

# Novel UV-transparent 2-component polyurethane resin for Chip-on-Board LED micro lenses

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## Abstract

An optical high-performance plastic based on polyurethane elastomer (PU) was developed, which combines excellent UV transparency with high thermal stability, good hardness, high surface tension and a long pot life. The material is well suited for microlens applications for Chip-on-Board (CoB) LED technology.

## Goal

Lighting optics with micro lenses and LEDs must be manufactured in a particularly cost-effective and flexible manner. The major challenge is to achieve excellent transparency, high temperature stability, good mechanical strength and long-term stability of the polymers.

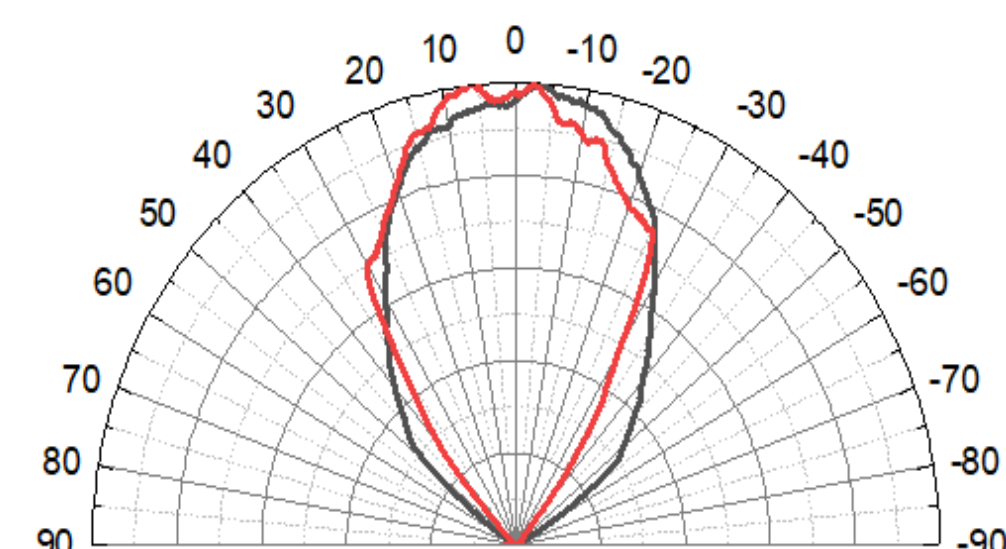
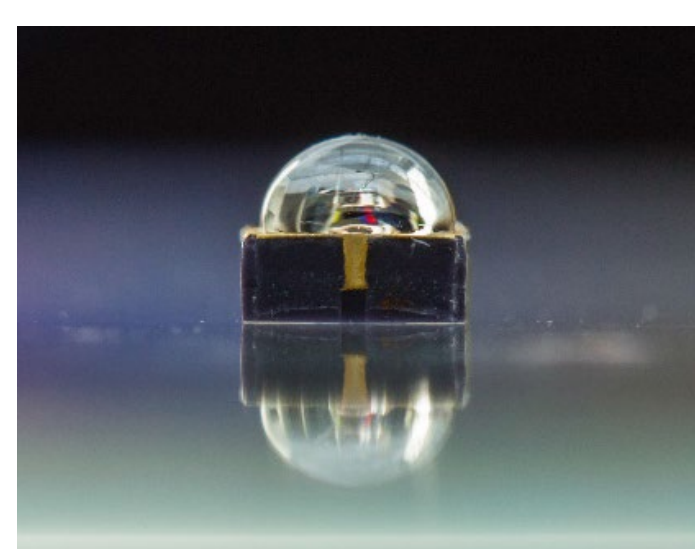
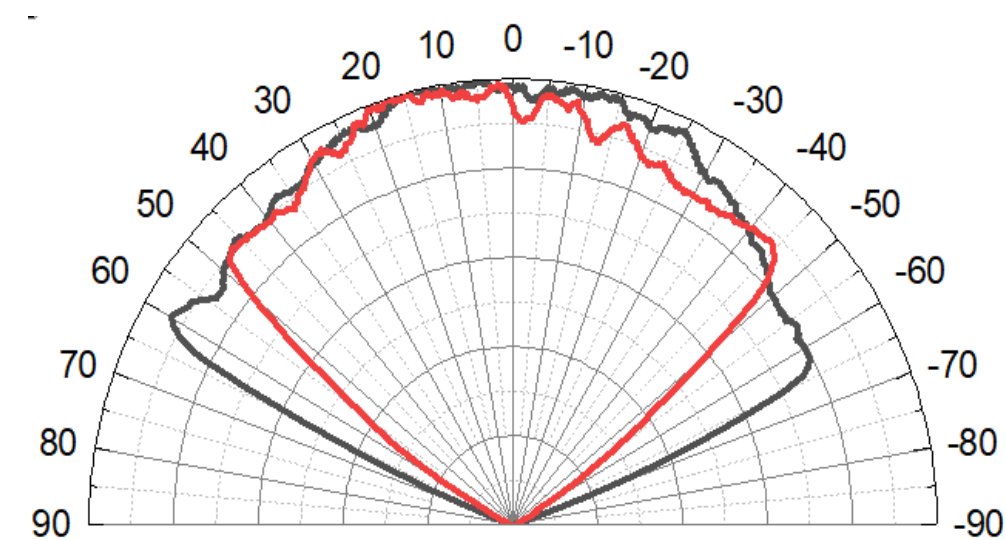
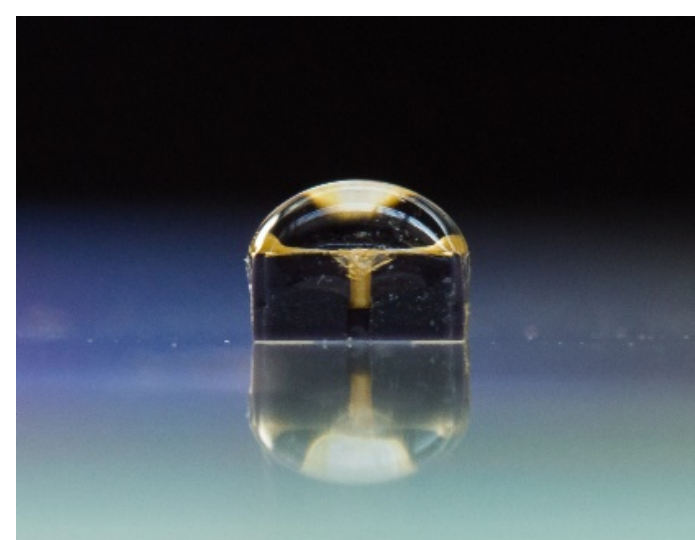
## PU material and component specification

