**R E P O R T**

# Measurement of the transmittance and reflectance of Nanogel samples

**commissioned by**

**Cabot GmbH**

**Report ZAE 2 - 0410 - 02 (2010)**

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# R E P O R T

July 20, 2010

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| **Client:** | | Cabot Nanogel GmbH<br>Mr. Georg Gertner<br>Industriepark Höchst, D660<br>65926 Frankfurt am Main |
| **Your Order:** | | 345 OS Rev – 0 dated 31/03/2010 |
| **Our Offer:** | | 202 / 100028 dated 22/03/2010 |
| **Our Order No.:** | | 203 / 100044 |
| **Subject of Investigation:** | | Measurement of the transmittance and reflectance of Nanogel samples |
| **Measuring Devices:** | | Integrating sphere arrangement, photodiodearray spectrometer, FTIR-spectrometer |
| **ZAE Employees Involved:** | | Dr. W. Körner |
| **Number of** | **Pages:** | 7 |
| | **Figures:** | 5 |
| | **Tables:** | 2 |

# 1 Aim of the Investigation

The normal-hemispherical transmittance and reflectance of Nanogel layers was determined in the solar spectral range. The samples consist of **Nanogel TDL 302** with a thickness of 10 mm, 25 mm and 60 mm and **Nanogel TLD 301** with a thickness of 10 mm and 60 mm. Additionally the normal-hemispherical transmittance and reflectance of a layer of **Nanogel TDL 302** with a thickness of 10 mm was determined in the infrared spectral range (wavelengths between 2 µm and 35 µm).

# 2 Apparatus

The transmittance and reflectance of the samples in the solar spectral range was measured using an integrating sphere arrangement with a sphere diameter of 70 cm and a sample port size of 15 cm. The samples were filled into sample holders with a diameter of 15 cm. The walls of the sample holder were coated with a high reflecting metallic film (solar reflectance > 0.9) to compensate for lateral losses. Front and backside of the sample were covered with films which show a high transmittance in the solar spectral range.

Additional transmittance measurements in the visual spectral range were performed using a smaller integrating sphere (diameter 30 cm) using a large area illumination and a photodiodearray-spectrometer with a high spectral resolution.

Transmittance and reflectance of the front and backside films are known. The transmittance and reflectance of the system film – Nanogel layer – film can be calculated using the same algorithms used for triple glazing. Reversing this algorithm the transmittance and reflectance of the Nanogel layer can be determined from the measured data of the system.

The measurement of the infrared transmittance and reflectance of a 10 mm thick layer of Nanogel TLD 301 were performed using a FTIR spectrometer Bruker IFS 66V equipped with an integrating sphere attachment with a horizontal sample position. The Nanogel layer is covered with a polyethylene film on one side, the incoming radiation reaches the uncovered side for both transmittance and reflectance measurements.

# 3 Results

Figures 1 shows the measured normal-hemispherical transmittance of both samples (including the two cover films), figure 2 the measured normal-hemispherical reflectance.

