Tuning the Optical and Rheological Properties of Host-Guest Systems based on an Epoxy acrylate and MMA

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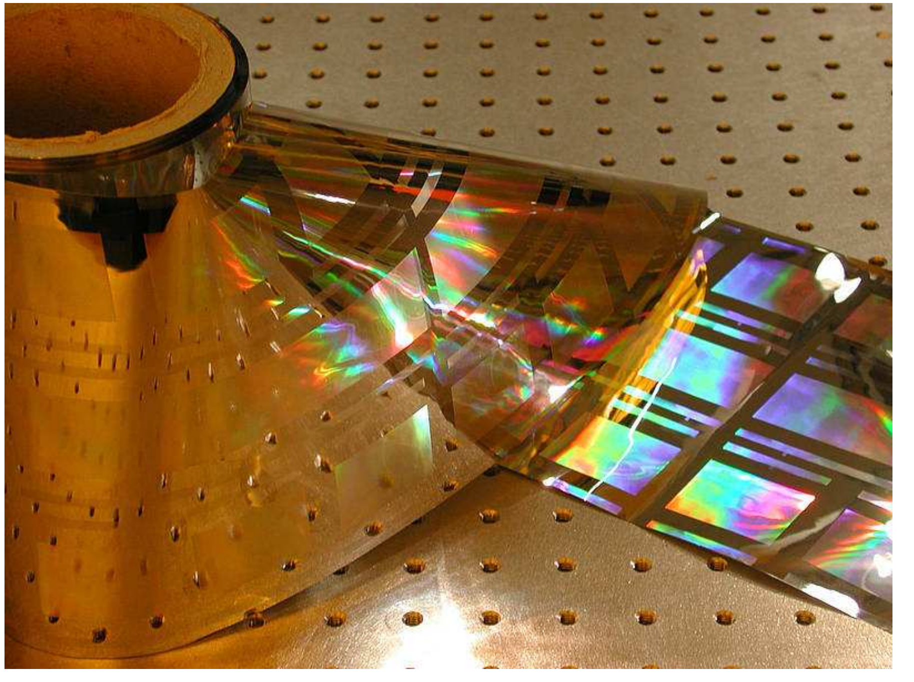
PlanOS
SFB/TRR 123
HOT - Hannoversches Zentrum für optische Technologien
IMTEK - Institut für Mikrosystemtechnik

Planar Optronic Systems

Collaborative Research Center

- Polymer-based sensor network
- Large-area foils
- No electronic components
- Measurement of
  - Temperature
  - Strain
- Sub-projects
  - Suitable materials
  - Construction of fibre optics
  - Light sources
  - Spectrometers / detectors



