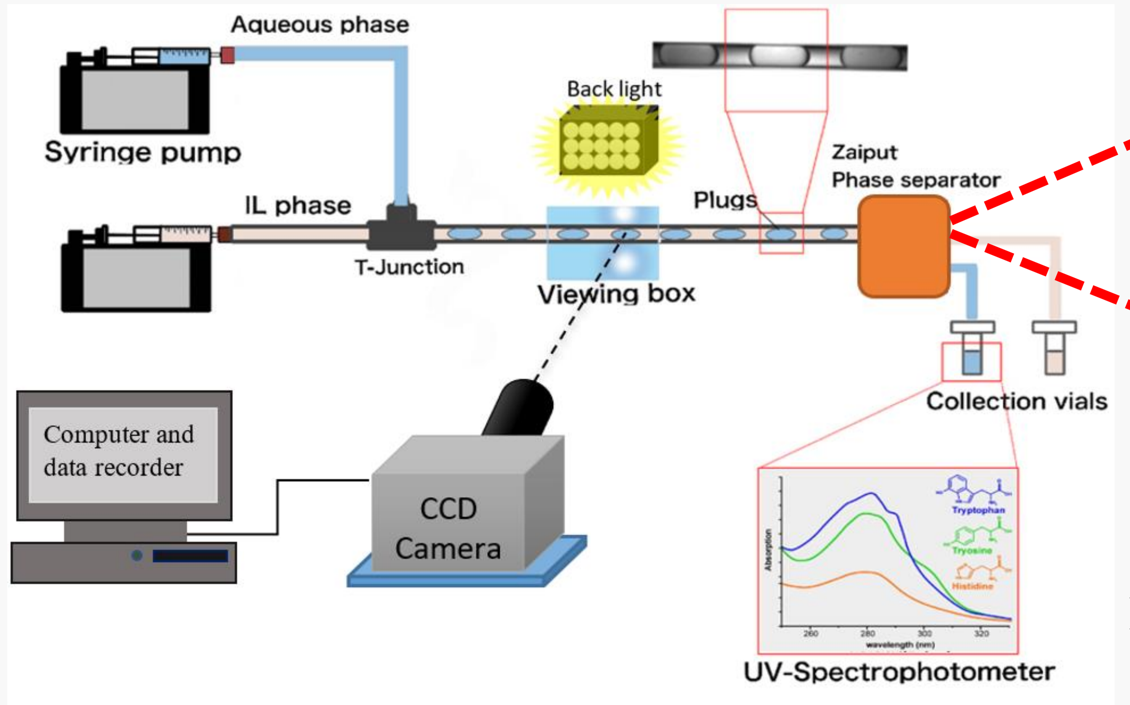
❖Solvent extraction is one of the most widely used separation techniques however, it is still carried out in batch or semi- batch operation, preventing it from integrating with upstream and downstream production equipment.

❖Double process intensification has been achieved in small channels using hydrophobic ionic liquids.

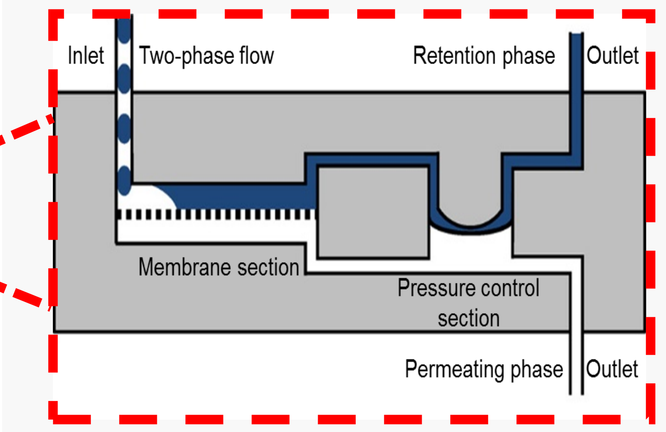
❖The benefits of both microchannels and green ionic liquids as alternatives to traditional separation equipment and volatile organic solvents respectively are displayed.