Polyurethane resPUR	OT-3000	OT-T24000	OT
<b>A-component</b>	Polyester polyol		
Polyol OH content [mg KOH/g]	> 130	> 50	> 130
<b>B-component</b>	P-MDI**	HDI*	HDI*

\*Aliphatic isocyanate hexamethylene diisocyanate oligomer (HDI)

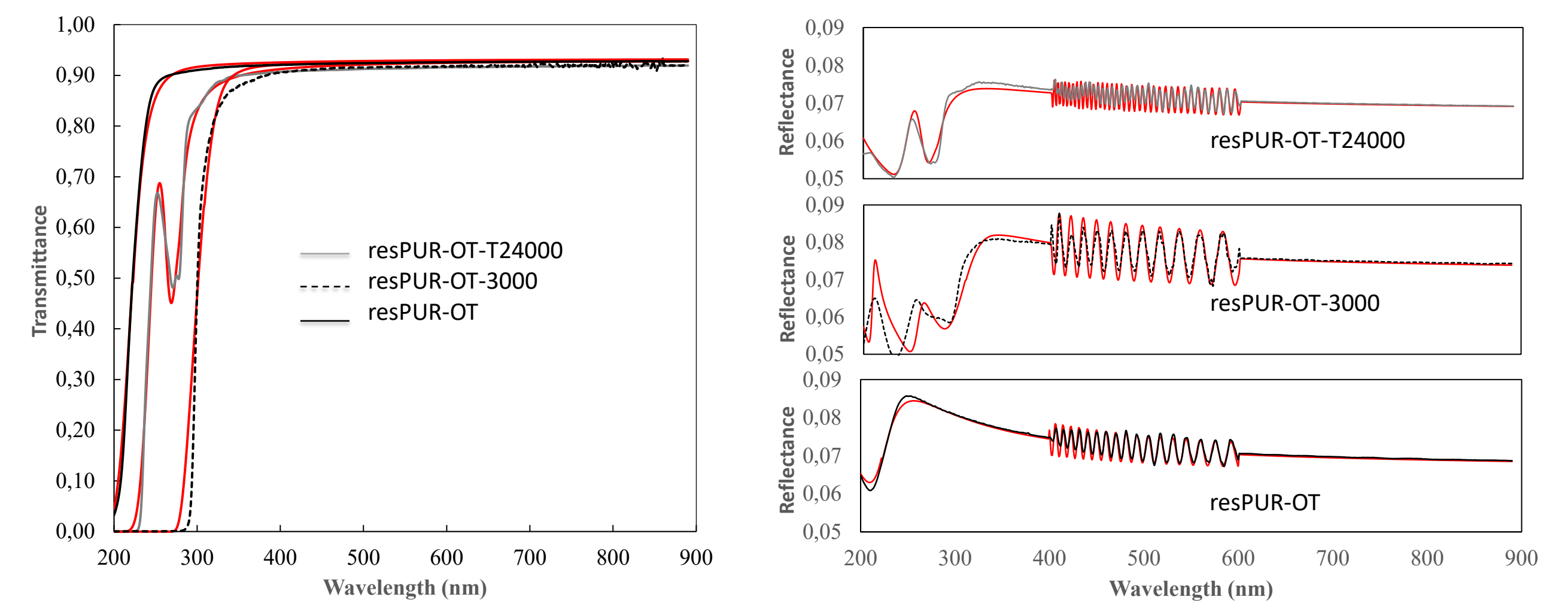
\*\*Aromatic methylenediphenyl diisocyanate polymers (P-MDI)

## Packaging and lens forming

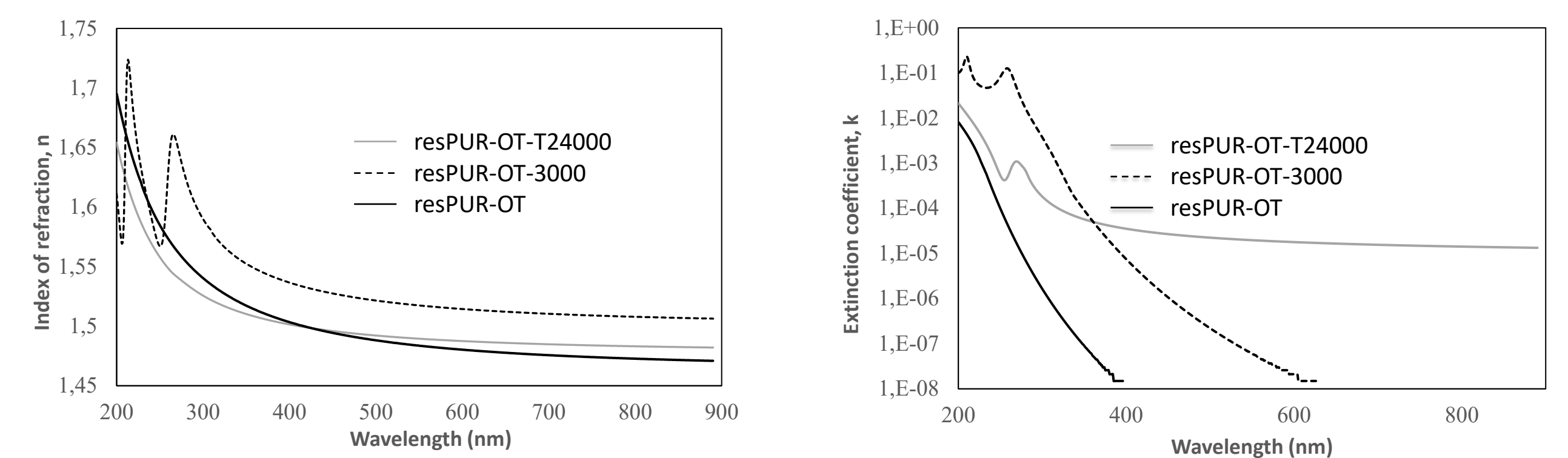


Fabrication results dome-type package of InGaN-CoB-LED with resPUR-OT at different surface tension and corresponding light distributions at  $\lambda = 525$  nm.

