Optical Properties of UDEL® and RADEL® Sulfone Polymers

Sulfone polymers are a family of engineering resins that combine transparency along with exceptional performance attributes to deliver unique advantages for demanding applications. Solvay Advanced Polymers offers three transparent sulfone polymers: RADEL R polyphenylsulfone (PPSU), RADEL A polyethersulfone (PES), and UDEL polysulfone (PSU). In addition, new ultra-high Tg grades are currently in development.

Transparency in the Visible Wavelength Range

In their natural state, sulfone polymers are transparent materials. Among the three sulfone polymers Solvay Advanced Polymers offers, UDEL polysulfone has the highest overall clarity, lowest haze, along with a light transmittance value in the neighborhood of 85% for the special low-color NT-06 grade.

Sulfone polymers are not completely colorless. UDEL polysulfone exhibits a slightly yellow tinge. RADEL A polyethersulfone and RADEL R polyphenylsulfone, on the other hand, exhibit a light amber coloration. Typical light transmittance curves for UDEL polysulfone, RADEL A polyethersulfone and RADEL R polyphenylsulfone are shown for three different thicknesses in Figures 1-3.

A Combination of High-Performance Properties

In addition to their good optical properties, sulfone polymers offer among the highest heat deflection temperatures of any amorphous polymers. The HDT of UDEL PSU is 174°C, while those of RADEL A PES and RADEL R PPSU are 204°C and 207°C, respectively.

RADEL R resin is the highest performance member of the sulfone polymers family. In addition to its superior thermal properties, it features super toughness, elongation, and impact resistance characteristics comparable to those of polycarbonate.

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.

Table 1

Typical Light Transmittance, Haze and Yellowness Indices at Various Thicknesses

Property	ASTM Method	UDEL P-1700 NT-06	RADEL A-300 NT	RADEL R-5000 NT
Light Transmittance%	D-1003			
0.07”		86	80	80
0.10”		85	76	77
0.13”		84	72	74
Haze (%)	D-1003			
0.07”		1.5	3.9	3.1
0.10”		2.0	5.1	4.3
0.13”		2.5	5.9	5.1
Yellowness Index	D-1925			
0.07”		7.0	19	19
0.10”		10	27	28
0.13”		13	35	36

Table 2

Refractive and Chromatic Dispersion Properties

Property	UDEL P-1700 NT-06	RADEL A-300 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 (μm^{-1})	- 0.160	-0.174	-0.212

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

Selected transparency characteristics of UDEL, RADEL A and RADEL R resins are shown in Table 1.

Refractive Index and Dispersion Properties

In addition to their good transparency attributes, polysulfones offer very high refractive indices. The high refractive indices are desirable for many lens applications as they allow thinner and/or higher power lenses than are possible with other commercially available transparent polymers like polycarbonate and acrylic.

The dispersion and Abbe value of a polymer provide quantitative measures of the material's refractive index variation with the wavelength of incident light. This property is usually obtained by measuring the refractive index of the plastic at three characteristic wavelengths of the visible spectrum referred to as the F line, the D line and the C line. These monochromatic wavelengths are at 0.4861, 0.5876 and 0.6563 micrometers (μm), respectively. To generate the data in Table 2, the refractive index, n, was measured for each polymer at these wavelengths using an Abbe refractometer employing the method of total internal reflection. From these three refractive index values, the dispersion, Abbe value (or Abbe V-number as it is also known), and the slope of the refractive index-wavelength plot were calculated.

