Zaiput Flow Technologies

Separation made simple

Liquid-Liquid/Liquid-Gas Separators

Providing in-line separation for batch/flow chemistry

Technical Data

Overview

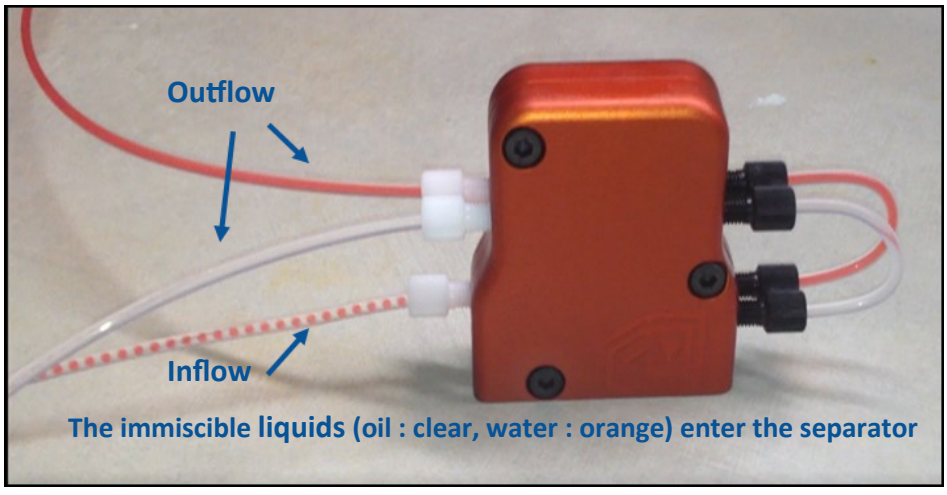
Zaiput Flow Technologies' patented liquid-liquid/liquid-gas separators *enable liquid separation in flow chemistry-based processes* and *provide a solution for challenging batch-based liquid separation steps* (i.e., slow settling time/separation of emulsions, elimination of the need to run batches at half capacity to provide space for subsequent extraction steps).

Zaiput's devices utilize membrane technology to exploit surface tension as a separation driving force. Zaiput's devices contain an innovative mechanical on-board pressure control system to provide plug-and-play functionality. The modularity allows for use in a variety of conditions and scalability ensures seamless process scale up from bench to production.

Zaiput's separators are rated for high pressure use, allowing in-line separation in pressurized flow systems. Finally, Zaiput's devices have broad chemical compatibility, easy maintenance and come at an affordable price.

Key Features

- Continuous operation for batch/flow chemistry
- Separation of emulsions
- Ability to separate liquids with same density
- Plug-and-play functionality
- Easy and direct scale-up
- Minimal internal volume
- Excellent chemical compatibility
- Allow operation under pressure
- Easy usage and maintenance
- No electrical power required



The immiscible liquids (oil : clear, water : orange) enter the separator

Principle

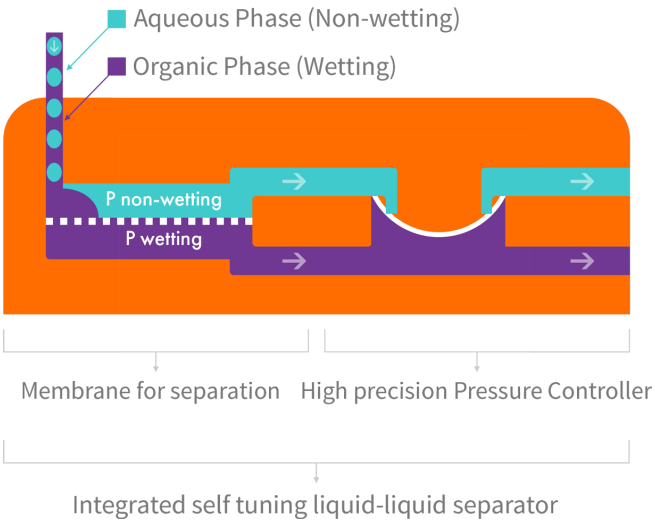


Fig 1—Schematic of the separator

When a hydrophobic membrane is in place, the wetting phase (purple), which in this case is the organic, passes through the membrane (dotted line) while the non-wetting phase (blue), which in this case is the aqueous, is retained.