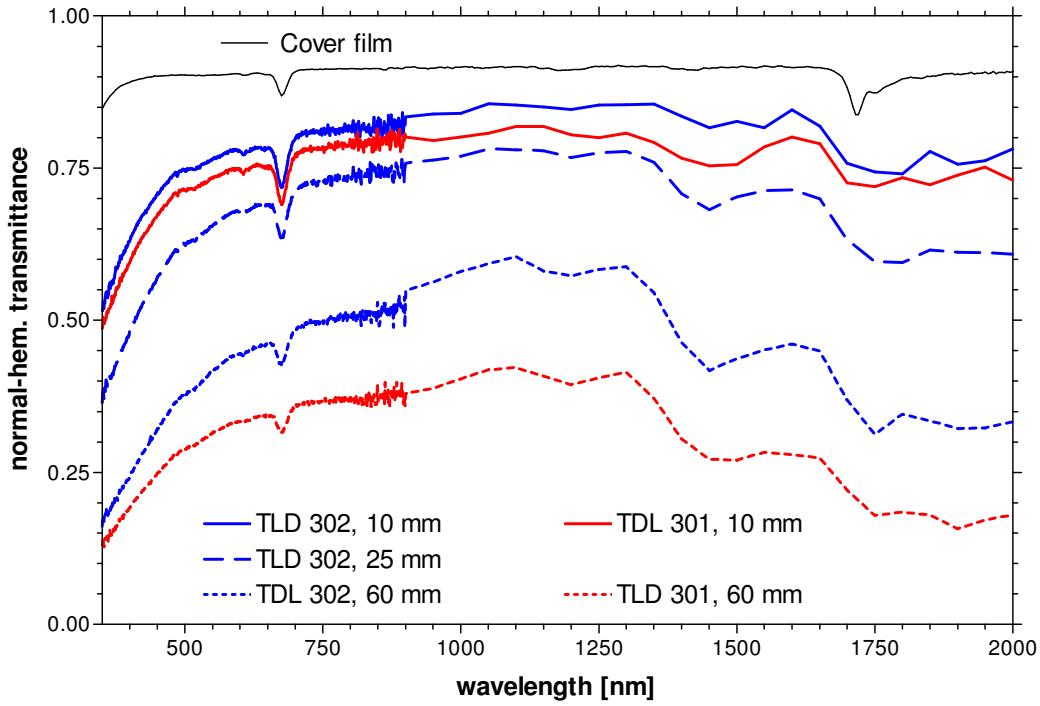


**Figure 1:** *Spectral normal-hemispherical transmittance of the different Nanogel layers including cover films. Additionally the transmittance of the cover film is shown.*

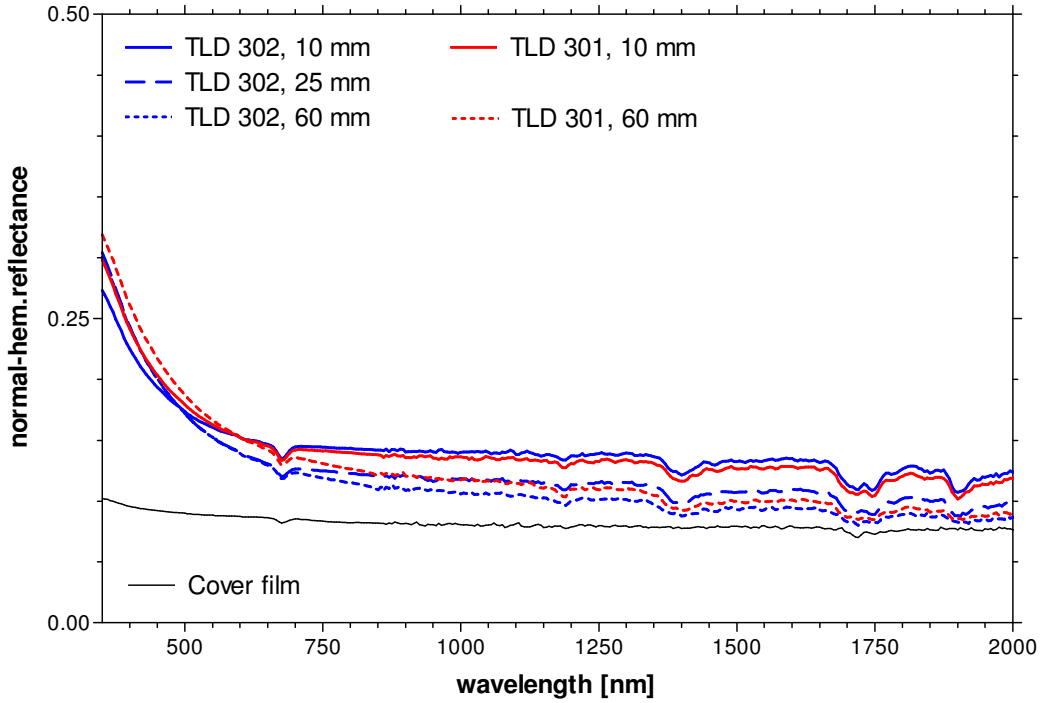


**Figure 2:** *Spectral normal-hemispherical reflectance of the different Nanogel layers including cover films.*

From this values the normal-hemispherical transmittance and reflectance of the Nanogel layers was calculated (figure 3 and 4). At the same thickness the transmittance of TDL 302 is significantly higher than that of TDL 301. The reflectance of all samples is very small at wavelengths above about 800 nm.

Figure 5 shows the transmittance and reflectance of a 10 mm thick layer of Nanogel TDL 302 in the infrared spectral range. In the infrared spectral range at wavelengths above about 2.5 µm the transmittance of the Nanogel layer is small except a window between about 3.5 µm and 5 µm. The reflectance of the Nanogel layer is negligible in the infrared spectral range.

Using the spectral transmittance values the visual and solar transmittance was calculated according to EN 410. The resulting values are shown in table 1 and 2.

