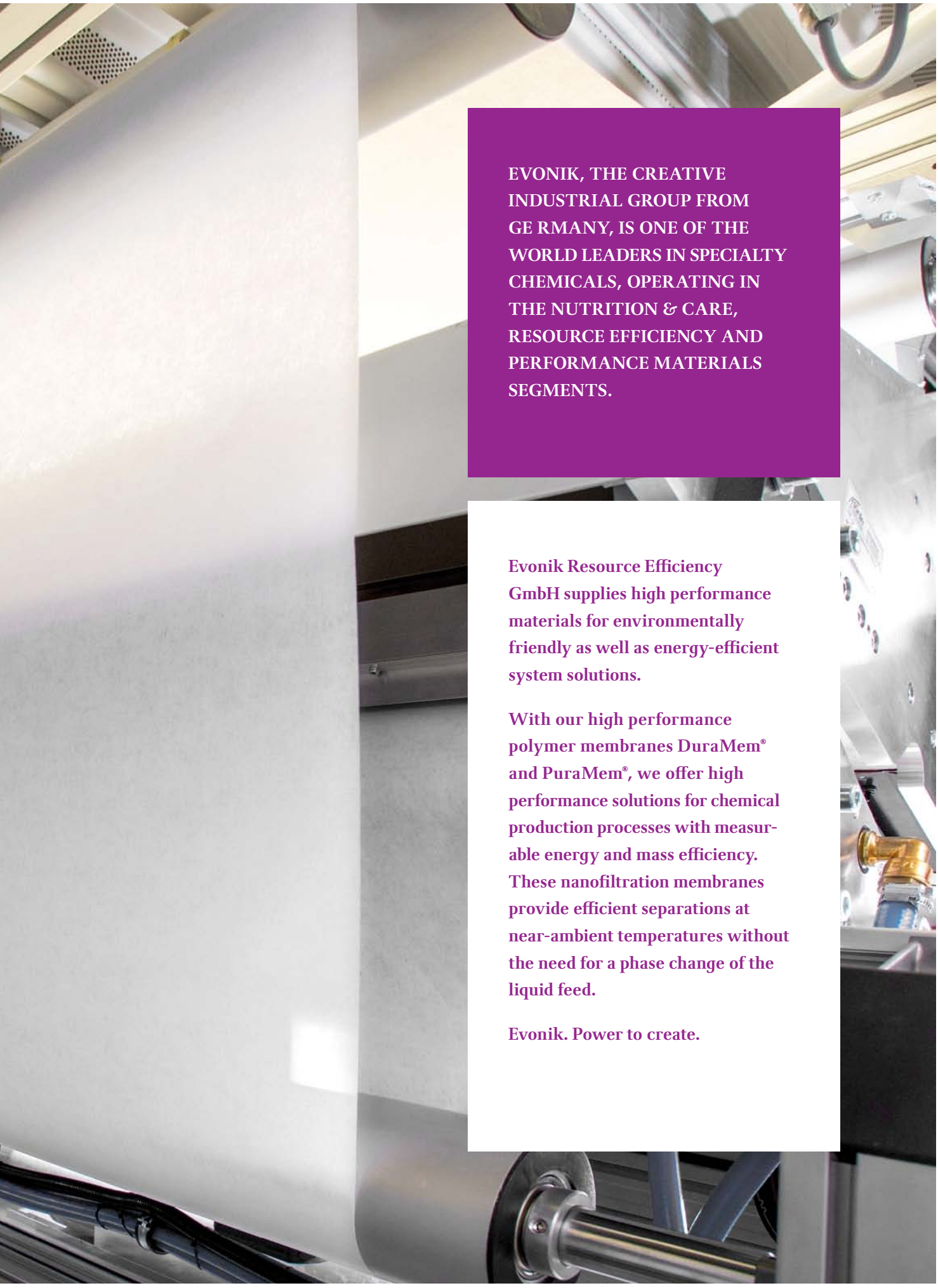
DuraMem® and PuraMem®

Integrate solvent-stable membrane technology

EVONIK
POWER TO CREATE

CONTENT



EVONIK, THE CREATIVE INDUSTRIAL GROUP FROM GE RMANY, IS ONE OF THE WORLD LEADERS IN SPECIALTY CHEMICALS, OPERATING IN THE NUTRITION & CARE, RESOURCE EFFICIENCY AND PERFORMANCE MATERIALS SEGMENTS.

Evonik Resource Efficiency GmbH supplies high performance materials for environmentally friendly as well as energy-efficient system solutions.