- Zaiput Flow Technologies' patented separators provide continuous separation of an immiscible phase (liquid-liquid or gas-liquid) by leveraging differences in wetting properties of the liquids onto a porous membrane.
- When a stream composed of two phases, such as an aqueous and an organic liquid or a gas and a liquid, enters the separator, one phase will have an affinity for the membrane and fill the pores ("wetting" phase). The other phase will be repelled and will not fill the pores ("non-wetting" phase).
- Once the membrane pores are filled with the wetting phase, a pressure differential is applied between the two sides of the membrane. This pressure differential is finely adjusted by Zaiput's patented internal pressure controller to apply just enough pressure to "push" through the wetting phase without forcing the non-wetting phase through the pores (**Fig 1**). Because the separator is designed to always maintain a constant pressure differential across the designated flow rates, as a result, the separator can be used as a "plug-and-play " modular unit.

Specifications

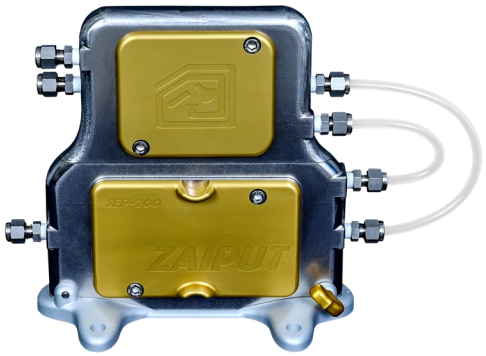
Batch Chemistry - Laboratory Scale

Part Number	**SEP—Lab**
Width x Depth x Height	165 mm (6.5 inch) x 272 mm (10.7 inch) x 127 mm (5inch)
Wetted Parts	Perfluorinated polymers (ETFE, PFA, FEP, PTFE)
Total Flow Rate	~10 ml/min
Max Temperature	130 °C
Internal Volume	~0.5 ml
Maximum Gas Flow Rate	~ 100 sccm

Flow Chemistry - Laboratory Scale

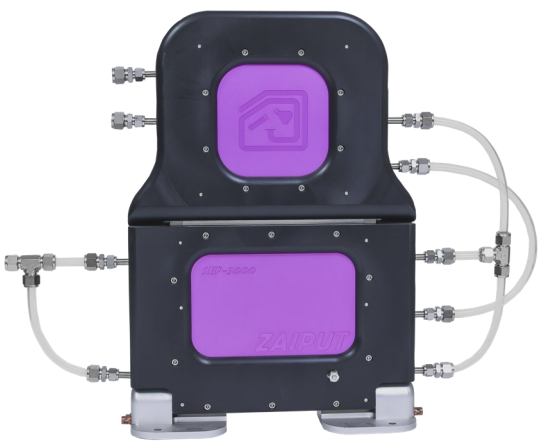
Part Number	SEP—10
Width x Depth x Height	77 mm (3.03 inch) x 29 mm (1.14 inch) x 71 mm (2.79 inch)
Maximum Pressure	2 MPa (290 psi)
Ports	¼ - 28 flat bottom
Wetted Parts	Perfluorinated polymers (ETFE, PFA, FEP, PTFE)
Total Flow Rate	0-10 ml/min
Max Temperature	130 °C
Internal Volume	~0.5 ml
Maximum Gas Flow Rate	~ 500 sccm

