Zaiput Flow Technologies

Separation made simple

Multi-Stage Extraction

Solving the most challenging extraction problems

Technical Data

Overview

Multistage Liquid Liquid Extraction (LLE) is a process where extraction steps are repeated in order to increase the recovery of a product. This process is required when, due to a small partition coefficient, the recovery in a single extraction step is insufficient.

In industrial applications, LLE is most often arranged with a countercurrent scheme (CC-LLE) that provides the smallest consumption of solvent. In this scheme the aqueous raffinate from one stage is fed to a former stage as a feed while the organic phase is moved in the opposite direction. Hence, even if the recovery of product in each stage is small, the overall system can achieve a high level of recovery. In other words, *with multistage extraction, selectivity of the extraction and process yield are decoupled* as the yield depends on the number of extraction stages used, thus providing greater freedom to the process developer.

Key Features

- Only existing tool for bench CC-LLE process development
- Minimal internal volume (~3 ml per stage)
- Easy scalable with our larger separators
- Easy to use and clean
- Simple to add/remove extraction stages
- Addresses difficult extractions
- High extraction efficiency

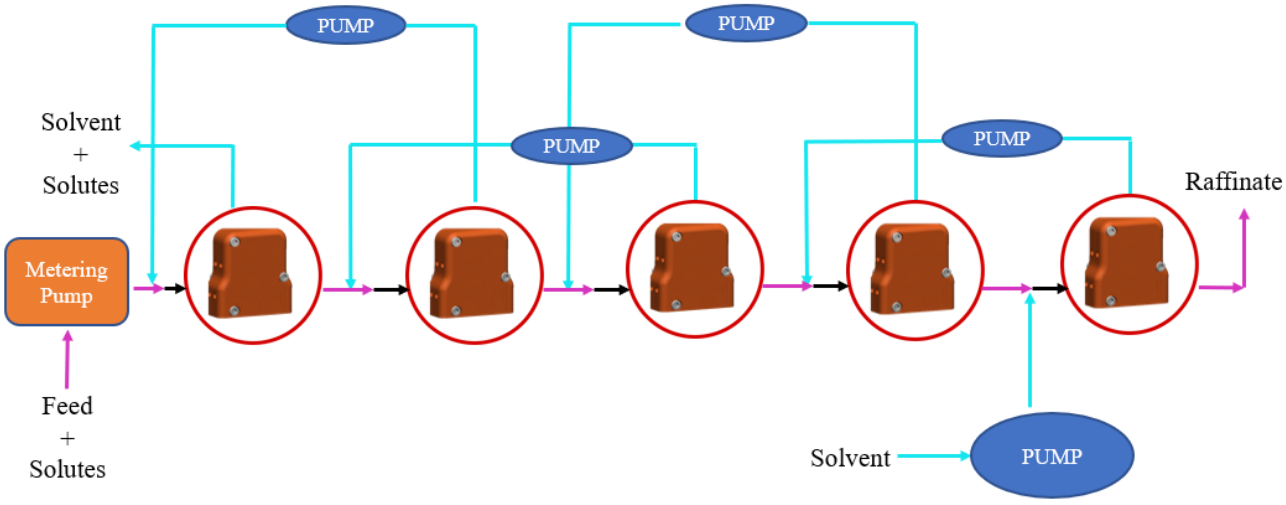


Fig 1—Schematic of the standard system plumbing

Process Description/ Advantages

- Each extraction stage is obtained by first contacting the two phases to achieve mass transfer (which is accomplished inside a length of tube with two phase flow—black lines in fig 1) and then phase separation is obtained with SEP-10 .
- Our process implementation reaches *Theoretical Efficiency*

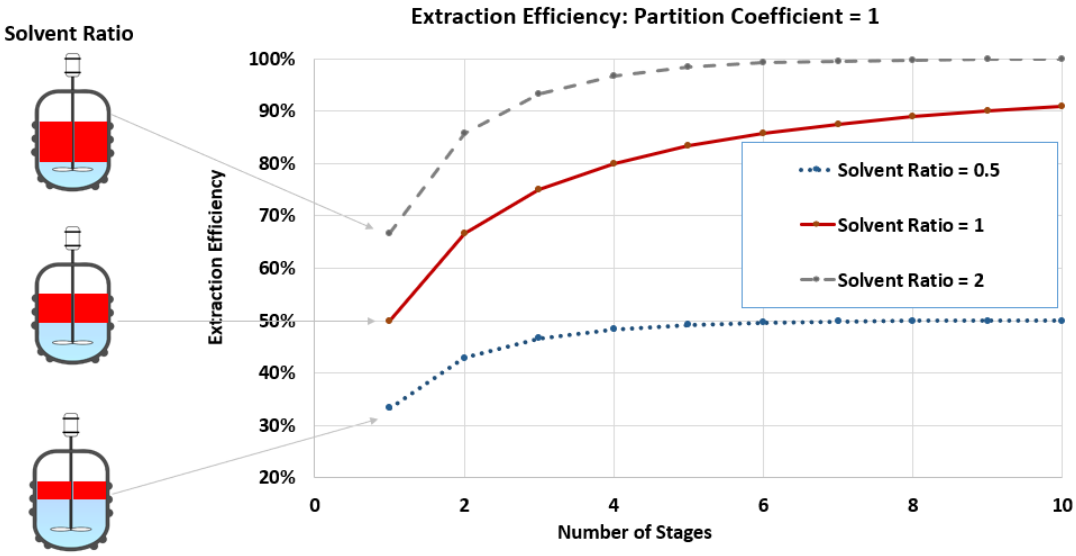
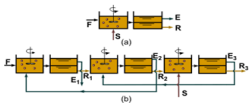
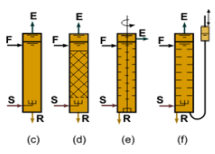
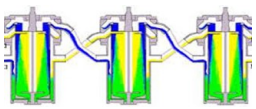


