Ultrason®

A versatile material for the production of tailor-made membranes

BASF
The Chemical Company

Ultrason® E, S, P

The Ultrason® resins are amorphous thermoplastics derived from polyethersulfone (PESU), polysulfone (PSU) and polyphenylsulfone (PPSU) and offer very high resistance to heat. Their wide spectrum of beneficial properties allows them to be molded into high-quality engineering parts and high-load mass-produced articles. They can be processed by almost all the techniques adopted for thermoplastics. Ultrason® can be successfully used for applications in which other plastics, e. g. polyamide, polycarbonate, polyoxymethylene and polyalkylene terephthalates, fail to meet the requirements. By virtue of their extra-ordinary versatility, Ultrason® resins can substitute thermosets, metals and ceramics.

Ultrason® – A versatile material for the production of tailor-made membranes

The scope of advanced, cost-efficient membrane processes is constantly expanding. Application fields include water purification, food processing, biomedical applications, manufacturing process separations and waste treatment. Especially in the innovative field of separation processes, membrane devices and especially raw materials are key driving forces. Demanding process conditions, the need for high separation selectivity and process efficiency have led to the widespread use of the high performance thermoplastics polyethersulfone (PESU), polysulfone (PSU) and polyphenylsulfone (PPSU) in this sector.

Properties of Ultrason® E, S and P

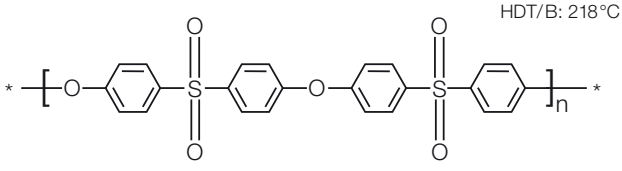
Portfolio

Ultrason® is BASF's brand name for the polymer class of polyarylene ethersulfones. It encompasses three different product lines of transparent, high-temperature and high-performance thermoplastics with excellent chemical and hydrolytic stability, high continuous-service temperatures of ≥160 °C as well as high mechanical strength. The products relevant for membrane applications are offered in various molecular weights as granules (PSU, PPSU) or in form of porous flakes (PESU) for faster dissolution.

Its mechanical properties in combination with its thermal and chemical resistance make Ultrason® superior to most other polymers. Ultrason® allows the production of membranes with high flux and a UF pore-size rating with narrow pore-size distribution at the same time. Many Ultrason® grades comply with FDA and European regulations for food contact applications. For details please contact BASF's Ultra-Infopoint: ultraplaste.infopoint@basf.com.

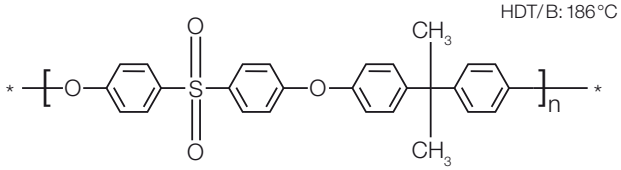
Ultrason® E (Polyethersulfone, PESU)
offers on top of this a higher intrinsic hydrophilicity and in comparison to PSU an even higher chemical stability (e. g. against oxidizing agents like sodium hypochlorite). Its mechanical and thermal properties are also superior. This turns Ultrason® E into a benchmark for repeated-use technical membranes used e. g. in UF water treatment that requires not only high water permeability but also long lifetime, low fouling and excellent resistance to chemicals (cleaners, disinfectants, etc.).
Most used grade: Ultrason® E 6020 P

Tg: 225 °C
HDT/B: 218 °C



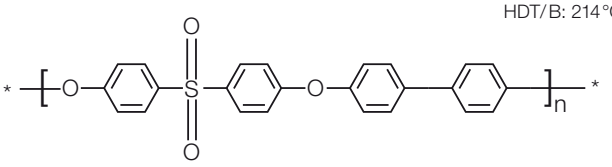
Ultrason® S (Polysulfone, PSU)
is an accepted standard for membrane applications. Due to its high purity (e. g. low content of gels and oligomers) it offers excellent process stability and good pore size control in the membrane production. It is a preferred choice for single use membranes.
Most used grade: Ultrason® S 6010 nat

Tg: 187 °C
HDT/B: 186 °C



Ultrason® P (Polyphenylsulfone, PPSU)
is a specialty having the best performance of the three polymers in respect of chemical resistance (molecular weight degradation). It has the tendency to form denser films or membranes (e. g. gas separation, NF membranes, pervaporation).
Most used grade: Ultrason® P 3010 nat