Experimental Procedure

- The aqueous phase containing the biomolecule to be extracted meets the ionic liquid, [C4mim][Tf2N] containing the extractant in a T-Junction configuration.
- From the T-junction the fluids entered the test channel and their velocity and flow patterns were observed and recorded using a high-speed camera.



Experimental set up of liquid-liquid extraction in small channels.



Zaiput phase separator with hydrophobic membrane.

- The two-phase flow was then separated in-line using a membrane-based flow separator (Zaiput).
- The concentration of biomolecule in the aqueous phase was measured using a UV-spectrophotometer and the percentage extraction was determined.

Motivation

❖The high costs associated with downstream processing aimed at the purification and recovery of target products is one of the major issues limiting the widespread use of many bio-base products [1].

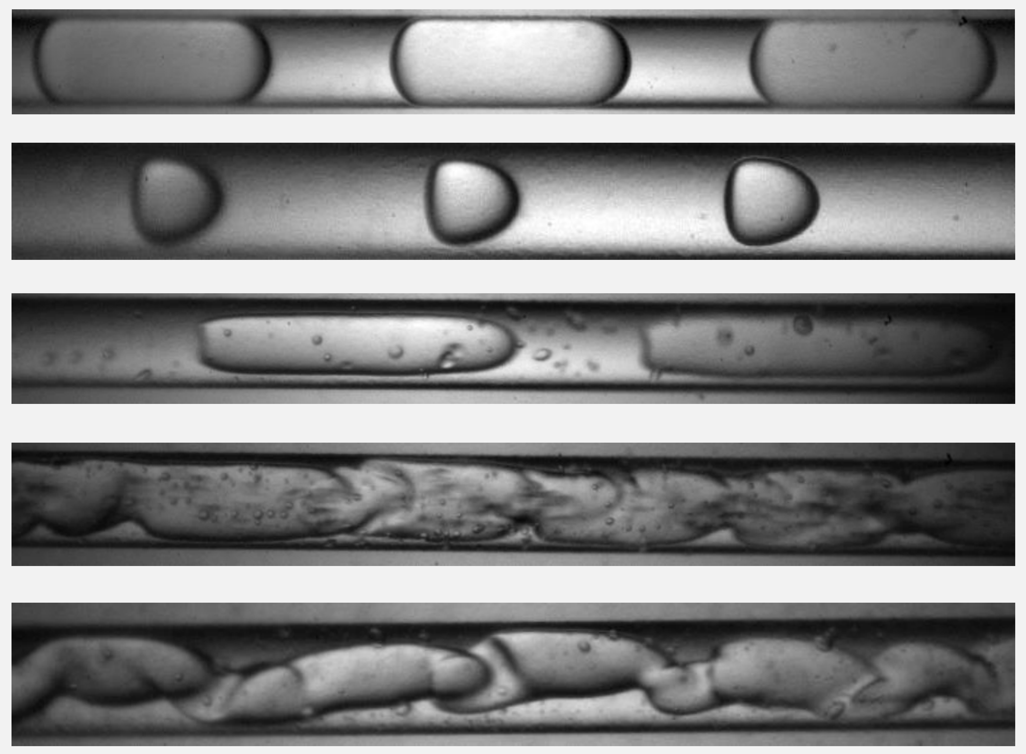
❖Continuous manufacturing offers a range of advantages for adaptation over batch **including speed, flexibility and safety**[2].

❖Continuous solvent extraction can be achieved by the application of small-scale two-phase contactors. The reduction of the apparatus size suggested by intensification leads to a range of benefits for chemical engineering and solvent extraction specifically.

❖Currently, volatile organic solvents are used as solvents in a large percentage of the chemical industry. Nonetheless, they are associated with many disadvantages including high flammability, volatility and toxicity and should be replaced [3-4].