Fig 2—Multistage extraction efficiency

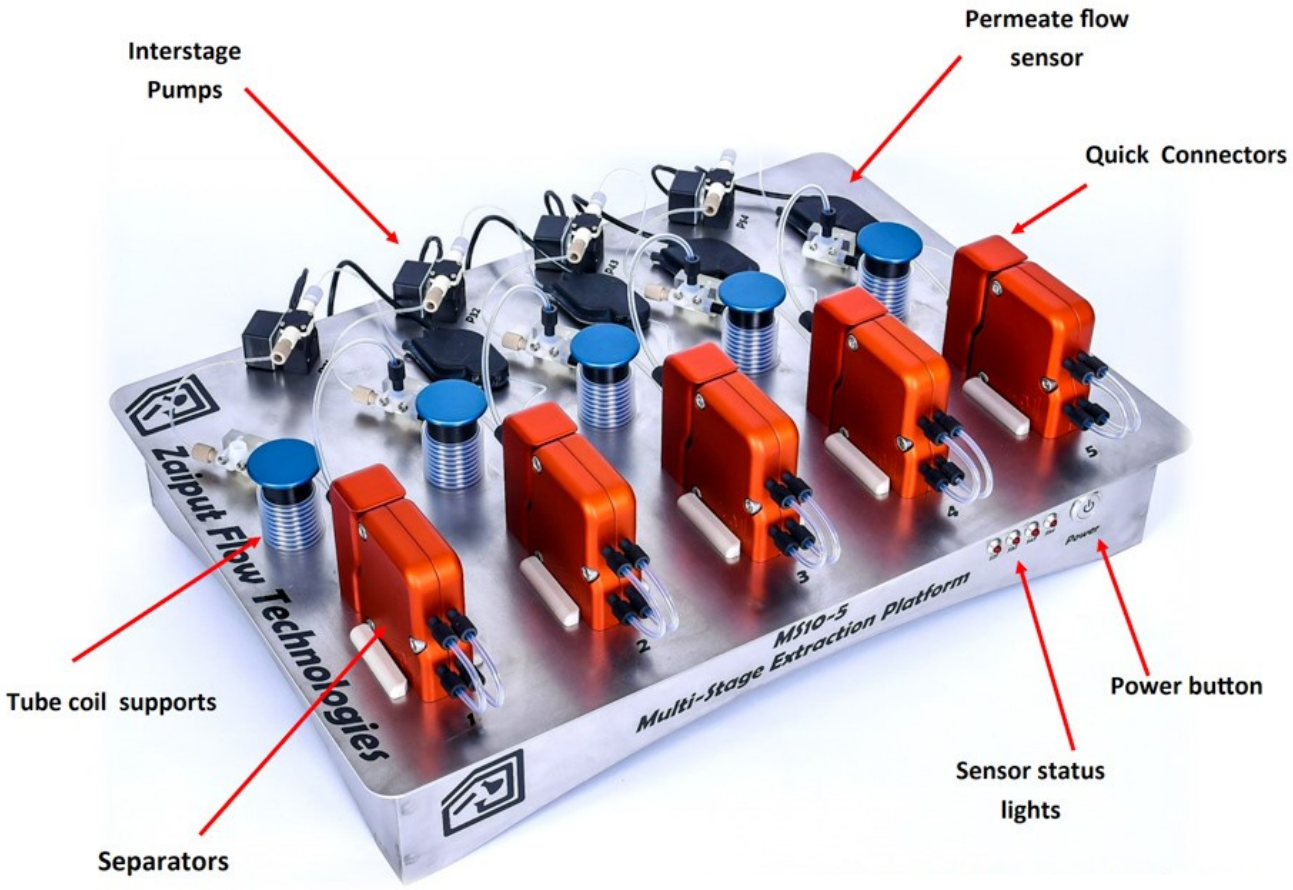
- The power of multistage extraction can be seen in **Fig 2** which shows the extraction efficiency of three different systems with a partition coefficient of 1 (50/50 partitioning of solute).
- As the number of stages increases, extraction efficiency increases, while still using the same amount of material that would be used if only one batch step was performed.
- Zaiput can assist you in modeling your expected extraction efficiency for different scenarios.