## Optical properties

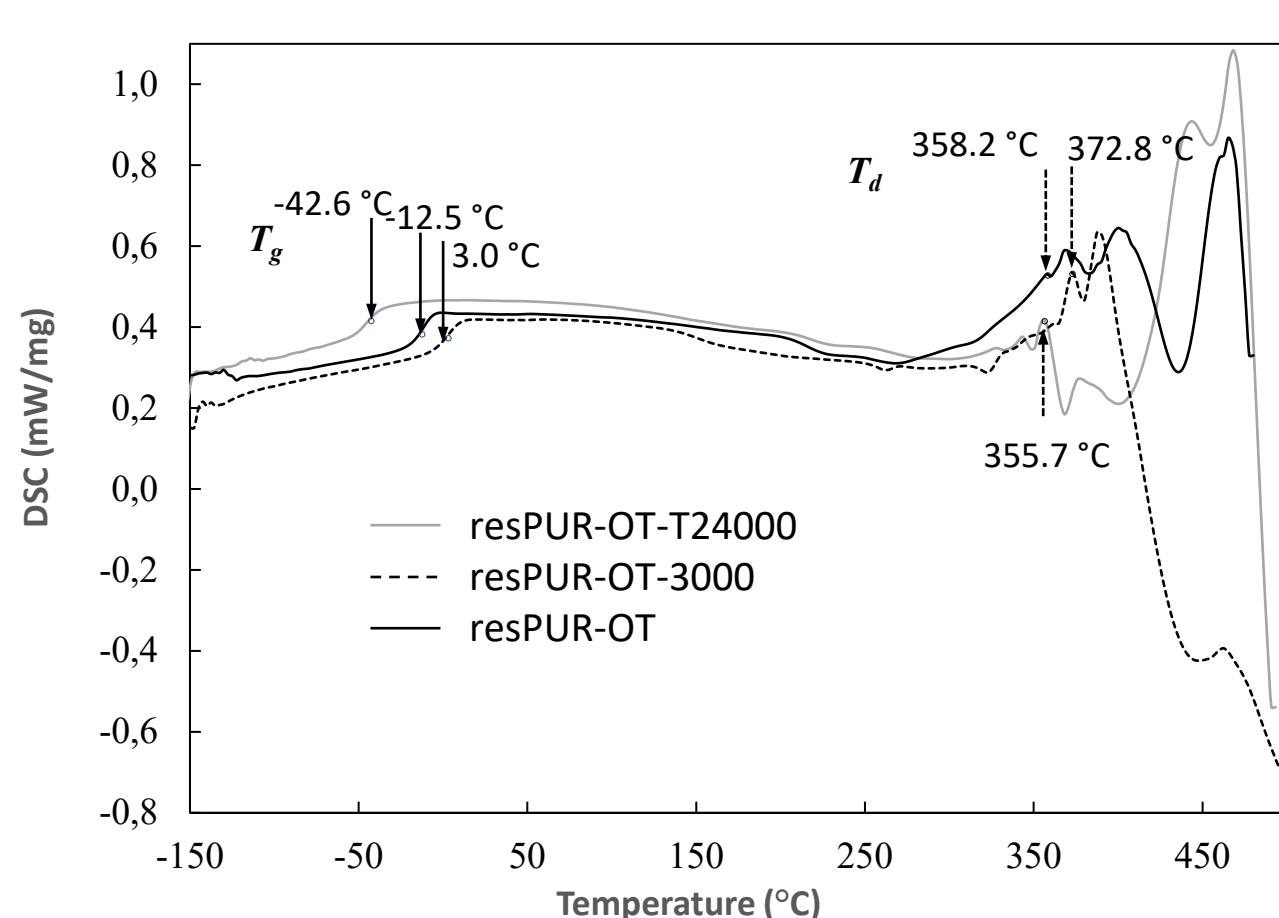


Simulated (red) and experimental (black) transmission and reflection spectra of PU thin films, measured with the low resolution ( $\lambda = 200 - 890$  nm) and superimposed with high-resolution reflection ( $\lambda = 400 - 600$  nm) spectrometer. The thin film interferences are used to determine the film thickness.