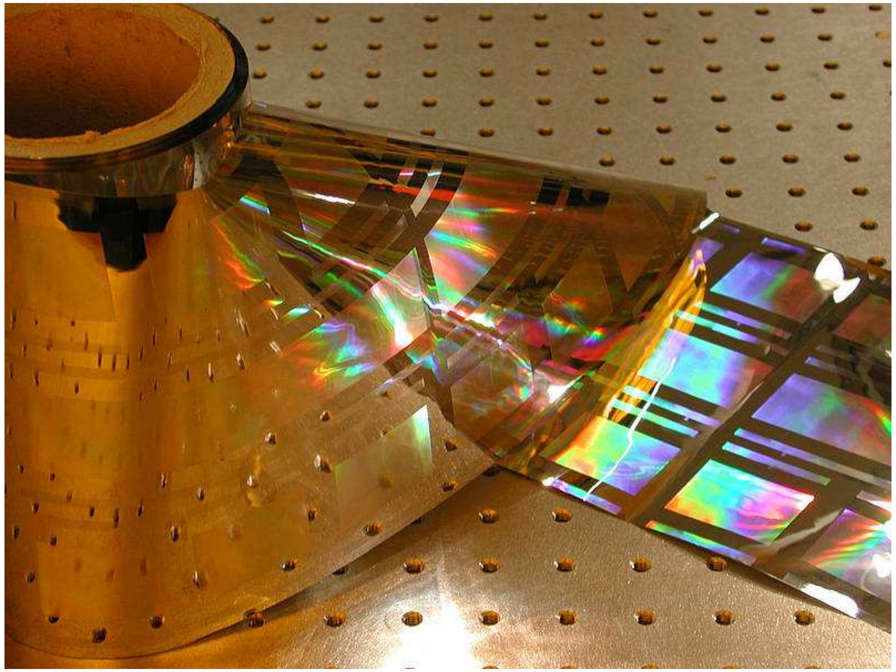
Polymer foil

[http://www.planos.uni-hannover.de]

Planar Optronic Systems

Why polymers?

- Modifiable to application
- Good processability
  - Hot embossing
  - NIL
  - Inkjet-printing
  - …
- Large-scale systems possible
- Thin layers = economic



Polymer foil

[http://www.planos.uni-hannover.de]

Planar Optronic Systems

Tailored polymers

- Adjusting viscosity
- Polymerization by UV-light
- Adjusting refractive indices
- Low optical damping
- Continuous operating temperature

Planar Optronic Systems

Tailoring viscosity

- Comonomer content
- Different shaping / molding processes
  - Inkjet printing
    ≈ 70 mPa·s (@ 70 °C)
  - Offset printing
    ≈ 200 mPa·s (@ RT)
  - Spin coating
    ≈ 100 mPa·s – 1000 mPa·s (@ RT)

Dimatix DMP 2831 [www.electronic-data.com]

Heidelberg Speedmaster SM 52 [www.heidelberg.com]

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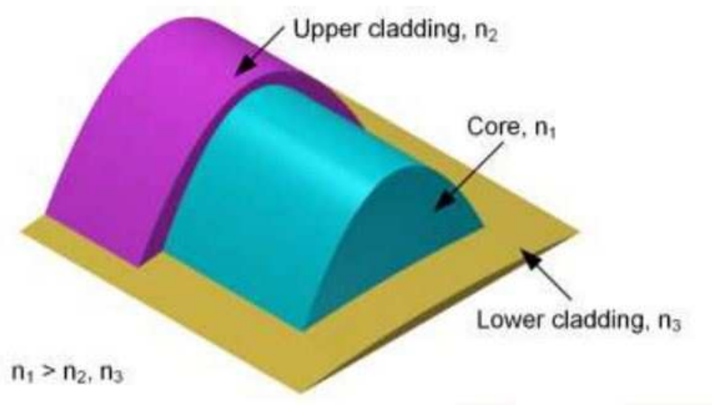
Adjustment of refractive indices

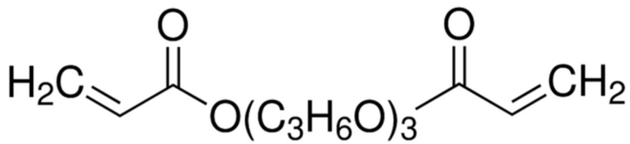
- Comonomer / dopant
- Waveguides
  - Core
  - Cladding
- Coupling structures



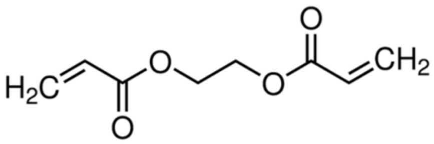
Computed 3D model of printed waveguide (Wolfer, University of Hannover 2013)

Friday, 11:00 Track 2

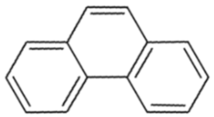
Materials



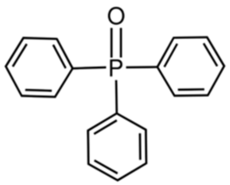
- Prepolymer
  - Syntholux® (SYNTHOPOL), 80 % TPGDA
- Comonomer
  - EGDMA