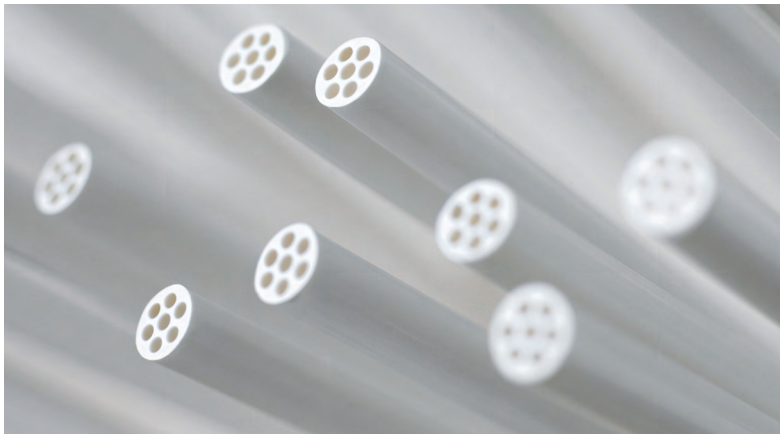
Tg: 220 °C
HDT/B: 214 °C



Bundle of hollow fibers

Advantages of Ultrason®

- excellent chemical resistance (e. g. to water, acids, NaOCl, caustic soda)
- can be used over a wide pH range (0 - 13)
- repeated sterilization possible with superheated steam (134 °C), ethylene oxide, γ-radiation
- complies with FDA and European standards for food contact (repeated use)
- soluble in solvents commonly used for membrane production
- good pore size control
- high flux



Ultrafiltration membranes

	Unit	Ultrason® S (PSU)		Ultrason® E (PESU)				Ultrason® P (PPSU)
Grade		3010	6010	2020 P	3010	6020 P	7020 P	3010
		pellets		flakes	pellets	flakes		pellets
Specific gravity	g/cm³	1.23		1.37				1.29
Moisture absorption (23 °C, 50 % r.h.)	%	0.3		1				0.6
Surface energy**	mN/m	40.2		44.8				42.7
Mean molecular weights								
Viscosity number (VN)	ml/g	72	81	56	66	81	100	71
Mw (GPC)*	g/mol	52,000	60,000	48,000	58,000	75,000	92,000	48,000
Dispersity (Mw/MN)		3.5	3.7	2.7	3.3	3.4	3.0	2.7
Thermal								
Glass transition temperature	°C	187		225				220

Fig. 1: Ultrason® product range for membrane applications

*PSU: THF/PS standard;
PESU, PPSU: DMAc/PMMA standard
** Owens, Wendt

Solvents and spinning solutions

Processing

Membranes and films can be produced from the melt by means of extrusion. For the most part, however, a solution spinning, casting or coating process is used. The typical solvents are NMP, DMAc or DMF (Fig. 2).

	Ultrason® S 3010		Ultrason® E 3010		Ultrason® P 3010	
Polymer concentration	10 %	25 %	10 %	25 %	10 %	25 %
Dichloro Methane						
Dimethylacetamide	√	√	√	√	√	
Dimethylformamide	√	√	√		√	
Dimethyl sulfoxide	80 °C		√	√	80 °C	
Kresole	√		√			
N-Methylpyrrolidone	√	√	√	√	√	√
o-Dichloro benzene	√	√	180 °C		180 °C	
Sulfuric acid 96 %			√			
Sulfolane	120 °C	140 °C	40 °C	80 °C	120 °C	140 °C
Tetrahydrofuran	√	√				
Trichlorethylen						

Dissolving time:

<4 h	4-12 h	>24 h	partial	not soluble	√ = stability of the solution >24 h

Fig. 2: Solvents for Ultrason®, at room temperature or as stated

Membranes made of Ultrason®

The membrane is generated in an immersion precipitation procedure where, in the case of hollow fiber spinning, the polymer solution (Ultrason®, PVP, PEG and/or other additives) is conveyed through a spinneret into a precipitation bath. This process is, among other parameters, very sensitive to the viscosity of the solution used. Since the viscosity number (VN; reduced viscosity) of Ultrason®, which is specified in a narrow range, shows a good correlation to the resultant solution viscosity, Ultrason® permits excellent control of this important membrane production parameter (Figs. 3 and 4).

