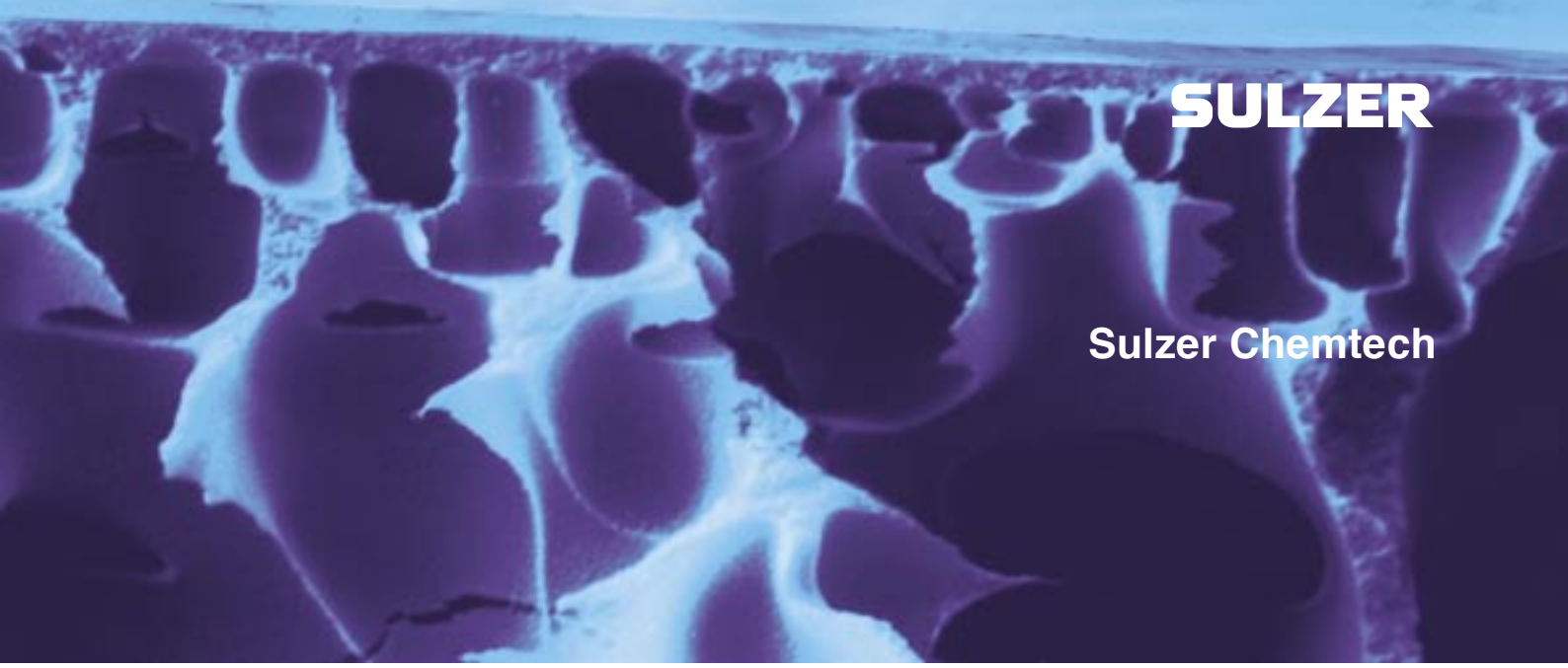


SULZER

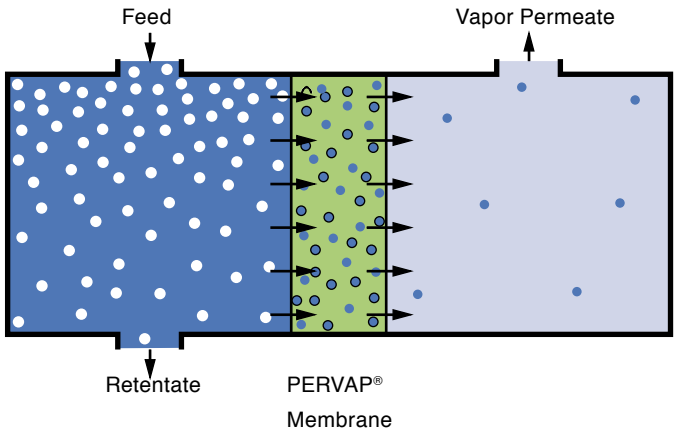
Sulzer Chemtech

Pervaporation and Vapor Permeation Technology

Removal of Water and Methanol from Organic Solvents

Pervaporation and Vapor Permeation Processes and Systems

Pervaporation is a membrane process for separating mixtures of volatile components. It enables solvents to be dehydrated without using any third substance or entrainer. Azeotropes can be dehydrated simply, cheaply and without problems irrespective of vapor-liquid equilibria. Similar to water, methanol can be removed out of organic solvents.