Flow Chemistry - Pilot Scale



Part number	SEP—200 (SS/HS/FP)
Width x Depth x Height	206 mm (8.11 inch) x 26 mm (1.02 inch) x 196 mm (7.71 inch)
Maximum Pressure	2 MPa (290 psi)
Ports	Swagelok for ¼'' OD
Wetted Parts	Mod HS: Hastelloy C 276, PTFE, PFA, FFKM Mod SS: SS 316, PTFE, PFA, FFKM Mod FP: ETFE, PTFE, PFA, FFKM
Total Flow Rate	20-200 ml/min
Max Temperature	130 °C
Internal Volume	~35 ml
Maximum Gas Flow Rate	~20,000 sccm

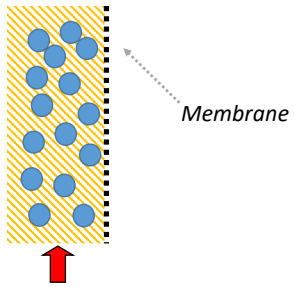
Flow Chemistry - Production Scale



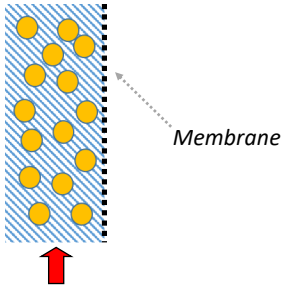
Part number	SEP—3000 (HS/SS)
Width x Depth x Height	460 mm (18.0 inch) x 150 mm (6.0 inch) x 607 mm (23.9 inch)
Maximum Pressure	1 MPa/ 2 MPa (290 psi) with metal external tubes
Ports	Swagelok 1/2'' OD
Wetted Parts	Mod HS: Hastelloy C 276, PTFE, PFA, FFKM Mod SS: SS316, PTFE, PFA, FFKM
Total Flow Rate	200-3000 ml/min
Max Temperature	130 °C
Internal Volume	~350 ml
Maximum Gas Flow Rate	~300,000 sccm

Advantages

Separation of Emulsions



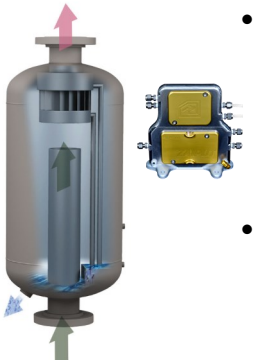
Water in Oil type:
Use **Hydrophobic** membrane
(Get the organic out so water coalesces)



Oil in Water type:
Use **Hydrophilic** membrane
(Get the aqueous out so organic coalesces)

- Emulsions and rag layers typically take long periods of time to gravity separate leading to plant inefficiencies.
- Zaiput's separator allows for easy separation of emulsions by removing the matrix fluid and forcing the emulsion to coalesce.
- Since separation is density independent, even the most challenging emulsions can be separated with ease.

Small Footprint



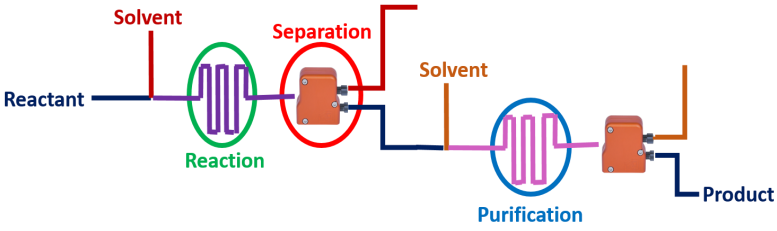
- Zaiput's separators requires a very small footprint compared to traditional batch separation processes since a storage/separatory tank is not required.
- Zaiput's devices can be easily stored on a cart or in a lab chemical hood, and one unit can be used for multiple reactors.

Small Internal Volume

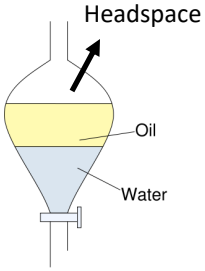
- Zaiput's separators have very low internal volumes, which could potentially reduce waste.
- Process safety is improved, especially when dealing with toxic or explosive substances.

