SIMULTANEOUS MEASUREMENT OF CHROMATIC DISPERSION AND THERMAL COEFFICIENTS OF HYGROSCOPIC LIQUIDS

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Chromatic dispersion and thermal coefficients of 3 hygroscopic liquids: ethylene glycol, triethylene glycol and propane-1,2-diol (propylene glycol) were measured in the range from 390 to 1070 nm for temperatures from 1 to 45ºC. A modified Abbe refractometer was utilised. A special care was taken to avoid contamination of the liquids under the test with water. The measurement uncertainties were analysed. It was noticed that the dependence of the refractive indices on the wavelength and temperature could be factorised in the given range. Thus, Sellmeier equation was fitted to the experimental results for each temperature. Analogically, thermal coefficients were found for each wavelength used and the median was obtained. Both linear and quadratic dependence on temperature were tested.

EXPERIMENTAL SETUP AND RESULTS:

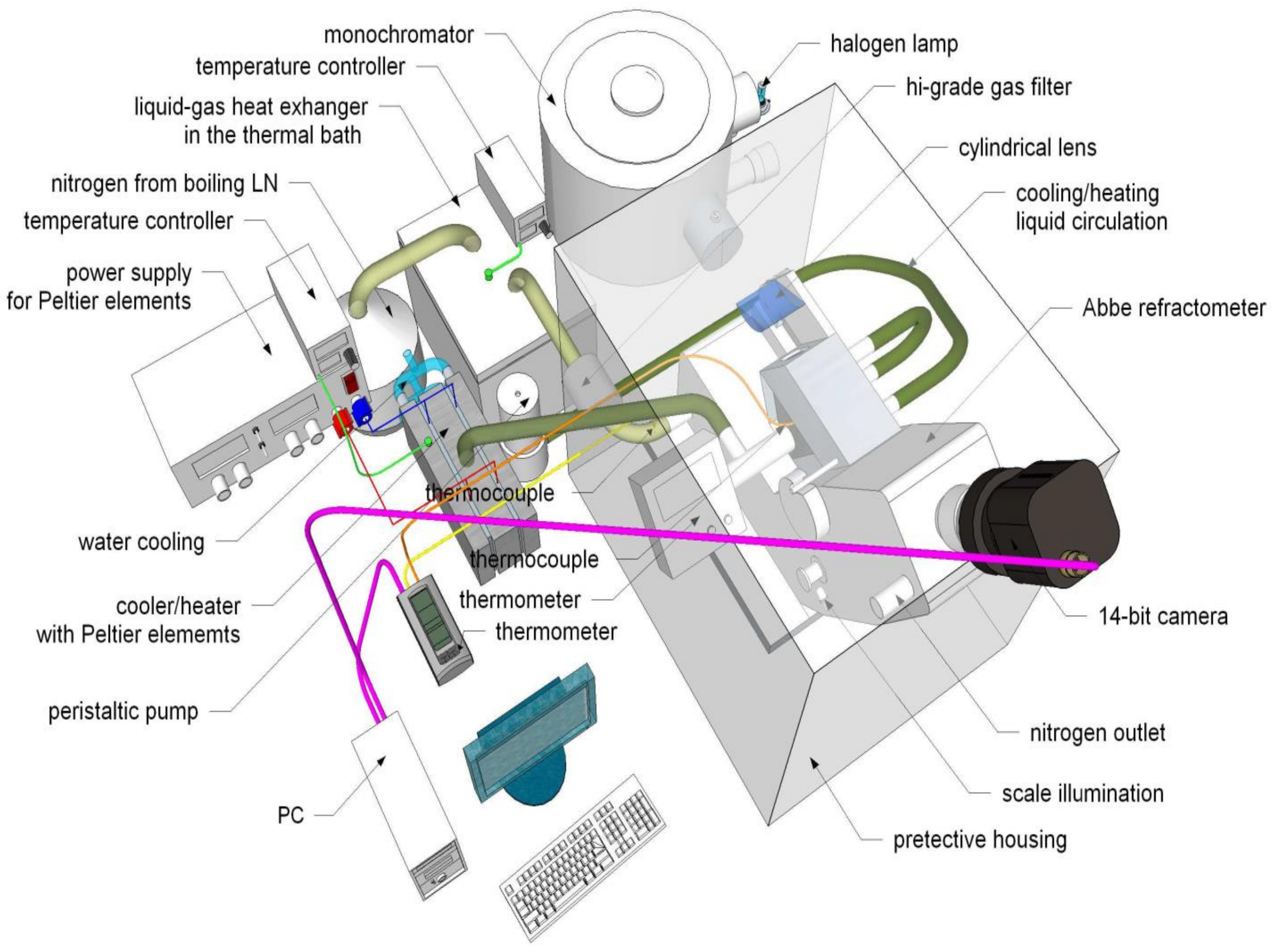

Fig. 1. Drawing of the measurement setup. Protective housing represented schematically.

We used the following samples:

- ethylene glycol, anhydrous, 99.8% Sigma-Aldrich lot # STBG3967V;
- triethylene glycol, 99%, Alfa Aesar lot # 10198029; and
- propylene glycol (propane-1,2-diol), ≥99.5%, Sigma-Aldrich lot # MKC80613V

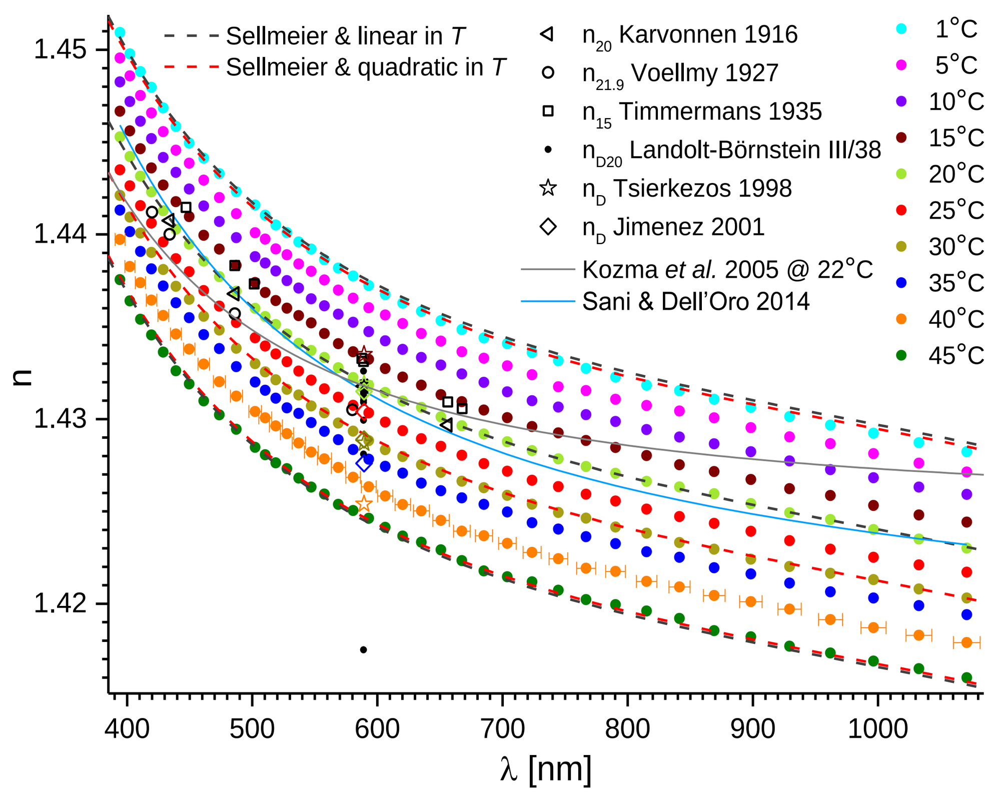

Fig. 1. Refractive index of ethylene glycol versus wavelength and temperature. Dashed lines represent fits with Sellmeier formula (eq. (1)) with parameters from Tab. 1. Black and red respectively: linear and quadratic dependence on temperature. The uncertainty of the wavelength are shown for clarity only for 40ºC.