Oligomer content

Whereas Ultrason® E (PESU) is characterized by an inherently low content of oligomers, Ultrason® S (PSU) tends to contain somewhat higher concentrations of these (mainly cyclic) components. Especially the cyclic dimer, due to his tendency to form crystals in the spinning solution, can cause problems in the membrane spinning process.Ultrason® S 3010 and Ultrason® S 6010 are optimized in this respect and have a low cyclic oligomer content (Fig. 5), as a result of which they improve:

- the spinning or casting solution stability (reduced maintenance costs of the spinning facility)
- the stability of the membrane production process
- the defect rate on the membrane surface

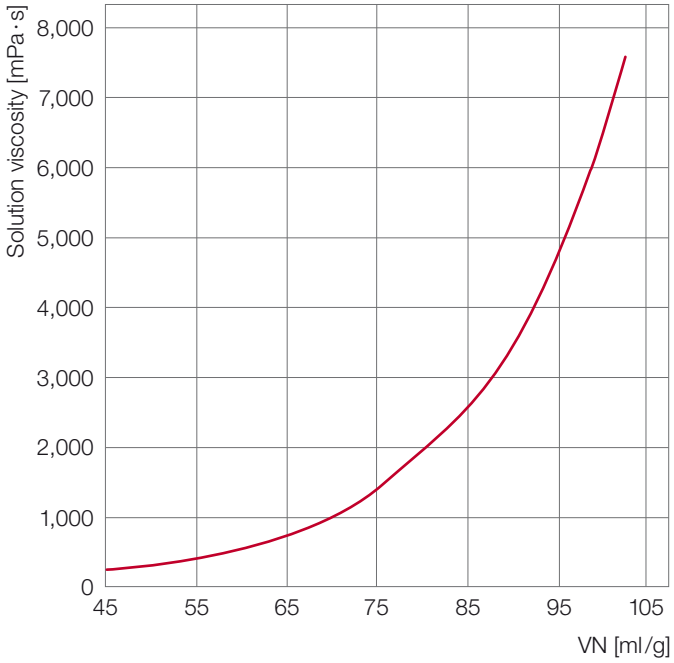


Fig. 3: Solution viscosity of polyethersulfone in DMAc (25%, 40°C)

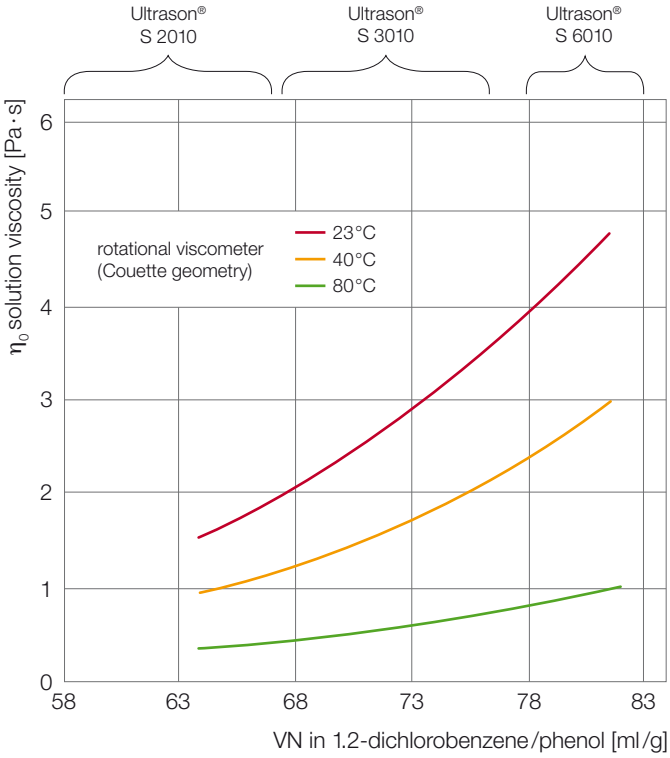
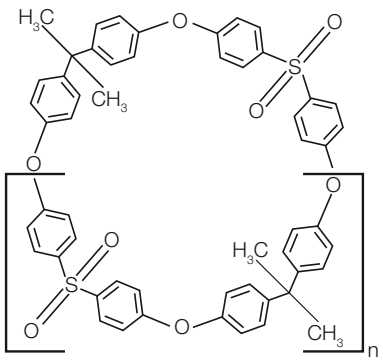


Fig. 4: Solution viscosity of polysulfone in DMAc (25%, 40°C)

Cyclic oligomer content in Ultrason® grades

Sample	Dimer*	Trimer*	Oligomers* (n=1-7)
	(area.-%)	(area.-%)	(area.-%)
Ultrason® S 3010	1.0-1.1	0.7	4.0
Ultrason® S 6010	1.0-1.1	0.6	3.6

*measured by SEC in THF with UV detection at 254 nm as area.-% of whole sample



Cyclic dimer (with n=1)

Fig. 5: Ultrason® S 3010 and Ultrason® S 6010 are characterized by a low content of oligomers, especially of the cyclic dimer

Membrane Performance

Fields of usage

Ultrason® is used in the entire range of membrane applications:

- particle filtration (wastewater treatment)
- micro-filtration (clarification of beverages such as wine)
- ultra-filtration (bacteriological and virological decontamination of drinking water)
- pretreatment for reverse osmosis (seawater desalination)

It is resistant to superheated steam, γ-radiation and ethylene oxide sterilization. It also shows, for example, good resistance to sodium hypochlorite and excellent resistance to caustic soda (sodium hydroxide), even at elevated temperatures (Fig. 6).