Process Integration

- Zaiput's separators can be easily integrated and used downstream or in-line to separate a biphasic stream.

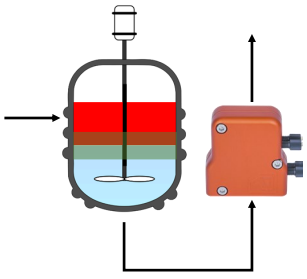


Lack of Headspace



- Zaiput's separators do not have any headspace which is present in separatory funnels or tanks.
- Depending on the chemistry in use, headspace might cause safety concerns. Our separators resolve this issue and simplify air sensitive separations and extractions.

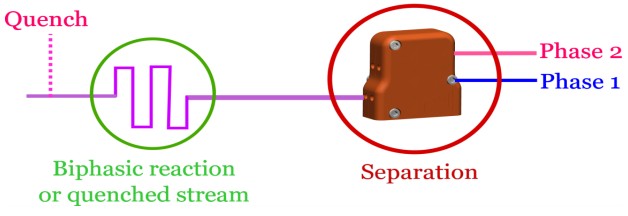
Faster Separations and Better Reactor Availability



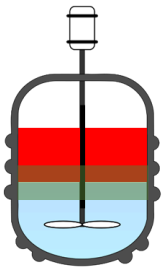
- Zaiput's separators allow continuous separation, which could speed up the overall process.
- The separation can be done faster compared to a typical batch process, and extraction can be done in line, allowing for more available reactor space for reactants, thus increasing output.

Quick Quench and Separation

- Very useful when the reaction stream needs to undergo a rapid quench, due to the presence of an unstable compound.



Key Issues of Current Gravity-Based Batch Processes



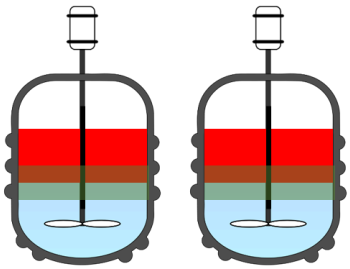
Reactors used at half capacity; "Rag" layer slow to separate

Challenge :

1. When a reaction is followed by an extraction, the batch reactor is used at half capacity.

2. The intermediate layers ("rag layers") determine time/ product losses.

Solution: Zaiput eliminates the need for using reactors at half capacity (see below).

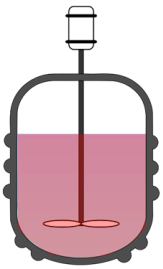


Multiple washes/extractions (2 washes, twice the time)

Challenge :

Multiple extraction/washes require an extensive amount of time as they cannot be done simultaneously.

Solution: With Zaiput, multiple extraction/wash steps can be performed simultaneously (see below).



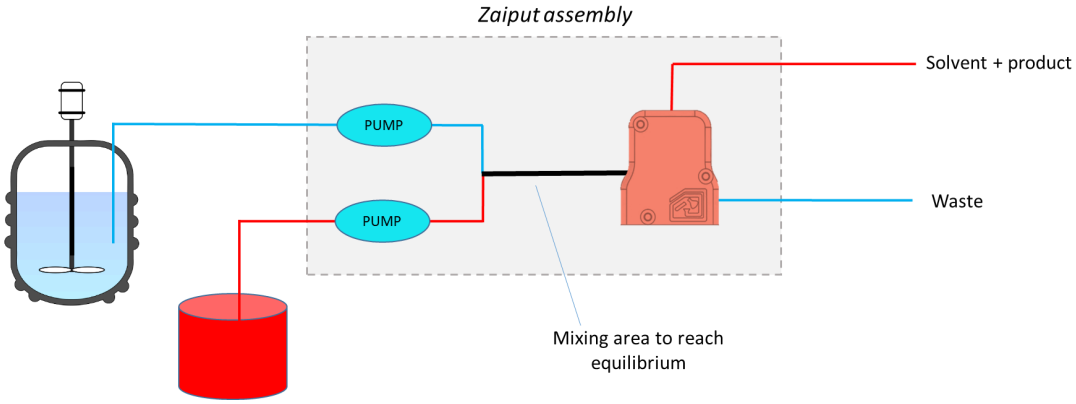
Emulsions

Challenge :

Emulsions take a long time to separate in batch-based processes, resulting in increased cost and process time.