DATA PROCESSING AND ACCURACY CONSIDERATIONS:

Median n for each l was found and a two-pole Sellmeier equation

$$n^2(\lambda) = A + \frac{B_{IR}\lambda^2}{\lambda^2 - C_{IR}} + \frac{B_{UV}\lambda^2}{\lambda^2 - C_{UV}} \quad (1)$$

was fitted, where A accounts for the short-wavelength absorption contributions to n at longer wavelengths, while B_{IR} and B_{UV} are absorption resonance strengths at wavelengths C_{IR}½ and C_{UV}½ respectively, for λ in µm.

The procedure was repeated for all studied liquids. It was later tested whether introducing a quadratic term into the temperature dependence

$$n(\lambda, T) = n(\lambda, T) + \frac{dn}{dT}\Delta T + \frac{d^2n}{dT^2}\Delta T^2 \quad (2)$$

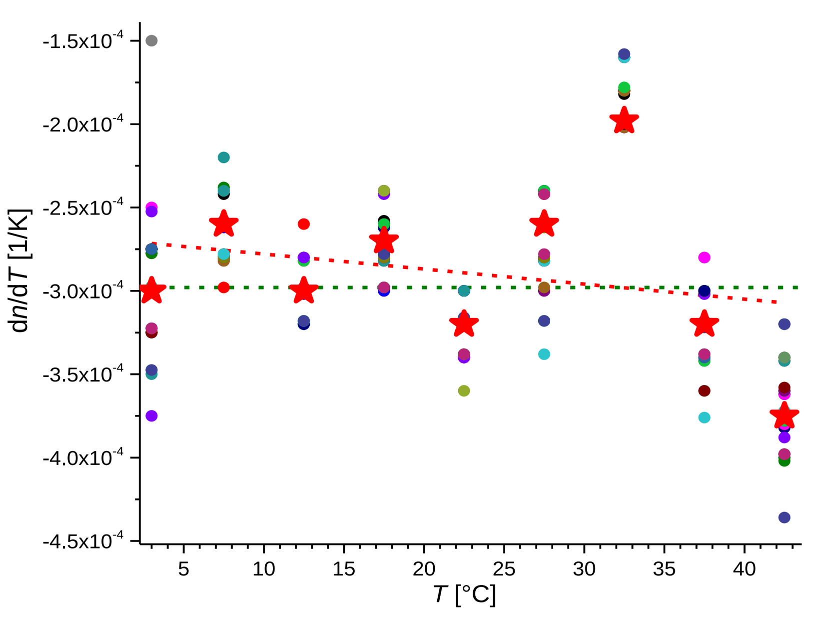

Fig. 4. dn/dT found for each 2 consecutive data points along the T variable for ethylene glycol. The median for for each temperature is shown as larger red asterisks. An overall median of $dn/dT = -3 \times 10^{-4} \pm 5 \times 10^{-5}$ is shown with the green dashed line. The linear fit to $\frac{dn}{dT}(T)$ is shown with red dashed line.

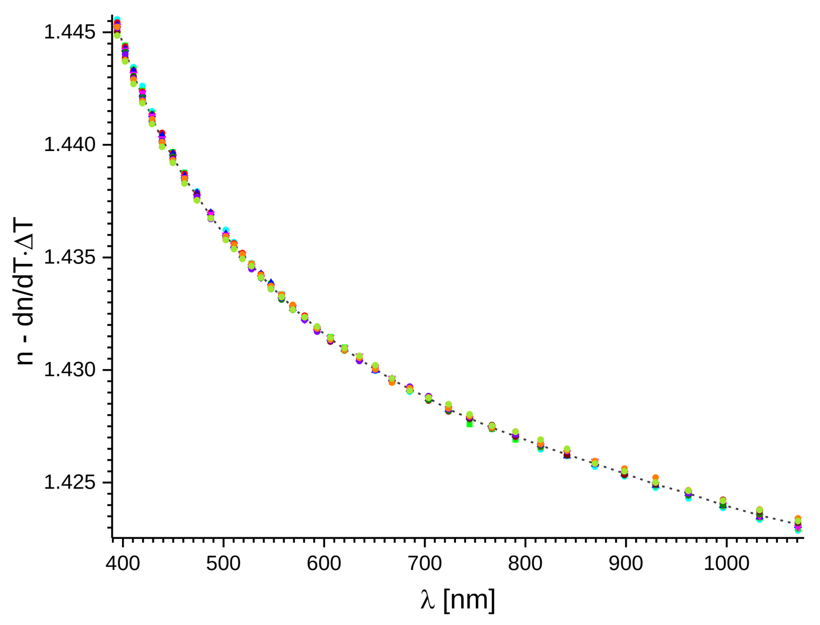

Fig. 5. $n(\lambda)$ traces for all temperatures for EG were linearly shifted to overlap the trace corresponding to 20ºC. The black dashed line shows the median of shifted traces.