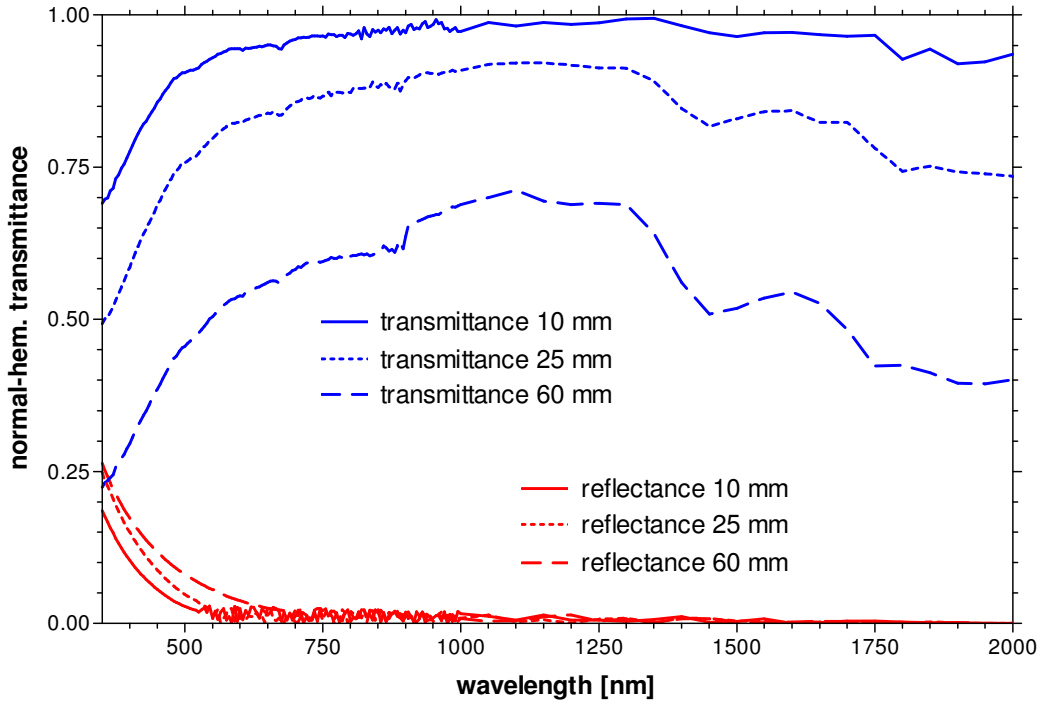


**Figure 3:** *Spectral normal-hemispherical transmittance and reflectance of Nanogel layers TDL 302 depending on the layer thickness.*

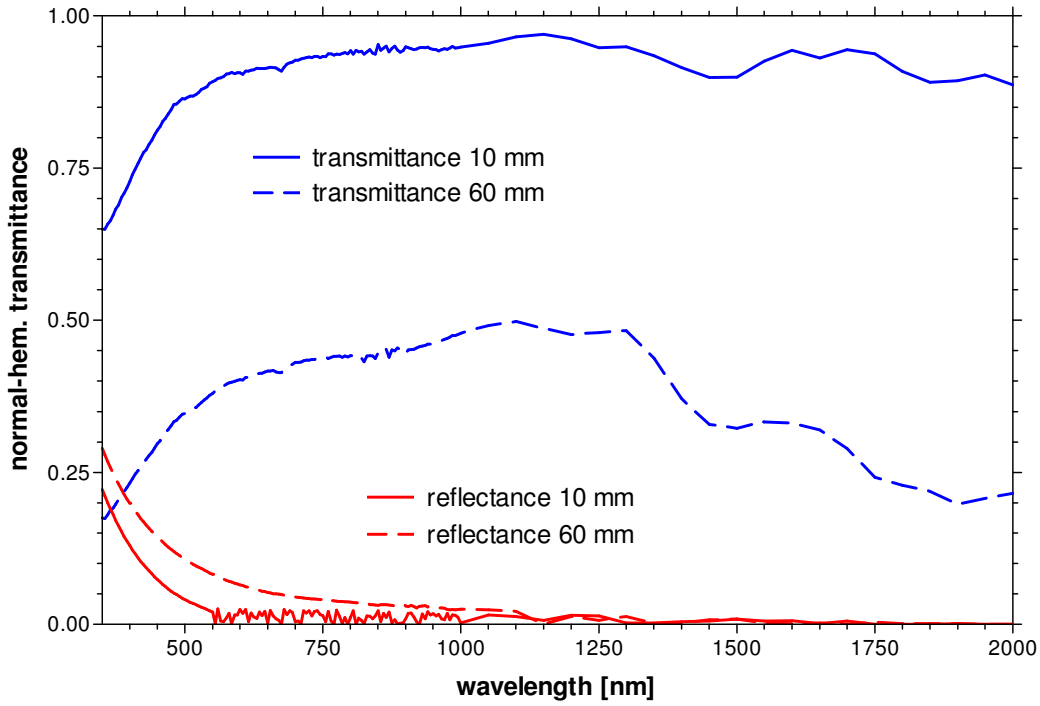


**Figure 4:** *Spectral normal-hemispherical transmittance and reflectance of Nanogel layers TDL 301 depending on the layer thickness.*