With our high performance polymer membranes DuraMem® and PuraMem®, 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.

Evonik. Power to create.

ADDING VALUE WITH GENTLE MOLECULAR SEPARATION

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).

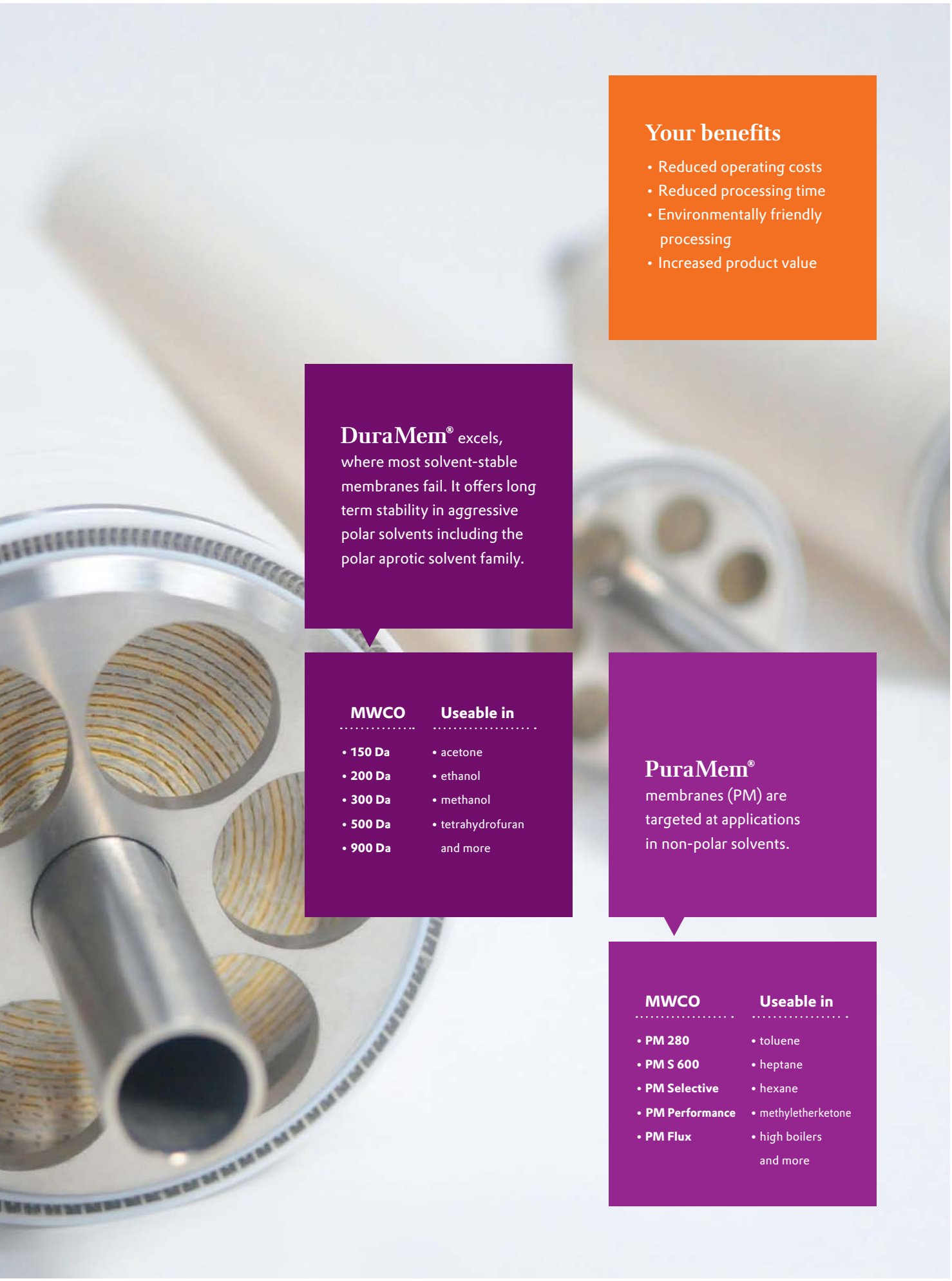
With the development of solvent-stable membranes, the application fields for nanofiltration are being extended to the full spectrum of chemical process industries, e.g. Pharma, Fine Chemicals and Flavour & Fragrance. The breakthrough in OSN technology with the commercialisation of the DuraMem® and PuraMem® range of membranes has opened up possibilities for applications in a variety of organic solvents ranging from non-polar through polar to polar aprotic. 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 two families of OSN membrane products with performance characteristics targeting the needs of the chemical process industries for separation-, purification-, recovery- or concentration-based applications.