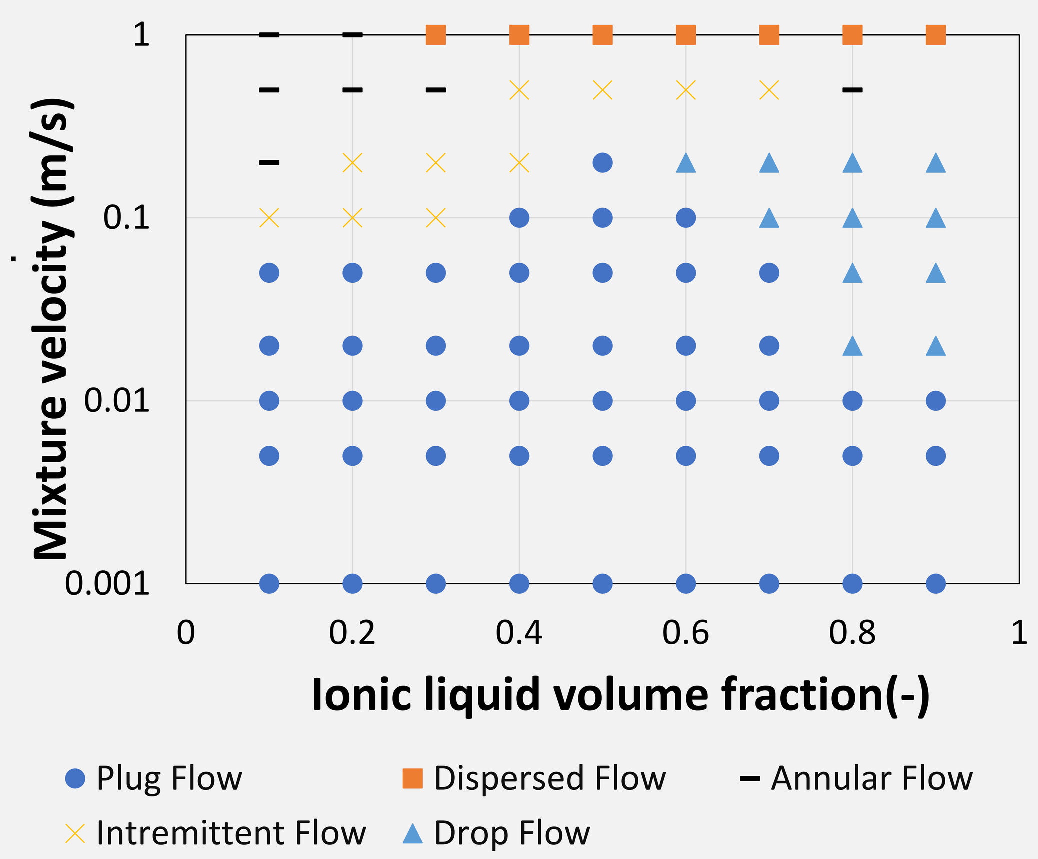
Flow patterns

- Flow patterns produced in microchannels have been directly associated with the transport phenomena observed.
- In microchannels the surface tension is known to be more important than the gravitational force and as a result annular flow patterns are more commonly observed.



Flow patterns observed in a 0.5mm internal diameter channel.

- Flow pattern map produced is used to identify the conditions that each pattern is observed.
- Plug Flow is the most extensively studied regime as it is considered the most efficient for mass transfer.
- Plug Flow allows for large interfacial areas to be available for mass transfer while the flow is easily controllable.