liquid	Sellmeier equation coefficients				
	A	B_{IR}	C_{IR}	B_{UV}	C_{UV}
ethylene glycol	0.6 ± 0.8	0.0076 ± 0.0051	2.5 ± 0.7	1.4 ± 0.8	0.007 ± 0.004
propylene glycol	1.50 ± 0.12	0.04 ± 0.06	7. 4 ± 8.8	0.52 ± 0.12	0.017 ± 0.003
triethylene glycol	1.1 ± 0.3	0.005 ± 0.004	2.4 ± 0.8	1.0 ± 0.3	0.011 ± 0.003

Tab. 1 Sellmeier equation coefficients for λ in mm for 3 glycols, found from the presented experiments. Uncertainties represent standard errors.

liquid	thermal coefficients		
	linear only	linear dn/dT + quadratic d^2n/dT^2	
ethylene glycol	$-3.0\times10^{-4} \pm 5\times10^{-5}$	$-2.7\times10^{-4} \pm 3\times10^{-5}$	$-9\times10^{-7} \pm 1\times10^{-6}$
propylene glycol	$-3.4\times10^{-4} \pm 6\times10^{-5}$	$-3.1\times10^{-4} \pm 4\times10^{-5}$	$-8\times10^{-7} \pm 2\times10^{-6}$
triethylene glycol	$-3.4\times10^{-4} \pm 4\times10^{-5}$	$-3.2\times10^{-4} \pm 2\times10^{-5}$	$-7\times10^{-7} \pm 8\times10^{-7}$

Tab. 2 Thermal coefficients for 3 glycols found from the presented experiments. Uncertainties represent standard errors.