This system address **3 key challenges** typically encountered in developing multistage LLE:

- **Lack of Information.** In multicomponent systems, equilibrium data are generally obtained by thermodynamic models (e.g., UNIQUAC, NRTL) but they are often inaccurate due to (1) lack of equilibrium data, (2) unavailable physical property data, especially for unidentified molecular species. As a result, experimental work is needed.
- **Difficult scale up**. Scalability of CC-LLE is challenging with standard equipment (centrifuges, columns, mixer settlers) and requires a lot of time and material for optimization. This platform offers seamless scalability up to production.
- **Lack of material.** Our laboratory platform needs 1 to 2 orders of magnitude less material per experiment than any other method.

	Mixer Settler	Columns	Centrifuges	Zaiput
Technology				
Typical Internal Volume per Stage at Lab scale (ml)	**25-100**	**150**	**100**	**3**

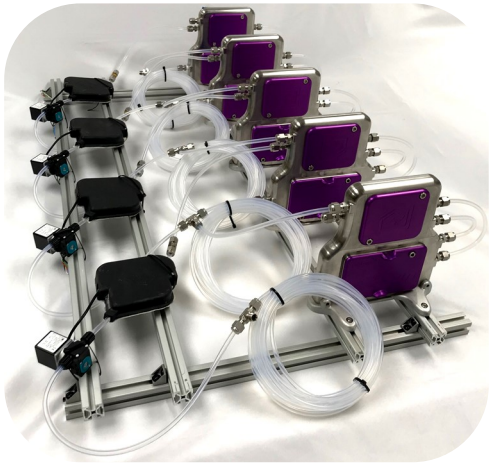
Device Description



Operation requires only **external metering pumps** (not provided) to supply aqueous and organic.

Fig 3—Multistage Liquid-Liquid Extraction Platform

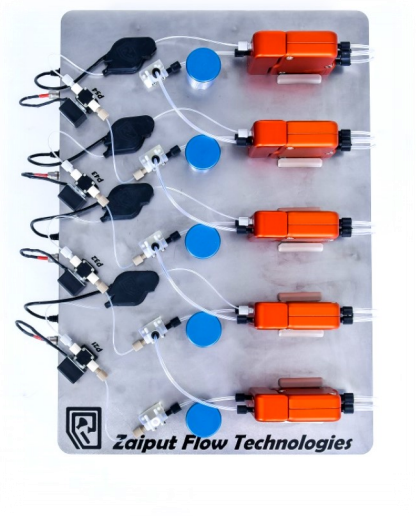
Process Scale Up



- A process that has been optimized at the laboratory/bench scale can be scaled up using our pilot plant units (SEP-200) or production scale unit (SEP-3000).

- Set up for the larger units is typically customized for the specific application/ process developed at the MS-10 scale. Please contact us for assistance.

Ordering Information



Part number	**MS10-5**
Width x Depth x Height	500 mm (19.7 inches) x 400 mm (15.7 inches) x
Total flow rate	0 -10 ml/min
Wetted parts:	
Separators	ETFE, PFA, FEP, PTFE
Tubing/ flow sensors	PFA
Interstage pumps	FFMK, PVDF
Ports	1/4-28 Flat bottom
Max temperature of operation	80°C
Hold-up volume per stage	~3 ml

Contact us if you need more than 5 stages. Platforms can be easily connected together.

Selected Publications

70+ Publications

PNAS MIT Technology Review nature Science

- Weeranoppanant, N., Adamo, A., Saparbaiuly, G., Rose, E., Fleury, C., Schenkel, B., Jensen, K, Design of Multistage Counter-Current Liquid–Liquid Extraction for Small-Scale Applications ***Ind. Eng. Chem. Res.*** Apr 2017.
- Shen, Y, Weeranoppanant, N., Xie, L., Chen, Y, Lusardi M., Imbrogno J., . Bawendi, M., Jensen, K., Multistage extraction platform for highly efficient and fully continuous purification of nanoparticles ***Nanoscale*** Mar 2017.
- Peer, M., Weeranoppanant, N., Adamo, A., Zhang, Y., Jensen, K., Biphasic catalytic hydrogen peroxide oxidation of alcohols in flow: Scale up and extraction ***Org. Process Res. Dev.*** Aug 2016.