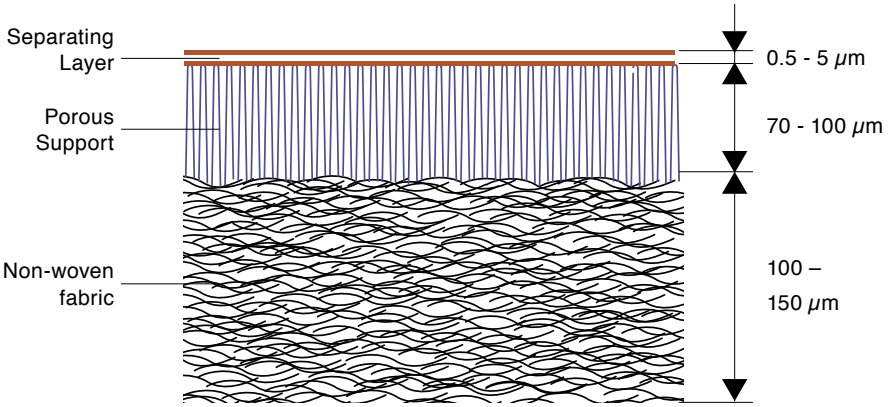
Pervaporation features:

- tailored non-porous membranes which selectively absorb and permeate one or more components
- driving force from vacuum applied to back side of the membranes, allowing almost complete removal of the permeating component
- permeating component leaves membrane as a vapor
- separation predominantly by polarity difference - polar compounds permeate faster through hydrophilic membranes
- feed can be liquid (pervaporation) or saturated vapor (vapor permeation)

PERVAP® Composite Membranes

Sulzer Chemtech fabricates a wide range of composite polymer membranes allowing the selection of the appropriate membrane depending on the solvent mixture and the water content to be treated. In harsh environments, more robust membranes are required and because permeate flux is lower, more surface is needed. Correct membrane selection is important since it impacts both the cost of the installation and the membrane lifetime. Tests can be performed to select the ideal membrane.

Pervaporation Bench System



Membranes for the Removal of Water and Methanol from Organics

The PERVAP® composite membranes use an active PVA separating layer, preferentially permeating the water.
The crosslinking of this layer determines the behavior of the membrane regarding permeate flux, selectivity and chemical resistance.
Less crosslinked membranes are used to separate methanol from other organics.

PERVAP® Plate modules

PERVAP® polymer composite membranes are installed in standard plate and frame modules housed in vacuum vessels. They are designed for high temperature processing of volatile organics such as alcohols and other solvents used.

Reliability:

Total solvent compatibility as no adhesives and elastomeric gaskets are used.

Safety:

Process fluids are securely isolated from personnel and the environment by the vacuum vessel - plate gaskets are used only to direct flow inside modules.

Universality:

Supply of spares and replacement is simple and quick because of the use of standard modules.

Plate and frame industrial and pilot scale module

Scope of supply

Sulzer Chemtech can design and supply complete separation systems based on pervaporation/ vapor permeation with or without distillation steps. These systems feature problem-free separation of water/methanol from organic mixtures irrespective of azeotrope formation, avoiding e.g. liquid/liquid extraction or water wash with high energy requiring purification steps. Sulzer Chemtech supplies completely preassembled units as well as (basic) engineering with components.