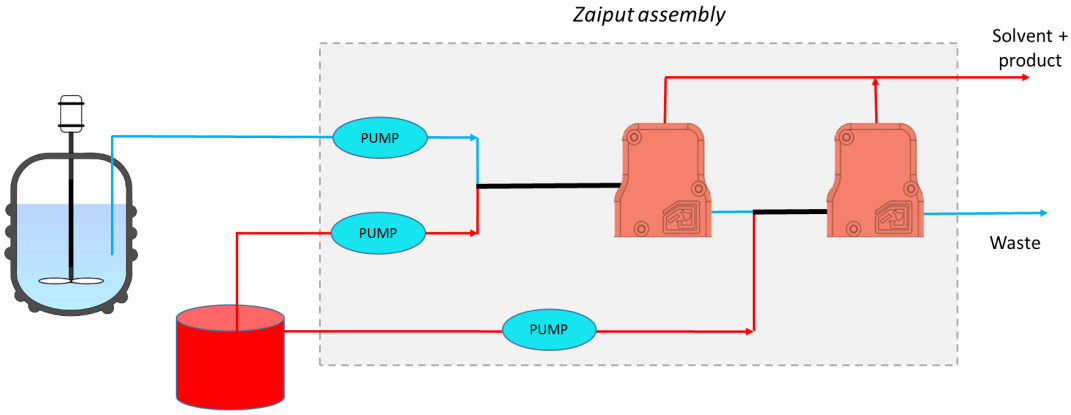
Solution: Zaiput's membrane-based technology readily separates emulsions.

Zaiput eliminates the need for using reactors at half capacity:



- Zaiput's technology can be used to perform an extraction outside of the reactor as liquids are transferred.
- This eliminates the need of running a reaction at half capacity.

Zaiput allows multiple washes in the same amount of time needed for one:

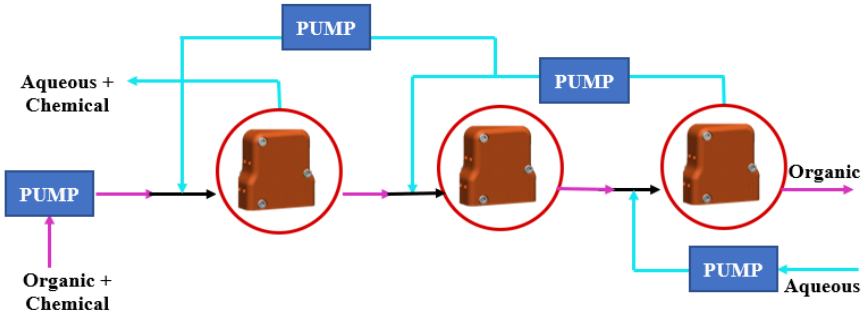


- Zaiput devices can be cascaded in series to achieve multiple washes/extractions at the same time.
- The time needed for one wash is the same as the time needed for many!