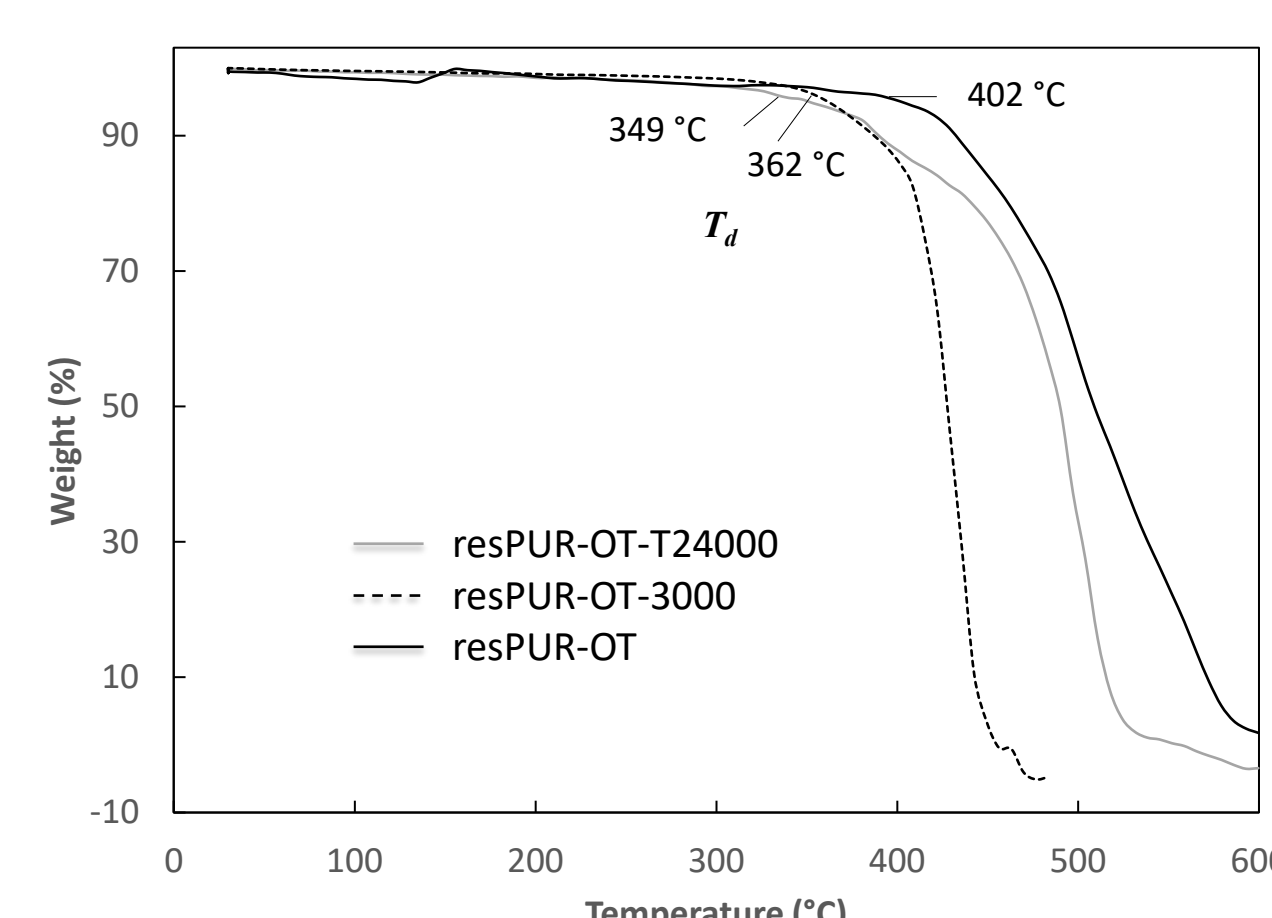


Optical properties of PU, refractive index  $n$  and extinction coefficient  $k$  determined by reflection and transmission measurement and Tauc-Lorentz [1, 2] and Lorentz exciton [3 - 5] oscillator model fit of thin films and thick plane-parallel plates of PU. The relatively high  $k$  in the long wavelength region of resPUR-OT-T24000 is caused by the exciton absorption and scattering effect.