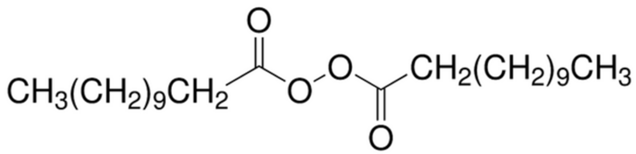
- Dopant
  - Phenanthrene



- UV initiator
  - phosphine oxide



- Thermal initiator
  - lauroyl peroxide



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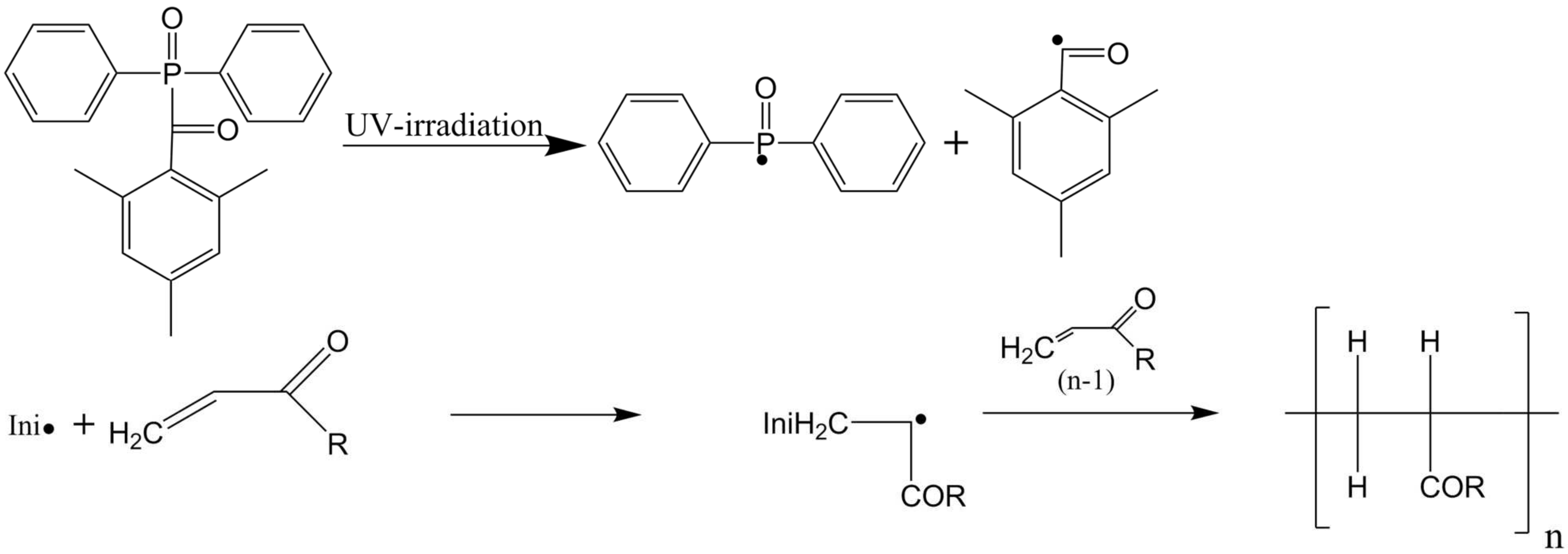
Radical polymerization



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Mixture preparation

- Materials are dispersed
  - up to 30.000 rpm
  - ambient conditions
- Ultrasonic bath

IKA T10 basic

[http://static.coleparmer.com]

- Viscosity measurement
  - Cone and plate rheometer

Bohlin Rheometer CVO 50

[http://mb.uni-paderborn.de/]

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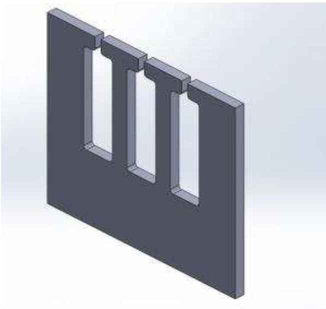
Sample preparation