Can be arranged in Cross-current or Counter-current

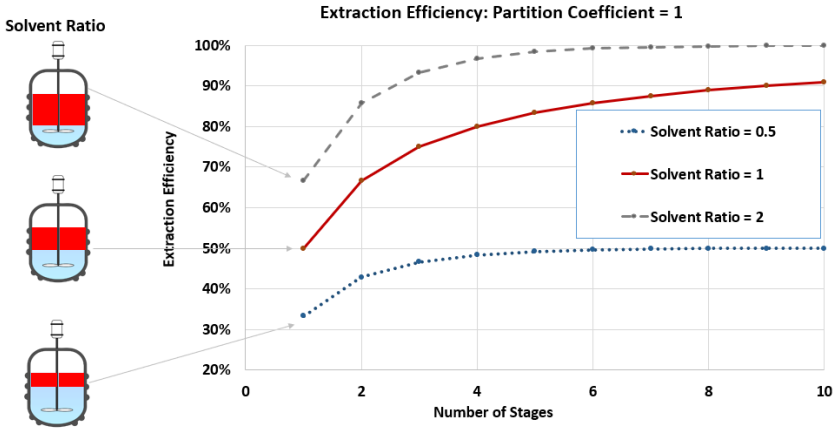
Mixing area to reach equilibrium

Counter-Current Liquid-Liquid Extraction



- Multistage extraction is a process where reaction steps are repeated to increase efficiency.
- The scalability of Zaiput's technology allows seamless processing from the laboratory to the production scale.
- At the laboratory scale we provide an integrated, ready to use platform.

- Zaiput's lab scale multistage platform (MS-10) has 5 stages.
- Scalable: 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).



- The power of multistage extraction can be seen in the chart which shows the extraction efficiency of three different systems with a partition coefficient of 1 (50/50 partitioning of solute).
- Solvent ratios of 2:1, 1:1 and 1:2 relative to the feed are portrayed along with their corresponding batch extraction set ups.
- As the number of stages increases, extraction efficiency increases, while still using the same amount of material that would be used if only one back step was performed.
- Zaiput can assist you in modeling your extraction efficiency for different scenarios.

Selected Publications

70+ Publications

PNAS MIT Technology Review nature Science

- Jamison, T.F et al, 2017. The assembly and use of continuous flow systems for chemical synthesis. ***Nature protocols*, *12*(11), pp.2423-2446**.
- Glotz,G et al , 2017 Integration of Bromine and Cyanogen Bromide Generators for the Continuous-Flow Synthesis of Cyclic Guanidines. ***Angewandte Chemie*, *129*(44), pp.13974-13977**.
- Adamo, A et al. On -demand continuous-flow production of pharmaceuticals in a compact, reconfigurable system. ***Science*, *352*(6281), pp.61-67**.
- See a full list on our Web Site, www.zaiput.com

Ordering Information

Separators

SEP-10
SEP-200-SS (Stainless steel 316)
SEP-200-HS (Hastelloy C276)
SEP-200-FP (Perfluorinated Polymers)
SEP-3000-SS (Stainless steel 316)
SEP-3000-HS (Hastelloy C276)

Membranes

- A variety of membranes both PTFE Hydrophobic and PTFE Hydrophilic are available in different pore sizes to optimize your separation.
- Membranes are low - cost and easy to maintain.

⇒ Membrane Sampler Package : MEM-10 (available on request for larger devices) - 7 packs of 10 membranes

⇒ Quick Start Package option : START-10 (membrane samples MEM-10 + replacement diaphragm)

⇒ Specific membrane ordering info:

XX-XXX - S XX e.g., - OB-100 - S 10
IL 400 - S 200

Wetting Phase (OB/IL)

- OB = Hydrophobic
- IL = Hydrophilic

Pore Size Selection

- 100 Very Small (OB)
- 200 Very Small (IL)
- 400 Small (OB/IL)
- 900 Medium (OB/IL)
- 2000 Large (OB/IL)

Instrument

- 10 = SEP-10
- 200 = SEP-200
- 3000 = SEP-3000

Contact us for the latest membrane offering

Contact

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- **Zaiput Flow Technologies**, an MIT spin-out, is focused on bringing innovative separation technology and related tools to market.
- We are looking forward to assist you with your questions, support needs, or to discuss your application.