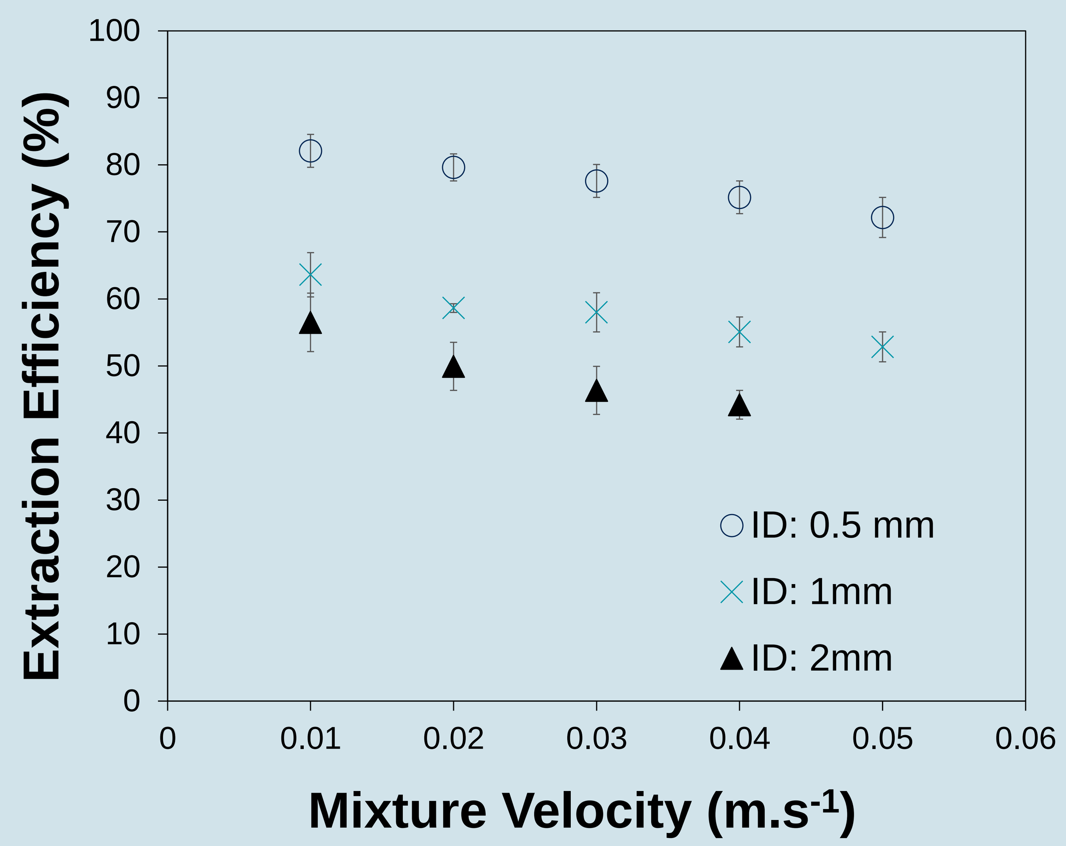


Flow pattern map of 0.5 mm internal diameter channel.

Extraction results

- All extraction experiments were performed in the plug flow regime.
- With decreasing channel diameter interfacial area available for mass transfer increases.
- Circulation within plugs increases with increasing channel diameter.
- As a result, smaller the channel internal diameter the greater the extraction reported.

$$Extraction\ Efficiency\ (\%) = \frac{\text{Actual amount extracted}}{\text{Maximum amount extracted}}$$



Percentage extraction for 0.5,1 and 2 mm internal diameter channels with increasing mixture velocity.

- For a constant channel diameter with increasing mixture velocity the plugs would become shorter.
- Therefore, larger area available for mass transfer with increasing mixture velocity.