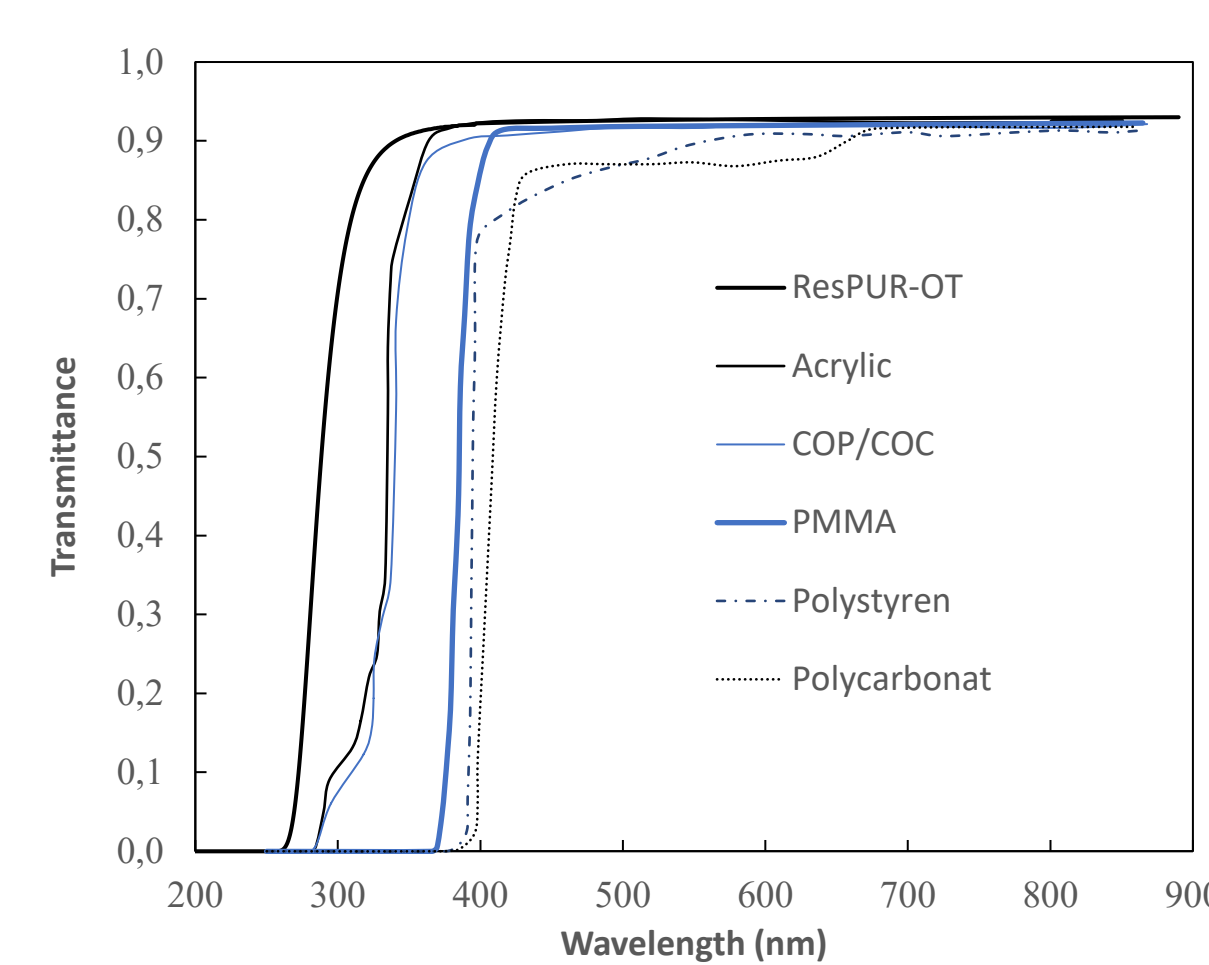
## Thermal properties



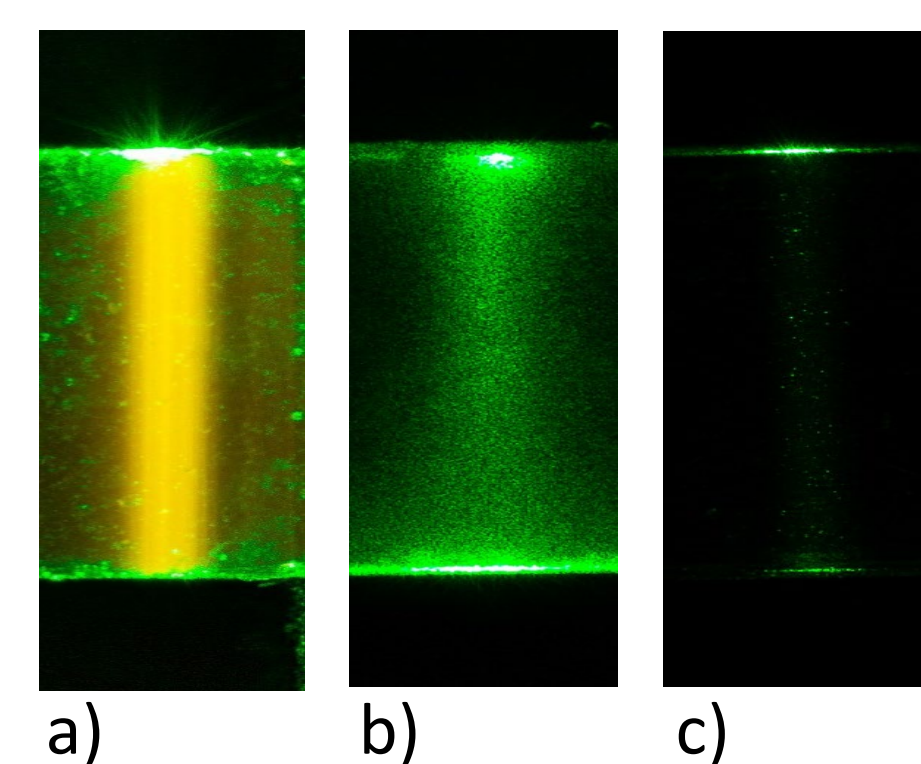
Differential scanning calorimetry (DSC) measurements at temperatures from -150 to 500 °C. The points indicate the glass transition temperatures  $T_g$  and the degradation temperatures  $T_d$  of the PU. Secondary reactions of the isocyanates are shown in the range from 150 to 220 °C.



Thermogravimetry (TGA) curve of the polyurethane. Temperature program: Heat from 20 °C to 600 °C with heating rate of 10 °C/min, in nitrogen atmosphere with a purge rate of 10 mL/min. Marked are the 5 % weight loss temperatures.



Transmittance of optical polymers [6] at film thickness of 3.174  $\mu\text{m}$  compared to resPUR-OT.



Laser scattering properties (532 nm Nd:YAG laser beam, 8 mm thick PU rods):  
a) resPUR-OT-3000 material shows fluorescence and has a scattering coefficient of  $k_s = 5.1 \cdot 10^{-6}$   
b) resPUR-OT-T24000,  $k_s = 7.5 \cdot 10^{-6}$   
c) resPUR-OT,  $k_s = 3.9 \cdot 10^{-7}$   
The scattering coefficient  $k_s$  was determined by using Lambert-Beer's law.

## References:

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## Summary:

- The optimized material (resPUR-OT) has an excellent transparency, high thermal stability up to 344 °C and provides the possibility of a simple and cost-effective dispensing technique to ensure a stable encapsulation of LEDs with the possibility of lens formation [7, 8].
- The optical properties and the parameters of the band structure of PU can be changed in a wide range by the mixing ratio of the material components.
- The method of determination of optical constants presented here turns out to be a useful approach for the development of optical materials. The result confirms that highly transparent PU can be produced from aliphatic isocyanates and polyester polyol with optimized mixing ratios.