Ultrason® E and S
Luvitec® K

Versatile materials for the production of tailor-made membranes

BASF Plastics
key to your success

BASF
The Chemical Company
The scope of advanced, cost efficient membrane processes is constantly expanding. Application fields include water purification, biomedical applications, manufacturing process separations, waste treatment and food processing.

The ongoing development being made in separation processes, membrane devices and especially raw materials are key driving forces behind this innovative field of endeavor.

Demanding process conditions and the need for high separation selectivity and process efficiency, have led to the widespread use of the high performance thermoplastics polysulfone (PSU) and polyethersulfone (PESU) in this sector.
Ultrason® S (PSU) and Ultrason® E (PESU) are the brand names for polysulfone and polyethersulfone that are available from BASF. They are offered in various molecular weights as granules (PSU) or else in form of powder or porous flakes (PESU) for faster dissolution.

Both are transparent, high-temperature and high-performance thermoplastics with excellent chemical and hydrolytic resistance, high continuous-service temperatures of 160/180°C (PSU/PESU) as well as high mechanical strength.
Properties

Ultrason® E and Ultrason® S are superior to most other polymers in terms of their mechanical properties as well as their temperature and chemical resistance. They can be used as raw materials in the production of high-flux and low-flux membranes and even in areas of application where a short-term temperature resistance of up to 180/220ºC is required (e.g. separation processes in the chemical industry). Both products comply with FDA and European regulations for food contact applications (repeated use).

Ultrason® S has already found wide acceptance as a base polymer in the membrane industry, while Ultrason® E 6020P is also gaining ground and attracting more attention thanks to its superior hydrophilic properties, better temperature resistance (since its Tg is 40°C higher) and superior mechanical properties. This renders Ultrason® E (PESU) very suitable for technical membranes, especially in aqueous systems, requiring not only high water permeability but also long lifetime, low fouling and excellent resistance to chemicals (cleaners, disinfectants, etc.).

Ultrason® E is soluble in NMP, DMAC and DMF, and is used in the entire range of membrane applications, from particle filtration (wastewater treatment) to microfiltration (clarification of beverages such as wine) to ultrafiltration (bacteriological and virological decontamination of drinking water) and reverse osmosis (seawater desalination). It is resistant to superheated steam, γ-radiation or ethylene oxide sterilization and also exhibits, for example, good resistance to sodium hypochlorite, even at elevated temperatures.
Ultrason® is an excellent product on the strength of its highly versatile properties

- Outstanding mechanical properties between -50°C and 220°C (it outperforms most other commercially available thermoplastics between 150°C and 220°C)
- High dimensional stability with
  - a low coefficient of thermal expansion (CTE)
  - no warpage, owing to the absence of crystallization
  - low creep, even at high temperatures
- Excellent long-term heat aging properties (RTI, UL 746B at 155°C and 180°C, PSU and PESU respectively)
- Short-term temperature resistance up to 180°C and 220°C respectively
- Excellent chemical resistance (e.g. to water, acids, bases, fuel, oil, grease, fluorine, NaOCl solution, even at high temperatures)
- Can be used over a wide pH range (0-13) (PESU is superior to PSU in terms of temperature resistance and extreme pH values)
- Repeated sterilization possible with superheated steam at 121°C or 134°C, ethylenoxide, γ-radiation
- Transparent (if compact) with low tendency to pick up color from food ingredients
- Complies with FDA and European standards for food contact (repeated use)
- Good pore size control
- Soluble in solvents commonly used for membrane production

