Zaiput Flow Technologies

Membranes for Liquid-Liquid Separators

Providing in-line liquid-liquid separation for flow chemistry

Selection Guide

A variety of membranes for your Zaiput separator are available to optimize separation performance and throughput. Membranes are available in both hydrophobic and hydrophilic, they are low cost and easy to replace.

Membrane selection process

The key parameters for identifying a suitable membrane for separation are the interfacial tension between the two phases and the viscosity of the permeating phase (this has an effect on throughput of the device).

In general, the lower the interfacial tension, the smaller the pore size needs to be. However, smaller pore size reduces the maximum viscosity that can be accommodated by the membrane.

For general applications, we recommend to use a hydrophobic membrane and to follow these 3 steps:

1. **Identify your mixture's interfacial tension.** Interfacial tension data for a variety of solvent systems is available at the end of this document, in literature or can be searched for online. For complex mixtures, an initial approximation can be obtained by looking at the interfacial tension between the largest component of your system. Please note that salts give a modest increase of the interfacial tension and solvents miscible in both aqueous or organic will decrease it. Often a good estimate is enough, a more accurate value is helpful when dealing with low interfacial tension systems (<5 mN/m).
2. **Know the viscosity of the permeating phase.** Usually an estimate of the viscosity of your permeating phase (organic for a hydrophobic membrane) is enough. Data can be found in literature, on our website or on the web. A more accurate value can be helpful for detailed assessment of maximum device throughput at production scale.
3. **Locate the values on the graph.** Figure 1 is a plot of the organic's viscosity (permeating phase) vs. interfacial tension with the aqueous. The colored regions indicate what membrane is suitable in each range of the parameters (Fig.2 shows details of Fig 1 for low values of viscosity). Use the values of viscosity and interfacial tensions of your systems to identify the adequate membrane for your case. If your system falls near the boundary of a colored area, selecting the smaller pore size membrane may save some trial time.

⇒ ***90% of separation will be successfully carried out with the OB-900 (medium) membrane that is installed on your device at the time of assembly.***

⇒ ***Larger pore sizes (OB-2400) are meant to be used for more viscous organics (light oils, essential oils, etc) or to increase device throughput for production needs.***