The use of caustic soda instead of sodium hypochlorite in the cleaning of water treatment membranes minimizes the exposure of the water to chlorine. This reduces the probability of the formation of chlorinated organics in the drinking water.

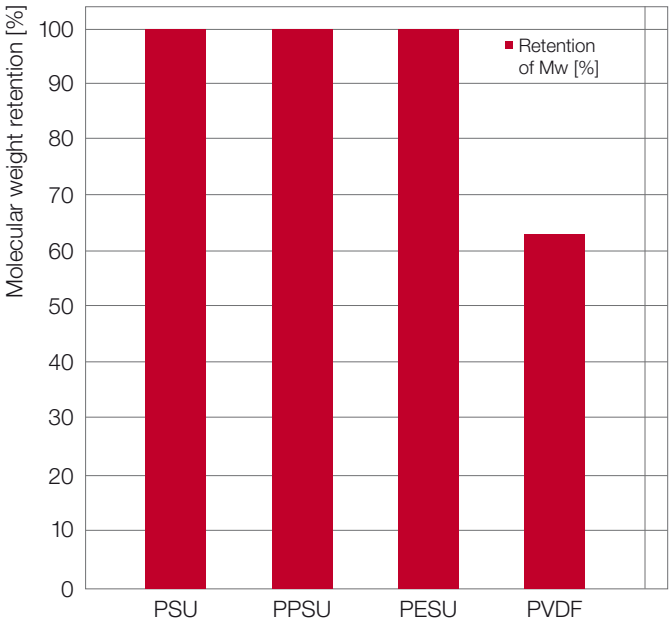


Fig. 6: Retention of molecular weight of membranes after 1,000 h in caustic soda (NaOH, 10 %, 40 °C)

Pore size

Even more important is the unique ability of Ultrason®, especially Ultrason® E (PESU), to allow for a very good control of the pore size with a narrow pore size distribution compared to PVDF membranes (Fig. 7). This allows the production of UF water treatment membranes which are able to remove parasites (like cryptosporidium or giardia, Fig. 8), bacteria and even viruses from drinking water. With this the need to super-chlorinate drinking water is further reduced.

In 2008, a study of the California Department of Health Services (CDPH) underlined the ability of PESU membranes to remove viruses while allowing at the same time for a high flux. As a model virus the MS2 Phage was used. Commercial PESU membranes were able to reach a Log Removal Value (LRV) around 4, meaning that only 1 out of 10^4 viruses managed to pass through the membrane (99,99 % of the viruses are removed; Fig. 9).

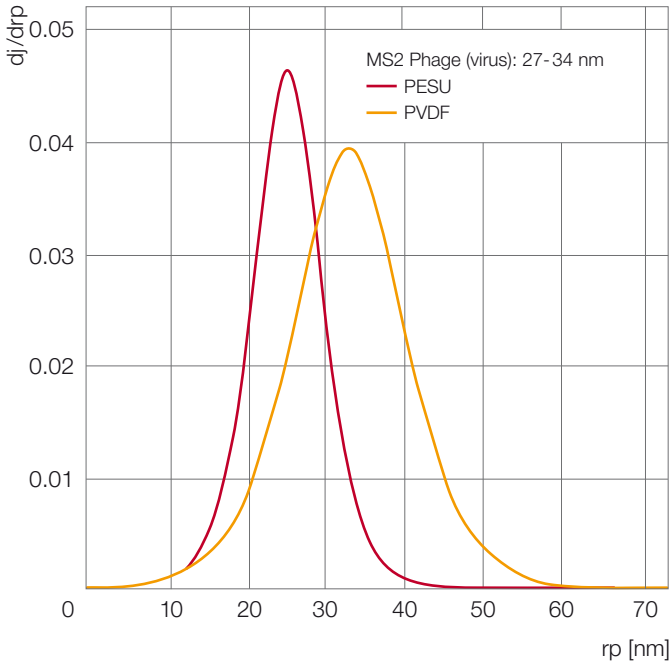
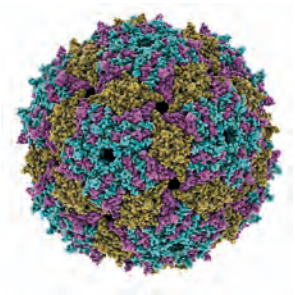
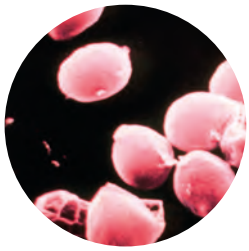