### Ultrason® – key properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Ultrason® S (PSU)</th>
<th>Ultrason® E (PESU)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product form</strong></td>
<td></td>
<td>pellets</td>
<td>porous flakes</td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass Density</td>
<td>g/cm³</td>
<td>1.24</td>
<td>1.37</td>
</tr>
<tr>
<td>Moisture absorption 23 °C, 50 % r.h.</td>
<td>%</td>
<td>0.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Surface tension (contact angle, water)</td>
<td>°</td>
<td>77°</td>
<td>80°</td>
</tr>
<tr>
<td><strong>Mean molecular weights</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viscosity number</td>
<td>ml/g</td>
<td>72</td>
<td>81</td>
</tr>
<tr>
<td>Mw (light scattering in NMP)</td>
<td>g/mol</td>
<td>37 - 45.000</td>
<td>45 - 55.000</td>
</tr>
<tr>
<td>Dispersity Mw/Mn (GPC in DMF)</td>
<td></td>
<td>3.0 - 4.0</td>
<td>4.0 - 5.0</td>
</tr>
<tr>
<td><strong>Thermal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass transition temperature</td>
<td>°C</td>
<td>187</td>
<td>225</td>
</tr>
</tbody>
</table>
Enhanced features

Whereas Ultrason® E (PESU) is characterized by an inherently low quantity of oligomers, polysulfone (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 causes problems in the membrane spinning process.

Ultrason® S products 3010, 6010 are optimized in this respect and have a low cyclic oligomer content, as a result of which they improve the following:

- 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. 1: Ultrason® S 3010 and S 6010 are characterized by a low content of oligomers, especially of the cyclic dimer.
Cyclic oligomer content in Ultrason® grades

<table>
<thead>
<tr>
<th>Sample</th>
<th>Dimer*</th>
<th>Trimer*</th>
<th>Oligomers* (n = 1-7)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(area.-%)</td>
<td>(area.-%)</td>
<td>(area.-%)</td>
</tr>
<tr>
<td>Ultrason® S 3010</td>
<td>1.0-1.1</td>
<td>0.7</td>
<td>4.0</td>
</tr>
<tr>
<td>Ultrason® S 6010</td>
<td>1.0-1.1</td>
<td>0.6</td>
<td>3.6</td>
</tr>
</tbody>
</table>

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

Fig. 2: Ultrason® S 3010 and S 6010 are characterized by a low content of oligomers, especially of the cyclic dimer

Cyclic oligomer content in Ultrason® grades

- **Sample**: Ultrason® S 3010 and Ultrason® S 6010
- **Dimer measured by SEC**: 1.0-1.1 area-%
- **Trimer measured by SEC**: 0.7 area-%
- **Oligomers measured by SEC**: 4.0 area-% (n = 1-7)

*Cyclic Dimer (with n=1)*

**SEC of the oligomer section**

![SEC of the oligomer section graph](image)

- **Relative frequency** range: 0.005 to 0.050
- **Molecular mass** range: 100 to 10,000
- **Exclusion limit for oligomer fraction**

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0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
100 1000
Molecular mass

Red: Ultrason® S 3010
Blue: Competitor low oligomer

Inset: Cyclic Dimer (with n=1)
Solution viscosities

Membranes and films can be produced from the melt by means of extrusion, but for the most part, a solution spinning, casting or coating process is utilized. The typical solvents are, for example, NMP, DMAc, DMF or CH₂Cl₂. The membrane is generated in an immersion-precipitation procedure where, in the case of hollow-fibre-spinning, the polymer solution (PESU/PSU, PVP, other additives) is conveyed through a spinneret into a water bath.

This process is very sensitive to the viscosity of the solution employed as well as to other parameters. Since the viscosity number (VN) of Ultrason® has a narrow specification range and a good correlation to the resultant solution viscosity, it permits excellent control of this membrane production parameter.
Solution viscosity of Ultrason® S grades

Figure 3: Correlation of solution viscosity and viscosity number (VN) for Ultrason® S measured with a rotational viscosimeter (Couette geometry).

Solution viscosity of Ultrason® E 6020P

Figure 4: Correlation of solution viscosity (in NMP), measured with a rotational viscosimeter (Couette geometry), and temperature for a typical Ultrason® E 6020P.
Polyvinylpyrrolidone (PVP) is widely employed in the membrane manufacturing process to better control the pore structure and to enhance hydrophilic properties of the membrane surface. BASF offers a broad range of PVP products under the brand name Luvitec® in order to meet specific viscosity and molecular weight requirements. In combination with Luvitec®, Ultrason® yields membranes having excellent chemical and temperature stability as well as

- higher porosity and permeability,
- better control of pore size and pore distribution,
- highly interconnected pores,
- improved hydrophilic properties of the surface and less fouling,

thus leading to a superior separation performance compared to systems without Luvitec® as an additive.

