SOLVAY
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Optical Properties of Sulfone Polymers

Solvay Specialty Polymers provides the industry's broadest offering of sulfone-based polymers, which includes Radel® polyphenylsulfone (PPSU), Veradel® polyethersulfone (PESU), and Udel® polysulfone (PSU). These materials deliver unique combinations of transparency, high heat resistance, toughness, hydrolytic stability and chemical resistance.

Transparency in the Visible Wavelength Range

In their natural state, sulfone polymers are transparent materials. Among Solvay's portfolio, Udel® PSU exhibits the highest clarity and the lowest haze. Udel P-1706 and P-3703 NT-06, a specialty low-color grade, provide over 85% light transmittance.

Sulfone polymers are not completely colorless. Udel® PSU exhibits a slightly yellow tinge. Veradel® PESU and Radel® PPSU, on the other hand, exhibit a light amber coloration. Typical light transmittance curves for Udel® PSU, Veradel® PESU and Radel® PPSU are shown for three different thicknesses in Figures 1-3.

A Unique Combination of Properties

In addition to good optical properties, sulfone polymers offer some of the highest heat deflection temperatures among amorphous polymers. The HDT of Udel® PSU is 174 °C (345 °F), while those of Veradel® PESU and Radel® PPSU are 204 °C (399 °F) and 207 °C (405 °F), respectively.

Radel® PPSU delivers the highest performance of our sulfone polymers, offering high thermal stability along with better impact resistance and chemical resistance than polycarbonate (PC) and polyetherimide (PEI).

Applications which take advantage of the clarity and high temperature capabilities of sulfone polymers range from the consumer area to the most demanding engineering environments. Examples include coffee decanters, automotive fuses and the face shield visor for astronaut space suits. Selected transparency characteristics of Udel® PSU, Veradel® PESU and Radel® PPSU resins are shown in Table 1.

Table 1: Typical light transmittance, haze and yellowness indices at various thicknesses

Property	Udel® P-1700 NT-06	Veradel® A-301 NT	Radel® R-5000 NT	Test Method
Light Transmittance [%]				ASTM D1003
1.78 mm (0.07 in.)	86	80	80	
2.54 mm (0.10 in.)	85	76	77	
3.30 mm (0.13 in.)	84	72	74	
Haze [%]				ASTM D1003
1.78 mm (0.07 in.)	1.5	3.9	3.1	
2.54 mm (0.10 in.)	2.0	5.1	4.3	
3.30 mm (0.13 in.)	2.5	5.9	5.1	
Yellowness Index				ASTM D1925
1.78 mm (0.07 in.)	7.0	19	19	
2.54 mm (0.10 in.)	10	27	28	
3.30 mm (0.13 in.)	13	35	36	

Table 2: Refractive and chromatic dispersion properties

Property	Udel® P-1700 NT-06	Veradel® A-301 NT	Radel® R-5000 NT
Refractive index, n_D	1.634	1.653	1.675
F-line refractive index	1.650	1.671	1.696
C-line refractive index	1.623	1.641	1.660
Dispersion, n_F-n_C	0.0273	0.0297	0.0361
Abbe value[1]	23.3	22.0	18.7
Slope of Ref. Index vs. Wavelength (m^{-1})	- 0.160	-0.174	-0.212

[1]Abbe value = (n_D-1) / (n_F-n_C)

Figure 1: Light transmittance of Udel® P-1700 NT-06 at various wavelengths and thicknesses

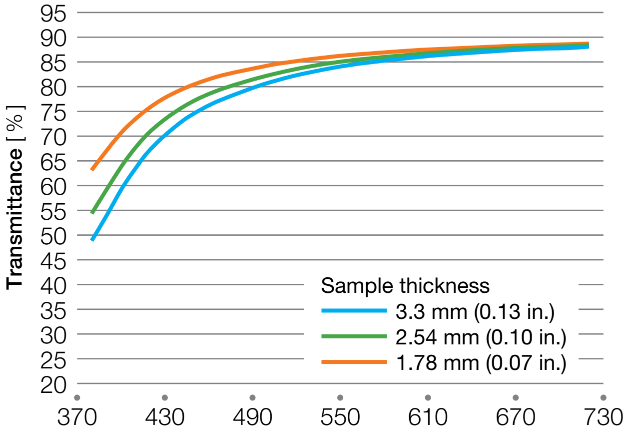


Figure 2: Light transmittance of Veradel® A-301 NT at various wavelengths and thicknesses