Multipurpose Batch Pervaporation Unit BP 802

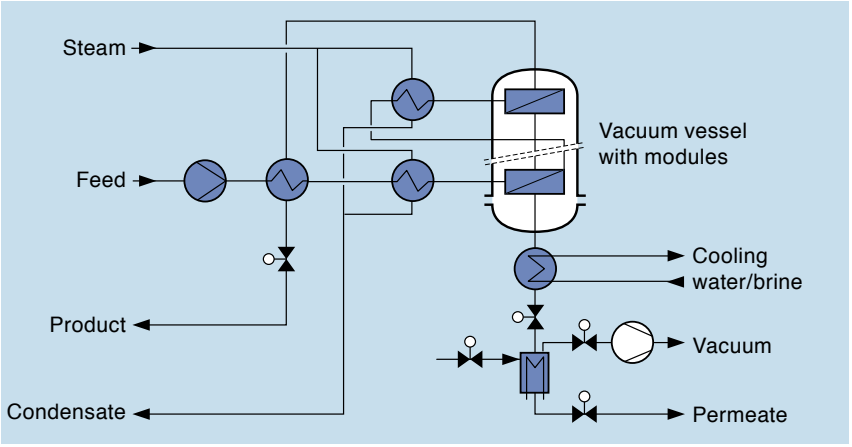
Sulzer Chemtech‘s pervaporation system features

- no introduction of additional chemicals - complete solvent dehydration by pervaporation membranes irrespective of azeotrope formation - no possibility of contamination
- a flexible process - a single unit can be designed to treat a large number of solvents
- a choice of batch or continuous pervaporation systems, or vapour permeation depending on the duty
- experience with a wide range of common solvents
- able to dehydrate esters without any decomposition
- vapor permeation process
  - combined with evaporation to recover solvents from mother liquors
  - combined with distillation to reduce capital costs and energy consumption
- both on and off-site piloting available
- standard skid mounted units for fast delivery and installation and minimum hook-up time
- very short payback time

PERVAP® Skid-Built Plants – Three Model Ranges

Continuous Pervaporation – Series PV
Batch Pervaporation – Series BP

PERVAP® pervaporation units are used for continuous or batchwise, efficient drying of a wide range of liquid organics.
Standard units are available at pressure ratings up to 12 bar and temperatures to 120°C, allowing economic dehydration down to ppm water levels.



PV Process Features:

- for continuous processing of solids-free feeds
- most economical process option for feeds with low water content

BP Process Features:

- simple equipment
- very flexible in operation
- ideal for multi-purpose plants, e.g. toll recycling

Pervaporation Unit BP 201 for THF dehydration

Take advantage of the cost savings of standardized skid-built units – customized with optional features

Standard skid-built units, complete and ready-to-run with exchangers, pumps, valves, instrumentation, controls, piping, wiring, control panel/junction boxes and insulation. Well developed designs allow ample access for equipment maintenance.

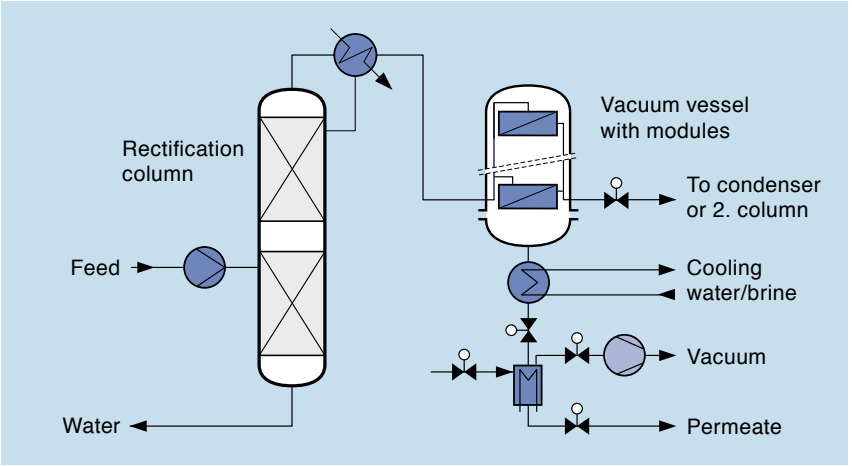
Vapor Permeation – Series VP

These units usually include a dedicated evaporator. However they can be directly fed with the net overhead or a vapor sidedraw from a rectification column. No extra energy is required to drive the process, but the column should be pressurized so as to provide vapor feed with 95-120 °C.