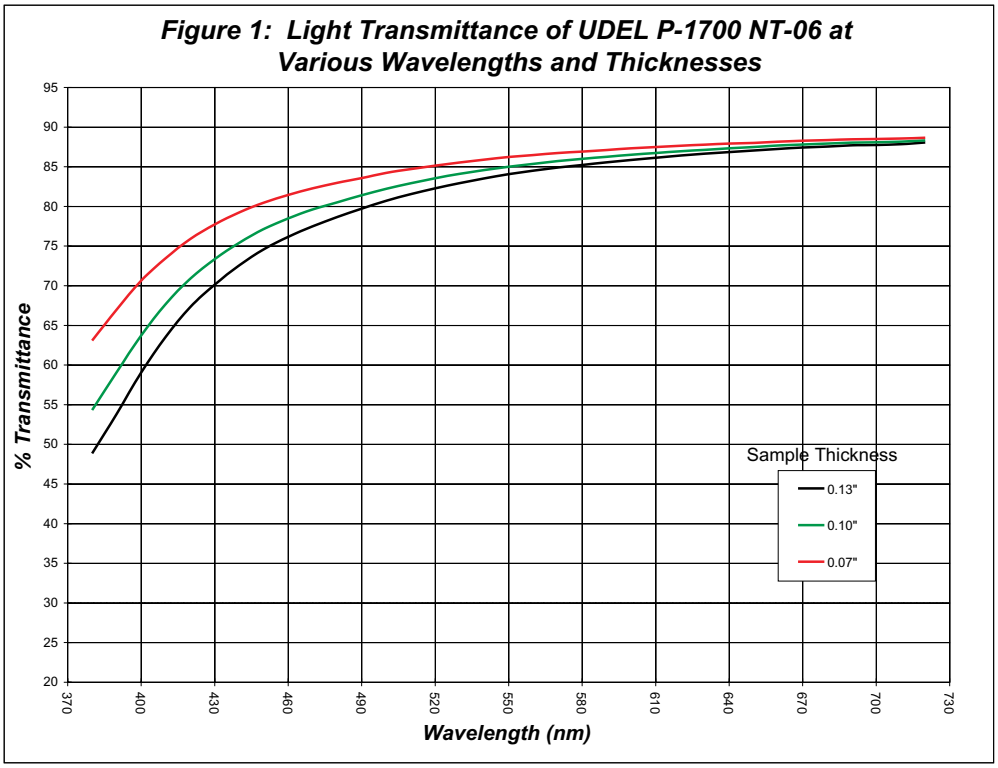


Figure 2: Light Transmittance of RADEL A-300 NT at Various Wavelengths and Thicknesses

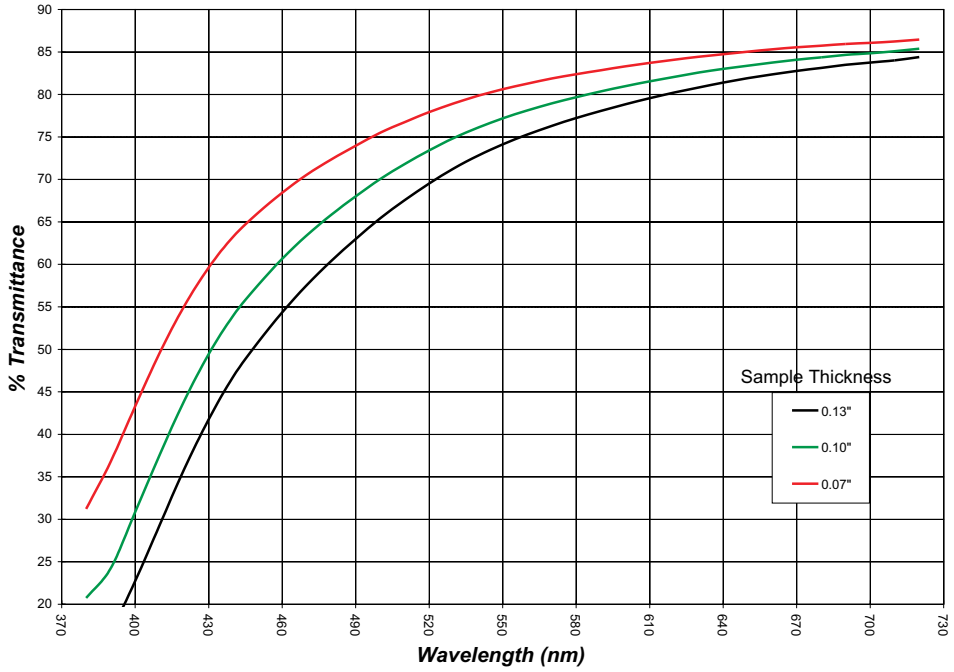


Figure 3: Light Transmittance of RADEL R-5000 NT at Various Wavelengths and Thicknesses