Selecting a Hydrophobic Membrane

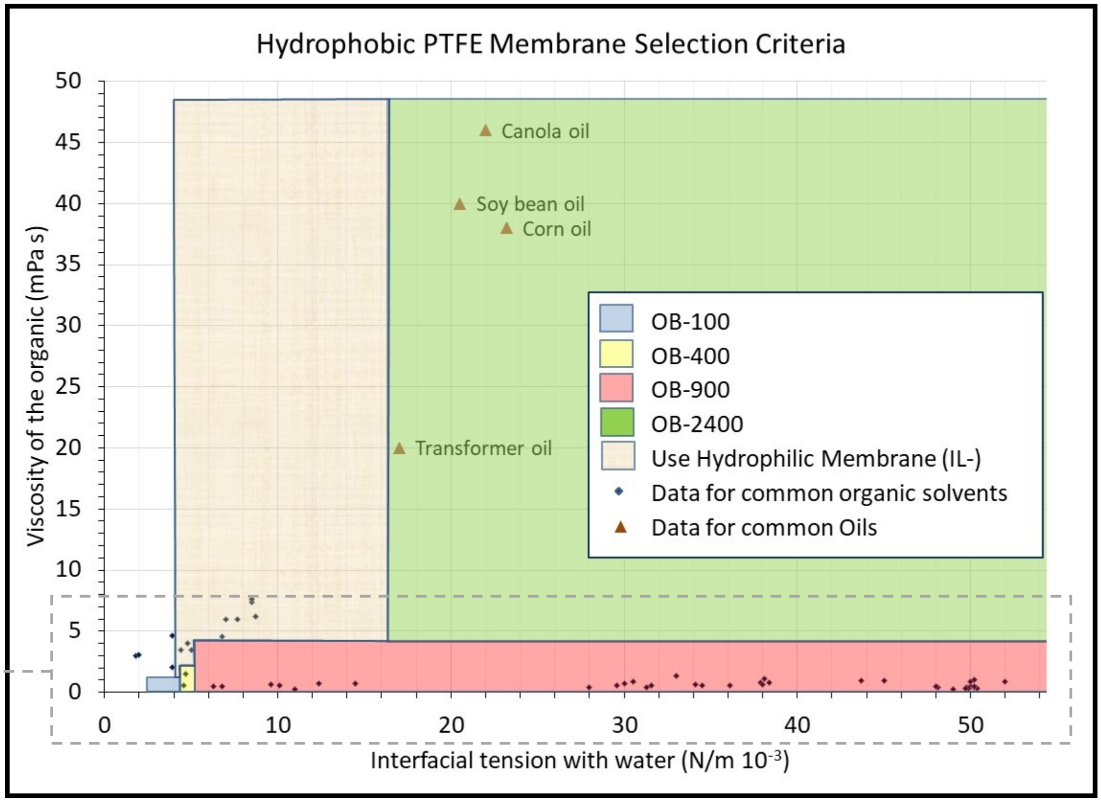


Fig 1—Membrane selection chart. *Locate your liquid-liquid system on the chart to find out the recommended membrane pore size. Dots represent values of viscosity, interfacial tension with water of common solvents used in organic chemistry.*

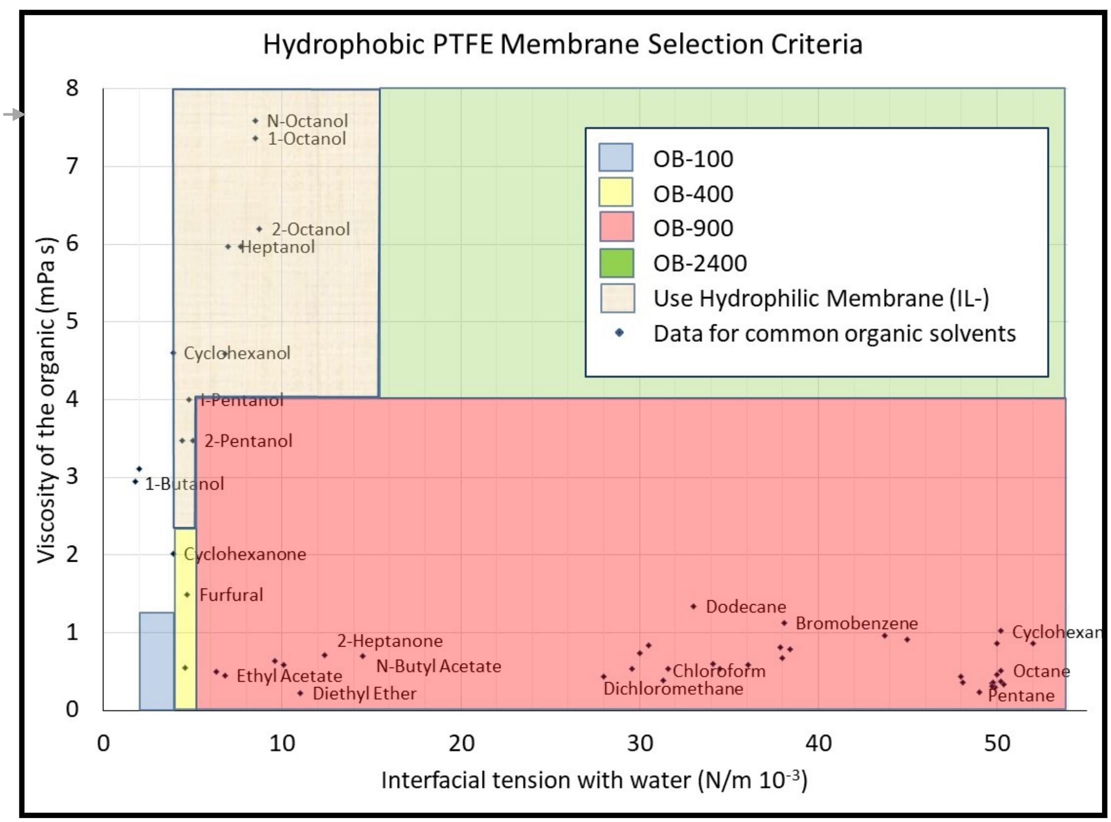


Fig 2—Membrane selection chart, expanded view of low viscosity values of box in Fig 1.