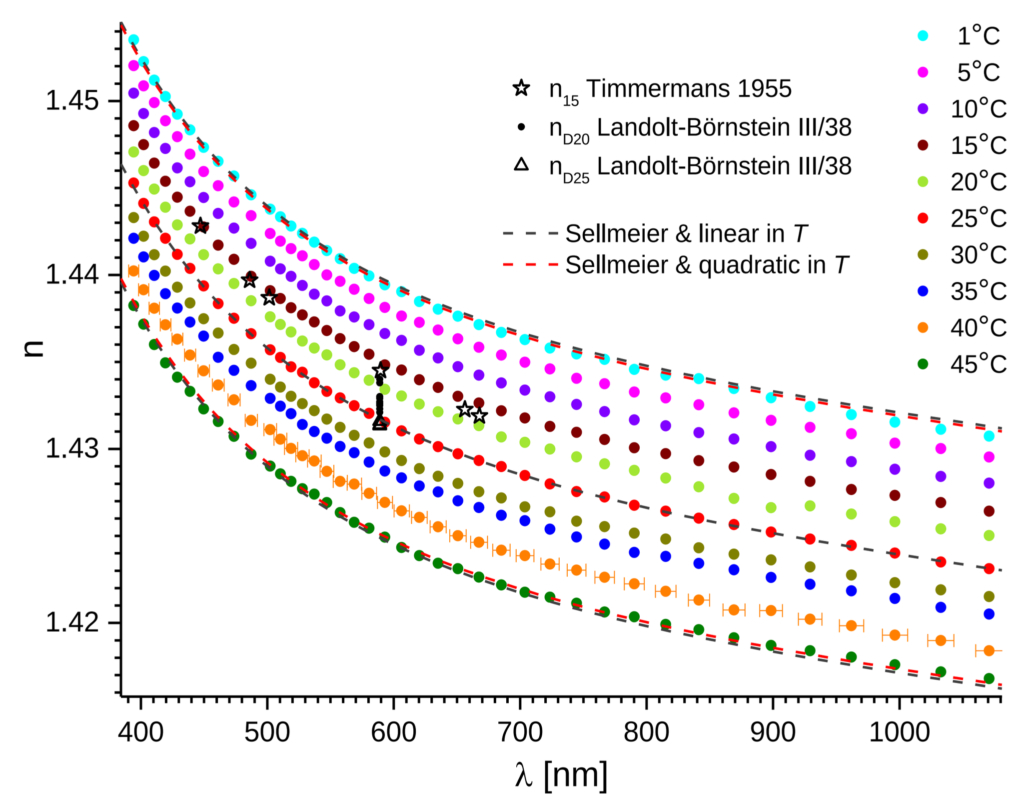

Fig. 2. Refractive index of propylene glycol versus wavelength and temperature. Dashed lines represent fits with Sellmeier formula (eq. (2)) with parameters from Tab. 1. Black and red respectively: linear and quadratic dependence on temperature. The uncertainty of the wavelength are shown for clarity only for 40ºC.

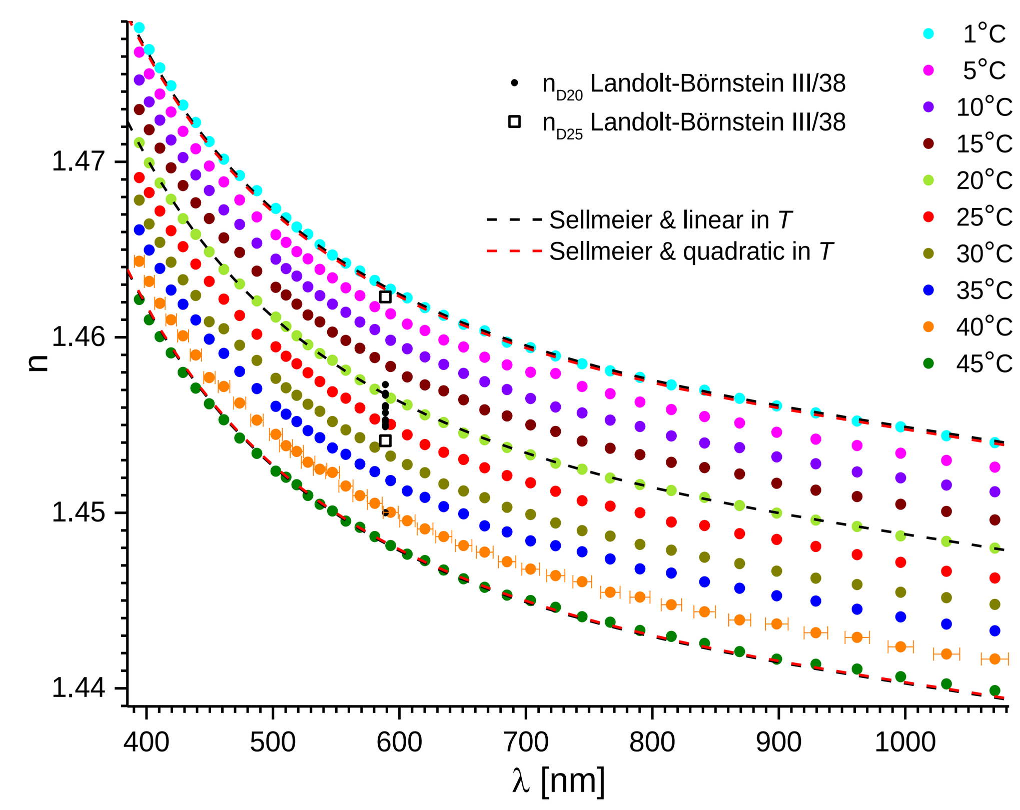

Fig. 3. Refractive index of tetraethylene glycol versus wavelength and temperature. Dashed lines represent fits with Sellmeier formula (eq. (2)) with parameters from Tab. 1. Black and red respectively: linear and quadratic dependence on temperature. The uncertainty of the wavelength are shown for clarity only for 40ºC.

LITERATURE:

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