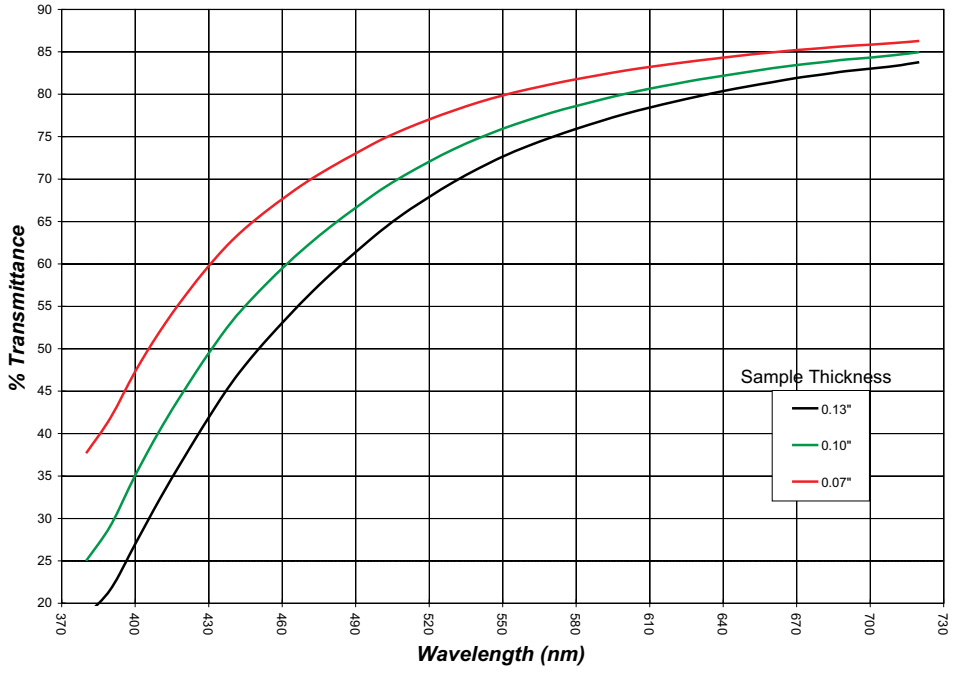
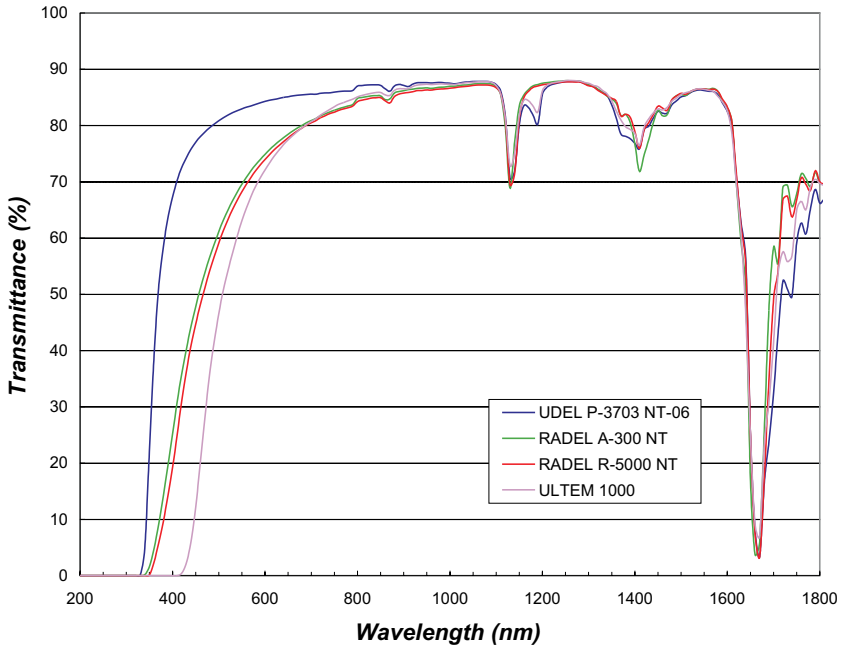


Figure 4: Spectral Transmittance of Various Resins in the 200-1800 nm Wavelength Range (at 2.5 mm thickness)



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, RADEL A and RADEL R natural resins over the wavelength range of 300-1800 nanometers (nm). At the wavelengths of 850, 1300 and 1510 nm, Solvay Advanced Polymers sulfone polymers transmit approximately 85% (87% for UDEL resin), 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 Advanced Polymers sulfone polymers, in the visible region surpass those of commercially available polyetherimides (e.g. ULTEM resin), by a good margin.

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