The solvent-stable DuraMem® membrane family is compatible with a wide range of organic solvents, and organic or aqueous solvent mixtures, including polar and polar aprotic solvents such as acetone, tetrahydrofuran and ethanol*.

The PuraMem® membrane family is also solvent-stable, but is compatible and designed for use with nonpolar solvents such as aromatic hydrocarbons, aliphatic hydrocarbons and ethyl acetate*.

* More details can be found on our membrane datasheets.



Your benefits

- Reduced operating costs
- Reduced processing time
- Environmentally friendly processing
- Increased product value

DuraMem® excels, where most solvent-stable membranes fail. It offers long term stability in aggressive polar solvents including the polar aprotic solvent family.

MWCO	Useable in
• **150 Da**	• acetone
• **200 Da**	• ethanol
• **300 Da**	• methanol
• **500 Da**	• tetrahydrofuran
• **900 Da**	and more

PuraMem® membranes (PM) are targeted at applications in non-polar solvents.

MWCO	Useable in
• **PM 280**	• toluene
• **PM S 600**	• heptane
• **PM Selective**	• hexane
• **PM Performance**	• methyletherketone
• **PM Flux**	• high boilers
	and more

WHERE CAN THEY BE USED?

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

1

Fine Chemistry and Pharmaceutical Industry

- Gentle API concentration and purification
- Non-thermal solvent recovery and management
- Room temperature solvent exchange

2

Bulk, Oil- and Petro Chemistry

- Homogeneous catalyst recovery
- Decolorization and polishing of products
- Dewaxing
- Additive removal from light hydrocarbons

3

Natural and essential oil and products

- Fractionation of crude extracts
- Enrichment of natural compounds
- Natural oils processing (dewaxing and enrichment)
- Gentle separation

1 Fine Chemistry and Pharmaceutical Industry

Gentle API concentration and purification

Processing APIs and their intermediates at lower (near-ambient) temperature minimises 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 DuraMem® and PuraMem® range of OSN membranes provides 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.

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, which 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 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.

3 Natural and essential oil and products

Fractionation of crude extracts

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, however, as a crude extract often is not practical and the molecules of interest constitute only a small part of the extract. The use of Evonik's OSN membranes with different cut-offs enables fractionation of the crude extracts according to MW or solubility of the molecules in (different) solvents and mixtures.

Enrichment of natural compounds

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

Natural oils processing (dewaxing and enrichment)

Natural oils are widely used as additives in the food, beverages 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).

Gentle separation

The separation with DuraMem® and PuraMem® membranes is performed at gentle conditions (near-ambient temperature) which maintains the bio-activity of natural components.

HOW DO THEY WORK?