Straight Ultrason® solutions display Newtonian behavior over a wide range of concentrations, temperatures and shear rates. However, PSU/PVP and PESU/PVP mixtures exhibit greater viscosity and enhanced viscoelastic properties, which indicates strong interactions between the polymers.

An additional modification of the membrane is possible by cross-linking the PVP by means of temperature, UV-radiation, γ-radiation, peroxide or E-beam.

BASF can supply manufacturers from a single source, offering Ultrason®, Luvitec® and many of the commonly employed solvents, as a complete membrane package, including full technical support.

Luvitec® K Value Added Service
Fig. 5: Significant interaction between Ultrason® and Luvitec® (PVP) leads to a higher solution viscosity and viscoelastic behaviour of the polymer-solvent system measured with a rotational viscosimeter (Couette geometry)

<table>
<thead>
<tr>
<th>Luvitec® – key properties</th>
<th>Polyvinylpyrrolidone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Luvitec®</td>
</tr>
<tr>
<td>Property</td>
<td>K17</td>
</tr>
<tr>
<td>K-value</td>
<td>15.0-19.0</td>
</tr>
<tr>
<td>pH value</td>
<td>3.0-7.0</td>
</tr>
<tr>
<td>Solids content, %</td>
<td>95.0-100.0</td>
</tr>
<tr>
<td>NVP monomer content, ppm</td>
<td>&lt; 100</td>
</tr>
<tr>
<td></td>
<td>K30</td>
</tr>
<tr>
<td>K-value</td>
<td>27.0-33.0</td>
</tr>
<tr>
<td>pH value</td>
<td>3.0-7.0</td>
</tr>
<tr>
<td>Solids content, %</td>
<td>95.0-100.0</td>
</tr>
<tr>
<td>NVP monomer content, ppm</td>
<td>&lt; 100</td>
</tr>
<tr>
<td></td>
<td>K85</td>
</tr>
<tr>
<td>K-value</td>
<td>84.0-88.0</td>
</tr>
<tr>
<td>pH value</td>
<td>5.0-9.0</td>
</tr>
<tr>
<td>Solids content, %</td>
<td>95.0-100.0</td>
</tr>
<tr>
<td>NVP monomer content, ppm</td>
<td>&lt; 100</td>
</tr>
<tr>
<td></td>
<td>K90</td>
</tr>
<tr>
<td>K-value</td>
<td>88.0-92.0</td>
</tr>
<tr>
<td>pH value</td>
<td>5.0-9.0</td>
</tr>
<tr>
<td>Solids content, %</td>
<td>95.0-100.0</td>
</tr>
<tr>
<td>NVP monomer content, ppm</td>
<td>&lt; 100</td>
</tr>
</tbody>
</table>
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Do you have technical questions about Ultrason® or Luvitec®? We will be happy to deal with your inquiry at our Ultra Infopoint for Ultrason® or at PVP Technical Applications for Luvitec®:

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Medical applications

BASF Aktiengesellschaft has not developed its products specifically for use in medical devices as set forth in the European Medical Device legislation, including the packaging of parenteral and ophthalmic products. For this reason BASF Aktiengesellschaft has no experience regarding the suitability of Ultrason® and Luvitec® in this field.

BASF Aktiengesellschaft does not supply products for the manufacture of implants and expressly advises against plastics supplied for other purposes being used for this medical application. BASF Aktiengesellschaft does not assume any liability in cases where BASF products are used improperly for the manufacture of implants.

Should BASF customers establish, from their own experience and from tests on Ultrason® or Luvitec®, that these products are suitable for the manufacture of products for medical applications involving short-term body contact or temporary implantation in the human body, or involving short-term or temporary contact with fluids or tissues present in the body or introduced into the body, and/or for the manufacture of packaging for parenteral and ophthalmic products, then BASF Aktiengesellschaft is prepared to supply Ultrason® or Luvitec® if an arrangement can be reached which takes into account the circumstances of each individual case.

Note

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