CONTENT

3 Foreword

4 Adding value with gentle molecular separation
   Our products

6 Where can PuraMem® membranes be used?
   Bulk-, Oil- and Petro Chemistry
   Natural and essential oil and products
   Fine Chemistry and Pharmaceutical Industry

10 How do PuraMem® membranes work?

11 From testing to piloting to industrial implementation
As a global innovation leader in membrane-based separation technology we boost the chemistry of high-performance polymers into highly efficient membranes for gas separation, organic solvent nanofiltration and for separation of volatile organic compounds.

With our PuraMem® high performance polymer membranes we offer high performance solutions for chemical production processes with measurable energy and mass efficiency. These nanofiltration membranes provide efficient separations at near-ambient temperatures without the need for a phase change of the liquid feed.
Until recently, molecular separations using membrane technology were almost exclusively based on aqueous systems. Nanofiltration was initially developed for water treatment and softening and its applications have broadened into sectors such as the food industry (milk and juice production) and fermentation processes (e.g. pharmaceutical production).

With the development of solvent-stable membranes, the application fields for nanofiltration are being extended to the full spectrum of chemical process industries, e.g. Oil-and Petro Industry, Fine Chemicals and Flavour & Fragrance. The breakthrough in OSN technology with the commercialisation of the PuraMem® range of membranes has opened up possibilities for applications in a variety of non-polar or slightly polar organic solvents. Highly selective membranes operating at room temperature and carrying out gentle molecular separation are the key features that reduce process costs and increase its efficiency!

Evonik provides OSN membrane products with performance characteristics targeting the needs of the chemical process industries for separation-, purification-, recovery- or concentration-based applications.

PuraMem® membranes are solvent-stable and are compatible and designed for use with nonpolar and slightly polar solvents, e.g. aromatic hydrocarbons, aliphatic hydrocarbons, long chain aldehydes and alcohols, THF and ethyl acetate*.

* More details can be found on our membrane datasheets.
PuraMem® membranes (PM) are targeted at applications in non-polar solvents.

**Products**
- PM Selective
- PM Performance
- PM Flux

**Usable in**
- toluene
- heptane
- hexane
- methyletherketone
- high boilers and more

**Your benefits**
- Reduced operating costs
- Reduced processing time
- Environmentally friendly processing
- Increased product value
WHERE CAN PURAMEM® MEMBRANES BE USED?

Evonik OSN membranes can be used in the following industries and applications:

1. Bulk, Oil- and Petro Chemistry
   - Homogeneous catalyst recovery
   - Decolorization and polishing of products
   - Dewaxing
   - Additive removal from light hydrocarbons

2. Natural and essential oil and products
   - Fractionation of crude extracts
   - Enrichment of natural compounds
   - Natural oils processing (dewaxing and enrichment)
   - Gentle separation

3. Fine Chemistry and Pharmaceutical Industry
   - Gentle API concentration and purification
   - Non-thermal solvent recovery and management
   - Room temperature solvent exchange
Homogeneous catalyst recovery

Homogeneous catalysts are very efficient but expensive materials that are difficult to separate in an active form with conventional separation technology. They are generally large molecules that are well retained by OSN membranes. This allows them to be recovered and re-used in a production process.

Decolorization and polishing of products

In many cases, the output of a chemical reaction is not the product in pure form. There is a variety of unwanted compounds present that originate from side reactions or post-reaction processing steps. These unwanted compounds lower the quality of the final product (undesired color, composition, density, melting and boiling point etc.) and have to be removed. When the MW of product and impurities differs an OSN membrane can be successfully applied for the product purification.

Dewaxing

Lube oil dewaxing is an energy-intensive operation within an oil refinery involving the evaporation and condensation of large volumes of solvent. OSN membranes can be applied to reduce the energy consumption in this process.

Additive removal from light hydrocarbons

Large molecules (e.g. additives) are commonly used in processing light hydrocarbons. The large difference in molecular weight between the additive and the hydrocarbon makes the removal of the additive possible with PuraMem® series membranes. This is a low-energy approach to additive removal.
Components derived from natural extracts (from fruit, vegetables, nuts, seeds, herbs) are used in a variety of different industries, e.g. pharmaceutical, nutraceutical, flavor & fragrance, etc. due to their inherent properties and chemical diversity. Their use as a crude extract, however, is often not practical and the molecules of interest constitute only a small part of the extract. The use of Evonik’s different OSN membranes enables fractionation of the crude extracts according to solubility or MW of the molecules in (different) solvents and mixtures.

Valuable compounds are often present in low concentration in the natural matter or extract. With the help of PuraMem® OSN membranes the target molecules can be enriched by separation from the extract or extraction solvent.

Natural oils are widely used as additives in the food, beverage and cosmetic industries. They enrich the taste, flavor or fragrance of products. Their ingredients, however, should not affect the appearance and quality of the final goods. Unwanted compounds (e.g. waxes in citrus oils) can be removed with Evonik’s OSN membranes replacing conventional high-energy consuming technologies (e.g. crystallization).