Vapor Permeation Unit VP 401 to remove methanol from methylester

VP Process Features:

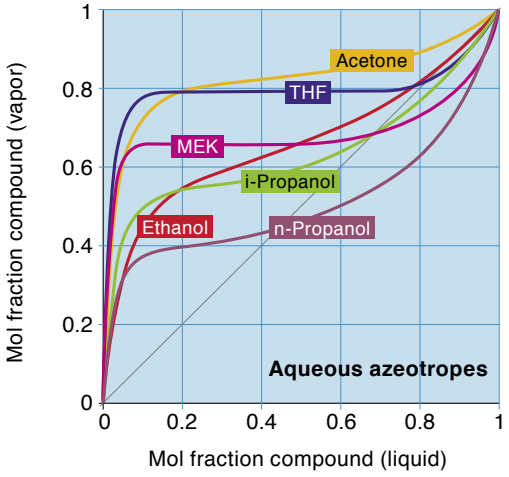
- simple process and equipment
- recommended for continuous removal of higher water/ methanol amounts
- preferred when dissolved or suspended solids are present in the feed – solids are removed by a periodic or continuous purge
- minimal energy consumption if the feed is taken directly from a rectification column



Applications of pervaporation and vapor permeation

Separation of aqueous/organic mixtures and azeotropes

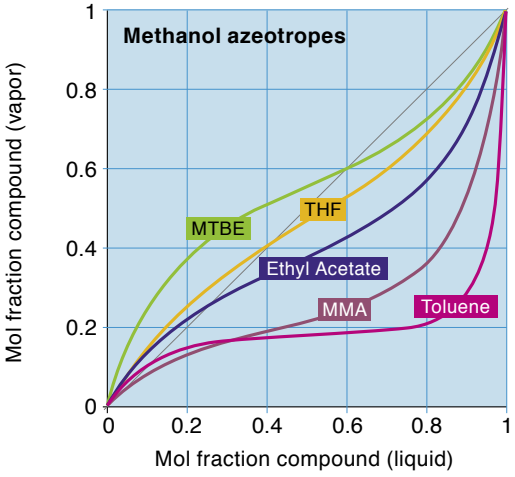
Because the pervaporation process does not depend on phase equilibria, it is well suited to separate azeotropic mixtures. A large number of alcohols, esters, ethers and other volatile compounds form azeotropes with water and/or methanol.



Azeotropes with water

Debottlenecking Distillation Systems

Distillation processes are driven by volatility differences. If these volatility differences are small, or become small under certain conditions, then columns need to operate with high reflux to achieve the desired separation.
Pervaporation/vapor permeation processes can be used very effectively to debottleneck distillation columns.



Azeotropes with methanol

Products Separated or Purified by Pervaporation

Alcohols	
Methanol	CH_4O
Ethanol	C_2H_6O
Propanol (both Isomers)	C_3H_8O
Butanol (all Isomers)	$C_4H_{10}O$
Pentanol (all Isomers)	$C_5H_{12}O$
Cyclohexanol	$C_6H_{12}O$
Benzyl alcohol	C_7H_8O

Ketones	
Acetone	C_3H_6O
Butanone (MEK)	C_4H_8O
Methyl isobutyl ketone (MIBK)	$C_3H_{12}O$

and under certain conditions:

Aromatics	
Benzene	C_6H_6
Toluene	C_7H_8
Ethyl benzene	C_8H_{10}
Styrene	C_8H_8
Xylene	C_8H_{10}