Selecting a Hydrophilic Membrane

Hydrophilic membranes are recommended in the following cases:

- Emulsion with aqueous as dispersing medium (see next page)
- Gas– aqueous separation. Best results are obtained when the aqueous is the permeating phase and gas retained.
- High viscosity organic with low interfacial tension. In this case the small pore size hydrophobic membrane may not be able to accommodate the flow of a viscous organic; if the aqueous has low viscosity the removal of the aqueous can address this type of separation.

For selection of a hydrophilic membrane, the steps are the same as described for hydrophobic except Figure. 3 should be used instead.

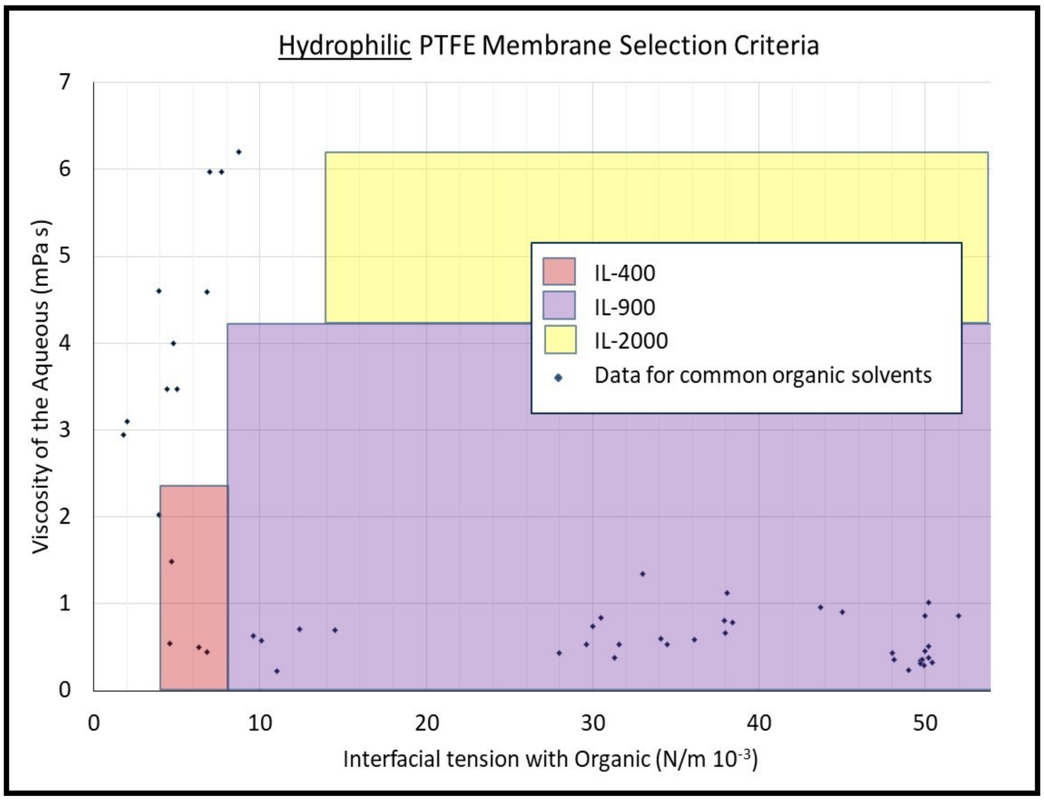


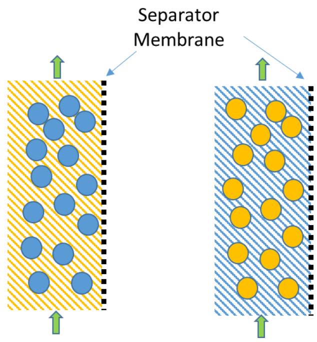
Fig 3—Hydrophilic membrane selection chart. *Locate your liquid-liquid system on the chart to find out the recommended membrane pore size. Dots represent values of viscosity, interfacial tension with water of common solvents used in organic chemistry.*

Membrane Lifetime

Membranes are sturdy and usually do not tear. Over time they may foul if the permeating liquid carries particulates; this typically results in some loss of permeating area and hence some retention is observed where normally a complete separation can be obtained ("retention" means that permeating phase is found – *retained*- with the non permeating phase).