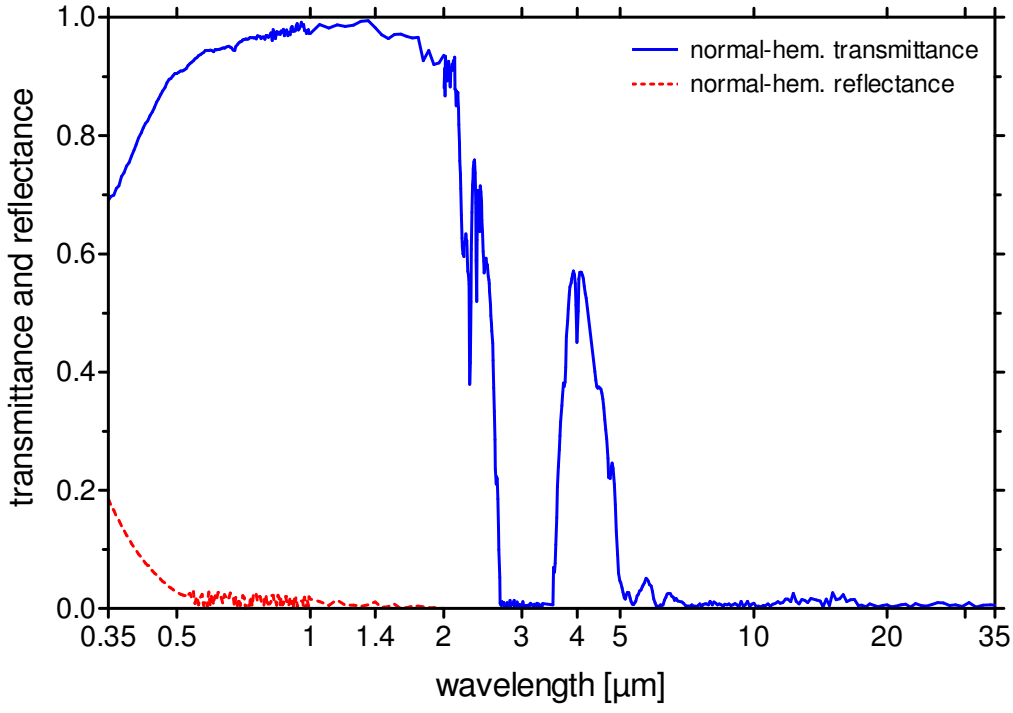


**Figure 5:** *Spectral normal-hemispherical transmittance and reflectance of a layer of Nanogel TDL 302 with a thickness of 10 mm in the infrared spectral range.*

**Table 1:** *Solar and visual normal-hemispherical transmittance ($\tau_{solar}$ and $\tau_{vis}$) and reflectance ($\rho_{solar}$ and $\rho_{vis}$) of Nanogel TDL 302 depending on the thickness of the layer.*

| Sample thickness | $\tau_{solar}$ | $\tau_{vis}$ | $\rho_{solar}$ | $\rho_{vis}$ |
|---|---|---|---|---|
| 10 mm | 0.93 | 0.93 | 0.03 | 0.02 |
| 25 mm | 0.81 | 0.80 | 0.04 | 0.02 |
| 60 mm | 0.53 | 0.50 | 0.05 | 0.06 |

**Table 2:** *Solar and visual normal-hemispherical transmittance ($\tau_{solar}$ and $\tau_{vis}$) and reflectance ($\rho_{solar}$ and $\rho_{vis}$) of Nanogel TDL 301 depending on the thickness of the layer.*

| Sample thickness | $\tau_{solar}$ | $\tau_{vis}$ | $\rho_{solar}$ | $\rho_{vis}$ |
|---|---|---|---|---|
| 10 mm | 0.89 | 0.89 | 0.03 | 0.02 |
| 60 mm | 0.38 | 0.38 | 0.07 | 0.08 |

Würzburg, July 20, 2010

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