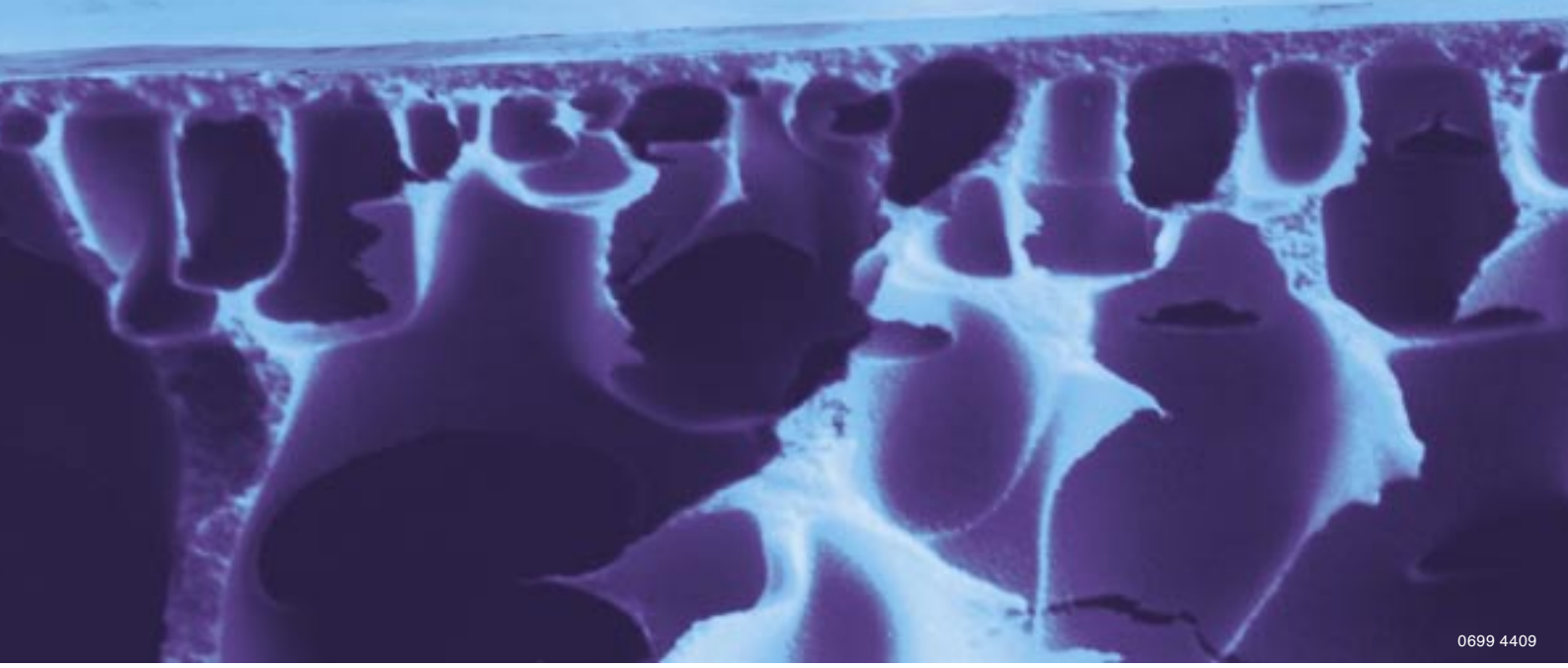
Esters	
Methyl acetate (MeAc)	$C_3H_6O_2$
Ethyl acetate (EtAc)	$C_4H_8O_2$
Butyl acetate (BuAc)	$C_6H_{12}O_2$

Ethers	
Methyl tert-butyl ether (MTBE)	$C_5H_{12}O$
Ethyl tert-butyl ether (ETBE)	$C_6H_{14}O$
Di-isopropyl ether (DIPE)	$C_6H_{14}O$
Tetrahydrofuran (THF)	C_4H_8O
Dioxane	$C_4H_8O_2$

Aliphatics	From C_3 to C_8

Chlorinated hydrocarbons	
Dichloro methane	CH_2Cl_2
Chloroform	$CHCl_3$
Trichloro ethane	$C_2H_3Cl_3$
1,1,1,1-Perchloroethylene	C_2Cl_4

We invite you to consult us with your separation problem. We have units running satisfactorily for a wide range of applications. If we have no experience with your feed we can perform tests to select the ideal membrane. Because we fabricate our own membranes, we can, if necessary, tailor membrane characteristics to your environment.



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Sulzer Chemtech Ltd, a member of the Sulzer Corporation, with headquarters in Winterthur, Switzerland, is active in the field of process engineering and employs some 1200 persons worldwide.

Sulzer Chemtech is represented in all important industrial countries and sets standards in the field of mass transfer with its advanced and economical solutions.

The activity program comprises:

- Process components such as packings, trays and internals for separation and reaction technology
- Systems and plants in the field of distillation, absorption, desorption and extraction
- Engineering services for separation and reaction technology such as optimizing energy consumption, plant optimization studies, pre-engineering for governmental approval, basic engineering
- Processes and plants for the separation and purification of chemicals by means of fractional crystallization and pervaporation
- Mixing and reaction technology with static mixers
- Catalyst supports and systems for many applications

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