Images of plugs with increasing mixture velocity in 0.5 mm channel

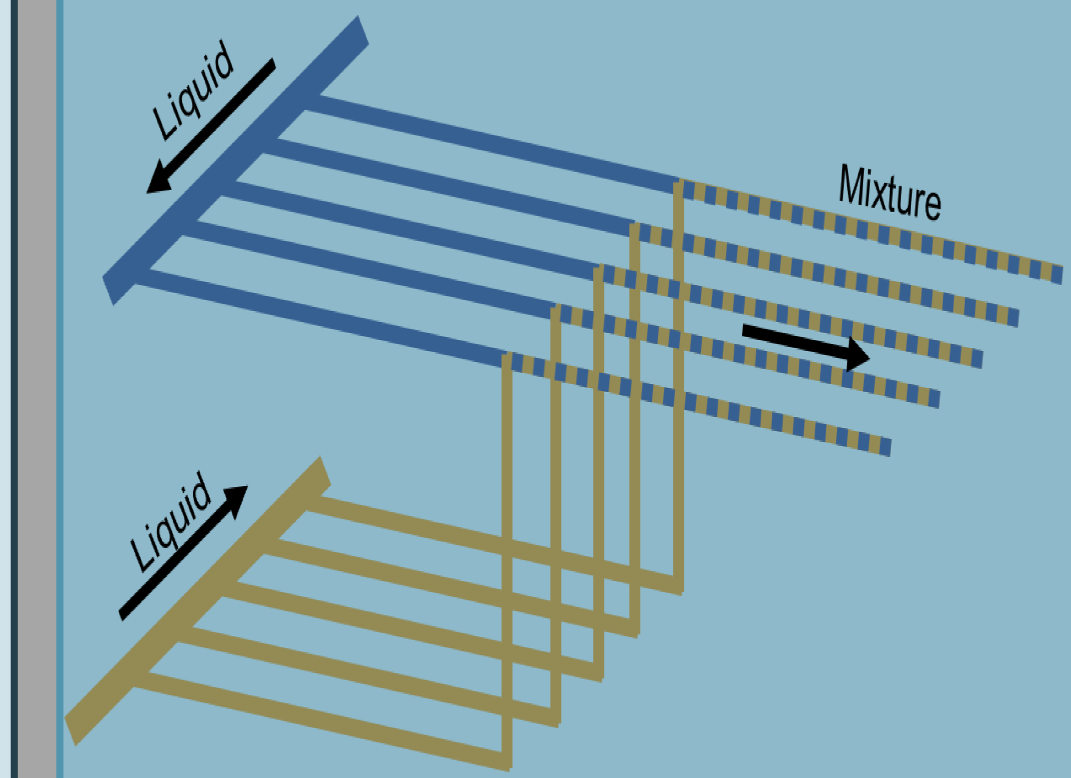
- Plugs are however moving faster therefore residence time is significantly less since channel length was kept constant. This results in the decreasing extraction efficiency with increasing mixture velocity.
- Residence time is nonetheless is only around 15s as oppose to 5- 30 min in conventional systems (e.g mixer-settler).

Conclusions & Future Work

✓Hydrodynamic and extraction experiments performed proved the **advantages of small-scale two-phase** systems

✓**Reported $K_L\alpha$** 1 to 2 orders of magnitude higher than in conventional contactors.

✓Scale- up of system with double manifold model keeping hydrodynamic advantages of small-scale system with higher throughputs.



Scale up for two- phase flow systems. [2]

References

[1] Behme, S. (2015). Manufacturing of pharmaceutical proteins. Weinheim: Wiley-VCH, pp.68-95.

[2] Garciadiego Ortega, E., Tsaoulidis, D. and Angeli, P., 2018. Predictive model for the scale-out of small channel two-phase flow contactors. *Chemical Engineering Journal*, 351, pp.589-602.

[3] Smirnova, S., Torocheshnikova, I., Formanovsky, A. and Pletnev, I. (2004). Solvent extraction of amino acids into a room temperature ionic liquid with dicyclohexano-18-crown-6. Analytical and Bioanalytical Chemistry, 378(5), pp.1369-1375.

[4] Tomé, L., Catambas, V., Teles, A., Freire, M., Marrucho, I. and Coutinho, J. (2010). Tryptophan extraction using hydrophobic ionic liquids. Separation and Purification Technology, 72(2), pp.167-173.

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