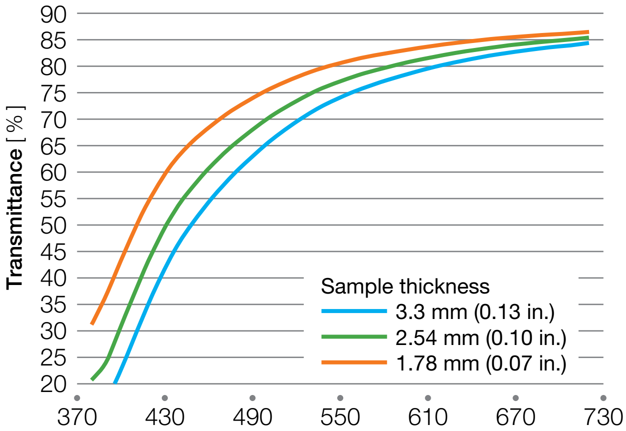
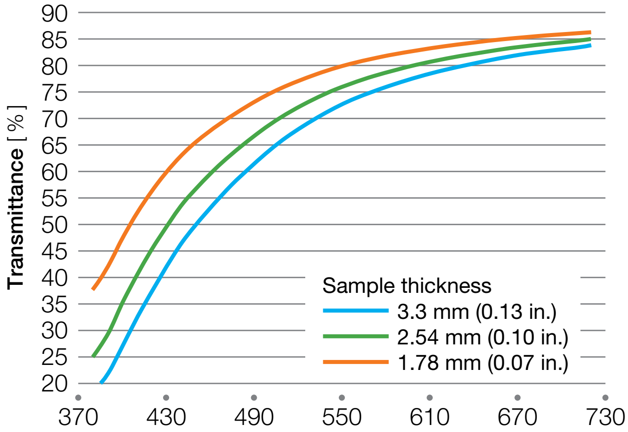


Figure 3: Light transmittance of Radel® R-5000 NT at various wavelengths and thicknesses



Refractive Index and Dispersion Properties

In addition to transparency, Udel® PSU offers very high refractive indices. The high refractive indices, enabling thinner, higher power lenses than those made from other transparent polymers like polycarbonate and acrylic.

Data is typically collected at three visible spectrum wavelengths (0.4861, 0.5876 and 0.6563 µm), which are referred to as the F line, D line and C line respectively.

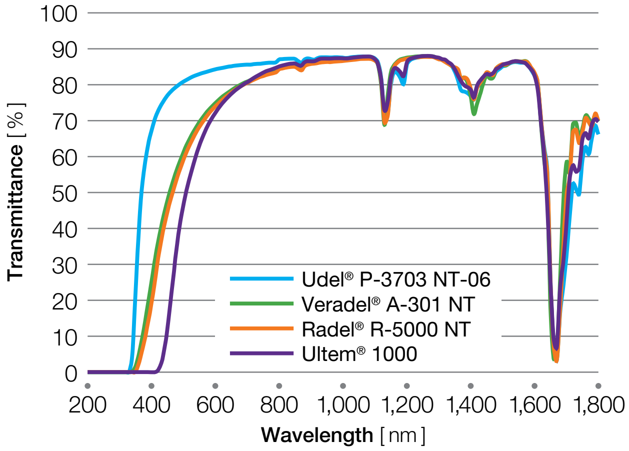
The refractive index, n, reported in Table 2 was measured at these three wavelengths using an Abbe refractometer employing the method of total internal reflection. The dispersion, Abbe value (also known as the Abbe V-number) and slope of the refractive index wavelength plot were calculated from the refractive index values.

Transmittance Properties Outside the Visible Range

Because of their high transmittance in the infrared region, an emerging area of use for these polymers is in optical signal transmission devices. Figure 4 shows typical spectral transmittance curves for Udel®, Veradel® and Radel® natural resins over the wavelength range of 300-1800 nanometers (nm). At the wavelengths of 850, 1300 and 1510 nm, transmission percentages for Udel® PSU, Veradel® PESU and Radel® PPSU are 87, 87 and 86 respectively.

Unlike their behavior in the IR region, sulfone polymers absorb heavily in the ultraviolet (UV) region. As a result, their use is generally not feasible in the UV range because of the long term effect of UV light on the polymer's chemical and physical integrity. The transmittance levels of Solvay's sulfone polymers in the visible region surpass those of commercially available PEIs (Ultem®) by a good margin.

Figure 4: Spectral transmittance in the 200-1800 nm wavelength range (2.5 mm thickness)



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