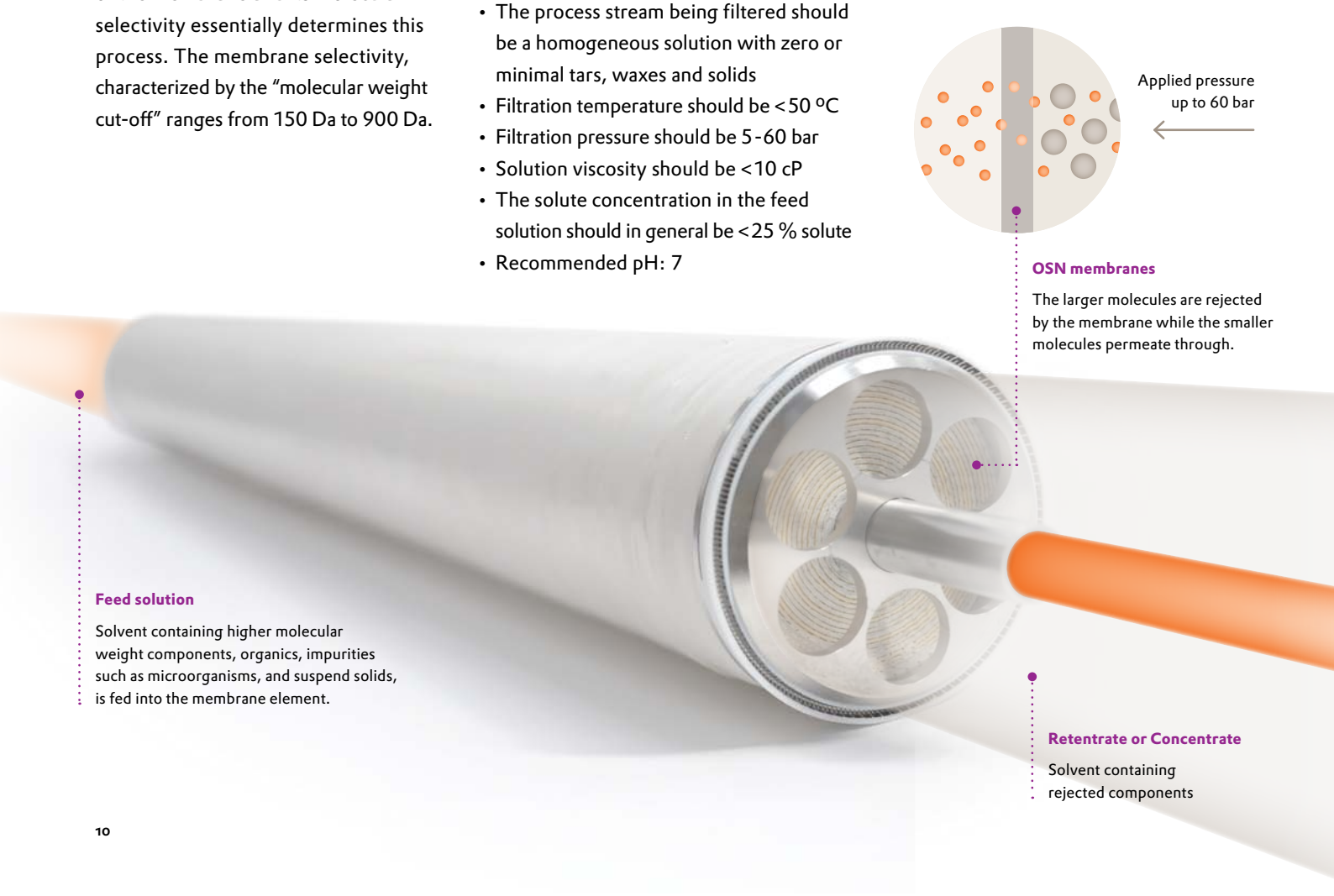
OSN involves a membrane and a solvent containing at least one solute (="feed"). The feed is pushed through the membrane with an applied pressure of up to 60 bar. Due to the nanoporous structure of the membrane, the solvent passes through the membrane and becomes the "permeate" whereas the concentrate 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. The membrane selectivity, characterized by the "molecular weight cut-off" ranges from 150 Da to 900 Da.

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

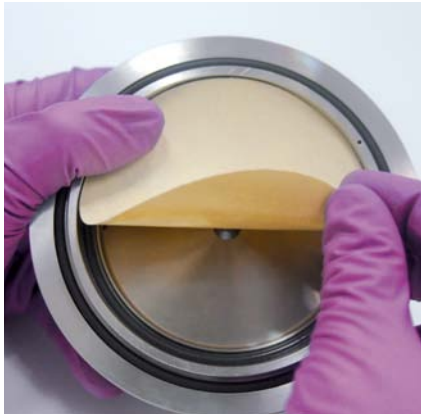
- At least 150 Da difference in molecular weight between key components, or a significant difference in molecular shape, or a significant difference in polarity.
- The molecular weight cut-off to highly retain a molecule is usually 100 to 150 Da smaller than the retained molecule, e.g. DuraMem® 300 is used to retain a product of 400 Da
- 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 °C
- 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, the DuraMem® and PuraMem® membranes are available in flat sheet format. The membranes are also available in spiral wound module format. 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 0.1 m^2 for the smallest module to about 29 m^2 for the largest.

Please contact us for more information about process conditions.



FROM TESTING TO PILOTING TO INDUSTRIAL IMPLEMENTATION



Evonik will accompany you through-out process development, from initial proof-of-concept to the proof-of-process. In addition to industrial upscaling to our two product families DuraMem® and PuraMem®, we also offer customized process development services and can 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.

Permeate (purified solvent)

The level of purification depends on membrane type (e.g. MWCO).

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 our 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 engineering assistance for the conceptualization, costing and building of a full industrial filtration set-up. For the industrial implementation we offer individual customer-focused application development projects. We have experienced OEM partners around the world that can provide state-of-the-art industrial installations.

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

Evonik Resource Efficiency GmbH

High Performance Polymers
Paul-Baumann-Straße 1
45772 Marl

Germany

PHONE +49 02365 49-4800
emet@evonik.com

www.puramem.com
www.evonik.com

01/GR/500/en

EVONIK
POWER TO CREATE