The separation with Evonik’s PuraMem® membranes is performed at gentle conditions (near-ambient temperature) which maintains the bio-activity of natural components.
Gentle API concentration and purification

Processing APIs and their intermediates at lower (near-ambient) temperature minimizes damage to these often complex molecules. APIs and intermediates can be concentrated or purified using OSN membranes without exposure to damaging heat.

Non-thermal solvent recovery and management

Our PuraMem® OSN membranes provide the separation capability for recovering process solvents without the need for boiling and condensing the solvent. Solvents can be recovered at high purity with an energy-efficient OSN process.

Room temperature solvent exchange

Many fine chemical synthetic routes require different process solvents for different reaction types. OSN membranes allow the solvents to be exchanged at room temperature without using conventional thermal techniques.
For initial membrane screening and proof-of-concept testing, PuraMem® membranes are available in flat sheet format. The membranes are also available as spiral wound modules. Smaller modules are typically used for proof-of-process and piloting trials, and the larger modules are used for commercial processes. Modules are available in industry standard sizes from 0.2 m² for the smallest module to about 30 m² for the largest.

OSN involves a membrane and a solvent containing at least one solute ("feed"). The feed is pushed through the membrane with an applied pressure of up to 60 bar. Due to the intrinsic properties of the membrane, the solvent passes through the membrane and becomes the "permeate" whereas the concentrate is retained by the membrane ("the retentate").

Applications may also involve a mixture of organic solutes in the solvent. One or more of the solutes passes through the membrane in the "permeate", while the other(s) are retained in the "retentate". The stability of the membrane and its molecular selectivity essentially determines this process.

There are some heuristic criteria (physical, process and chemical aspects) that need to be considered to make OSN with PuraMem® most valuable and successful:

- At least 150 Da difference in molecular weight between key components, or a significant difference in molecular shape, or a significant difference in polarity
- Generally molecules need to have a molecular weight above 250 Da to be retained
- The process stream being filtered should be a homogeneous solution with zero or minimal tars, waxes and solids
- Filtration temperature should be < 50 ºC
- Filtration pressure should be 5-60 bar
- Solution viscosity should be < 10 cP
- The solute concentration in the feed solution should in general be < 25 % solute
- Recommended pH: 7

For initial membrane screening and proof-of-concept testing, PuraMem® membranes are available in flat sheet format. The membranes are also available as spiral wound modules. Smaller modules are typically used for proof-of-process and piloting trials, and the larger modules are used for commercial processes. Modules are available in industry standard sizes from 0.2 m² for the smallest module to about 30 m² for the largest.
FROM TESTING TO PILOTING TO INDUSTRIAL IMPLEMENTATION

Evonik will accompany you throughout process development, from initial proof-of-concept to the proof-of-process. Additionally, we can assist in customized process development and are also able to provide customers with lab and pilot scale test equipment.

With our team of process engineers and our experience in process development, we offer comprehensive process solutions for your difficult separations using superior solvent stable membranes combined with customized process engineering solutions. A typical process implementation will go through three main steps.

1. **Proof of concept**
The feasibility testing is done using flat sheet membranes and determines the best performing membrane for a specific application. For this initial testing, equipment such as the METcell, a dead-end filtration cell, or our CrossFlow system are used.

2. **Proof of process**
The proof of process is carried out in pilot trials using small spiral wound membrane modules. Equipment such as Bench-Top Unit are used for this stage of process development. The Bench-Top Unit uses manual instrumentation so that it can be easily installed in the laboratory environment in a normal fume cupboard. It is especially suitable for longer-term testing of membrane modules. During this proof-of-process stage, valuable data are gathered that allows the technical design of the commercial scale installation to be completed and the process economics to be accurately evaluated.

3. **Industrial implementation**
Industrial implementation is the last stage, with full scale up of the process established in pilot trials. We provide the membranes and we will also assist you in finding solutions for the conceptualization as well as for the costing and building of a full industrial filtration set-up. For the industrial implementation we are able to arrange individual customer-focused application development projects. We have experienced OEM partners around the world that can provide state-of-the-art industrial installations.

---

Permeate (purified solvent)
The level of purification depends on membrane type (e.g. MWCO).
This information and all technical and other advice are based on Evonik’s present knowledge and experience. However, Evonik assumes no liability for such information or advice, including the extent to which such information or advice may relate to third party intellectual property rights. Evonik reserves the right to make any changes to information or advice at any time, without prior or subsequent notice.

**EVONIK DISCLAIMS ALL REPRESENTATIONS AND WARRANTIES, WHETHER EXPRESS OR IMPLIED, AND SHALL HAVE NO LIABILITY FOR, MERCHANTABILITY OF THE PRODUCT OR ITS FITNESS FOR A PARTICULAR PURPOSE (EVEN IF EVONIK IS AWARE OF SUCH PURPOSE), OR OTHERWISE. EVONIK SHALL NOT BE RESPONSIBLE FOR CONSEQUENTIAL, INDIRECT OR INCIDENTAL DAMAGES (INCLUDING LOSS OF PROFITS) OF ANY KIND.**

It is the customer’s sole responsibility to arrange for inspection and testing of all products by qualified experts. Reference to trade names used by other companies is neither a recommendation nor an endorsement of the corresponding product, and does not imply that similar products could not be used.

* = registered trademark