While exact membrane lifetime may change drastically depending on conditions of use, we have experienced that in pharmaceutical applications a membrane's lifetime is typically from a few days to a couple of weeks.

Separation of Emulsions



Water in Oil : **Hydrophobic** membrane

Oil in Water: **Hydrophilic** membrane

Emulsions are typically separated very well with our devices. Best performance is achieved when the wetting phase is the dispersing medium of the emulsions.

In other words, emulsions can be of two main types: :

- "*oil in water*", separated best with a hydrophilic membrane
- "*water in oil*", separated best with a hydrophobic membrane

The general idea is to remove the dispersing medium to foster coalescence of the dispersed one. Contact us for more information.

Specific Membrane Ordering Information

Membrane Part Number is structured in the following way:

XX-XXX - S XX

e.g. - OB-100-S10
IL -400-S200

Wetting Phase (OB/IL)

- OB = Hydrophobic
- IL = Hydrophilic

Pore Size Selection

- 100 Very Small (OB)
- 400 Small (OB/IL)
- 900 Medium (OB/IL)
- 2000 Large (IL)
- 2400 Large (OB)

Instrument

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

⇒ **Membrane Sampler Package : M-SAMPLER-S10 (available on request for larger devices)**

Zaiput Flow Technologies, an MIT spin-out, is focused on bringing innovative separation technology and related tools to market.

Interfacial Tension Chart

Liquid-Liquid Separators

Phase 1	Phase 2	Interfacial Tension (dync/cm or mN/m)
Water	n-Butanol	1.8
Water	i-Butanol	2
Water	Cyclohexanol	3.9
Water	n-Pentanol	4.4
Tetradecane	Methanol	4.6
Water	Furfural	4.7
Water	i-Pentanol	4.8
Perfluorohexane	Benzene	5.8
Tetradecane	Perfluorohexane	6.1
Water	2-Pentanone	6.3
Water	n-Hexanol	6.8
Water	Ethyl Acetate	6.8
Water	n-Heptanol	7.7
Water	n-Octanol	8.5
Water	Nitromethane	9.5
Water	2-Hexanone	9.6
Perfluorohexane	Carbon Disulfide	9.6
Water	Methyl Isobutyl Ketone	10.1
Water	Diethyl Ether	11
Water	2-Heptanone	12.4
Water	n-Butyl Acetate	14.5
Water	Diisopropyl Ether	17.9
Water	Dichloromethane	28
Water	1,1,2 - Trichloroethane	29.6
Water	Bromoethane	31.3
Water	Chloroform	31.6
Water	Benzene	34.1
Water	Toluene	36.1
Water	Xylene	37.2
Water	m-Xylene	37.9
Water	Bromobenzene	38.1
Water	Ethyl Benzene	38.4
Water	n-Butyl Benzene	41.4
Water	Tetrachloromethane	43.7
Water	Carbon Disulfide	48.1
Water	i-Hexane	48.9
Water	Pentane	49
Water	Hexane	49.7
Water	2,2 - Dimethyl Butane	49.7
Water	2,3 - Dimethyl Butane	49.8
Water	3 - Methyl Pentane	49.9
Water	2,2,4 - Trimethyl Pentane	50
Water	2,4 - Dimethyl Pentane	50
Water	i-Pentane	50.1
Water	Heptane	50.2
Water	Octane	50.2
Water	Cyclohexane	50.2
Water	3-Methyl Hexane	50.4
Water	n-Decane	52
Water	n-Dodecane	52.8
Water	n-Hexadecane	53.3

A broader set of interfacial tension data is available on our website