Fig. 7: Pore size distribution of two commercial membranes with nominal pore size “20 nm” (source: Ultrapure Water, (4/2010), 33 ff)



Bacteriophage MS2
capsid protein [1]



Cryptosporidium
parvum [2]

Giardia lamblia
protozoan [3]

Fig. 8: Waterborne parasites

		Polymer	Nominal type	Max. flux [lmh]	MS2 virus LRV	Max. TMP [bar]
Hydranautics	HYDRAcap 60	PESU	UF	119	>4	1.2
Inge	Dizzer	PESU	UF	156	3.5	2.0
Norit	SXL 225	PESU	UF	127	>4	2.1
GE-Zenon	ZW 1000	PVDF	UF	93	3.5	0.8
DOW	SFX 2860	PVDF	UF	102	2.5	2.1
Pall	Microza	PVDF	**MF**	204	0.5	3.0
Siemens Memcor	S10 V, L10 V, L20 V	PVDF	UF	88	1.5	1.5
Toray	HF S -2020	PVDF	UF	202	1.5	2.0

Fig. 9: Virus removal of commercial UF membranes (testing model: MS2 Phage)

Source (abridged): Alternative Filtration Technology Summary
California Department of Health Services (CDPH)
DDWEM Technical Programs Branch
www.cdph.ca.gov/certlic/drinkingwater, September 2008

- the target LRV is 4 or better (model: MS2 Phage)
- the permeability for PESU membranes is typically 2x of PVDF membranes
- lower pressure requirements result in significant energy savings

Municipal water treatment facility in Rötgen (Germany), taking advantage of the high productivity (flux), excellent separation performance (virus removal) and energy savings (low pressure) PESU membranes provide.

[1] © LAGUNA DESIGN / SPL / Ag. Focus [2] © A.B. DOWSETT / SPL / Ag. Focus [3] © DR. TONY BRAIN / SPL / Ag. Focus

Ultrason® E 6020 P

UF membrane for drinking water preparation

For its portable LifeStraw® Family water purification system, Vestergaard Frandsen uses Ultrason® E 6020 P (PESU). The easy-to-use plastic design simplifies on-site conversion of large quantities of dirty water into potable water. The primary element is an approximately 30 cm long plastic housing that contains filter membranes made from Ultrason® E.

Advantages of LifeStraw® Family:

- food contact approvals (FDA, EU)
- secure removal of parasites, bacteria and viruses
- simple handling without chemicals, electricity, pumps etc.
- produced water complies with EPA standards for drinking water

Thin hollow fibers made from the high-performance plastic Ultrason® E 6020 P in the light-blue filter unit of the LifeStraw® Family water purification system from Vestergaard Frandsen are responsible for purifying the water by removing bacteria and viruses. The same plastic has already been used for years in large-scale stationary water purification systems. In the new LifeStraw® Family system, this membrane material is being used for the first time in a portable water filtration application. BASF supplies the plastic in flake form; the customer then processes it into fibers.

Ultrason® E is used in the portable LifeStraw® Family water purification system.

Further BASF offerings

In addition to Ultrason®, BASF is also offering Luvitec® K (Polyvinylpyrrolidone, PVP) and solvents like Dimethylacetamide (DMAc) or N-Methylpyrrolidone (NMP), that are typically used in the membrane production.

Selected Product Literature for Ultrason®:

- Ultrason® E, S, P – Product Brochure
- Ultrason® E, S, P – Product Range
- Ultrason® – Resistance to Chemicals
- Ultrason® – Injection Molding
- Ultrason® – Special Products
- From the Idea to Production – The Aqua® Plastics Portfolio for the Sanitary and Water Industries

Note

The data contained in this publication are based on our current knowledge and experience. In view of the many factors that may affect processing and application of our product, these data do not relieve processors from carrying out own investigations and tests; neither do these data imply any guarantee of certain properties, nor the suitability of the product for a specific purpose. Any descriptions, drawings, photographs, data, proportions, weights etc. given herein may change without prior information and do not constitute the agreed contractual quality of the product. It is the responsibility of the recipient of our products to ensure that any proprietary rights and existing laws and legislation are observed. (June 2013)

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If you have technical questions on the products, please contact the Ultra-Infopoint:

KTES 1201 FE