- For refractive index
  - Casting mold (silicon)
  - Glass plates
  - Fluorine ethylene propylene (FEP) foil
  - Oxygen inhibition



casting mold

Planar Optronic Systems

Sample preparation

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mold assembly

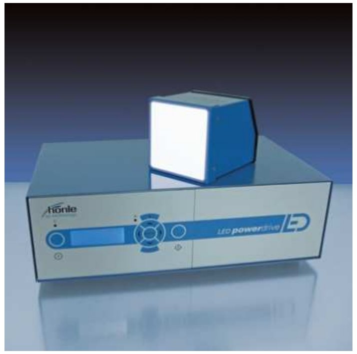
Planar Optronic Systems

Sample preparation

- For refractive index
  - Casting mold (silicon)
  - Glass plates
  - Fluorine ethylene propylene (FEP) foil
  - Oxygen inhibition

- Polymerization
  - Wavelength 405 nm
  - 8 min, 25 % power

mold assembly



Hönle UV-Spot 100

[www.hoenle.de]

Planar Optronic Systems

Sample preparation

- For refractive index
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  - Oxygen inhibition

mold assembly

- Polymerization
  - Wavelength 405 nm
  - 8 min, 25 % power

polymerized sample

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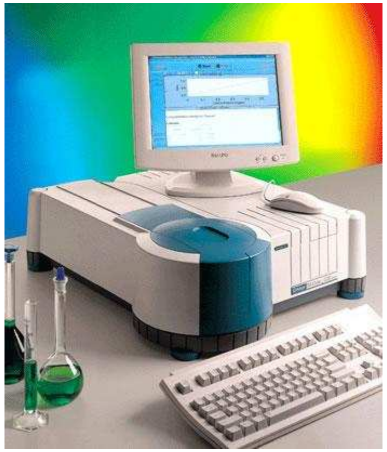
Sample characterization

- Refractive indices
  - Abbe-refractometer
  - Multi-wavelength
- Optical damping
  - UV-Vis spectroscopy
- Differential scanning calorimetry (DSC)
  - Glass transition temperature

ATAGO DR-M2/1550

[www.atagorus.ru]

refractometer surface



Varian Cary 50 UV-Vis

[www.speciation.net]

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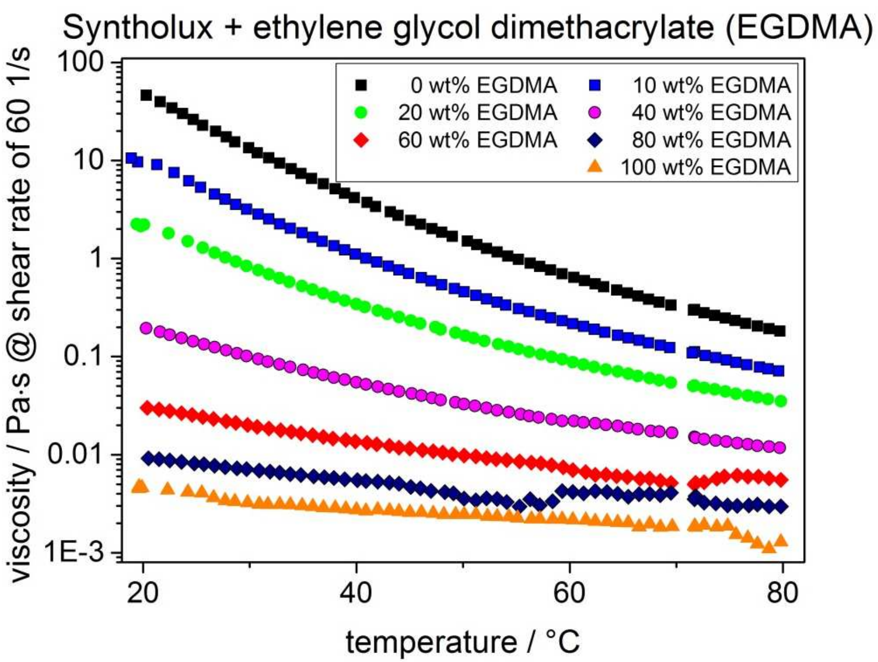
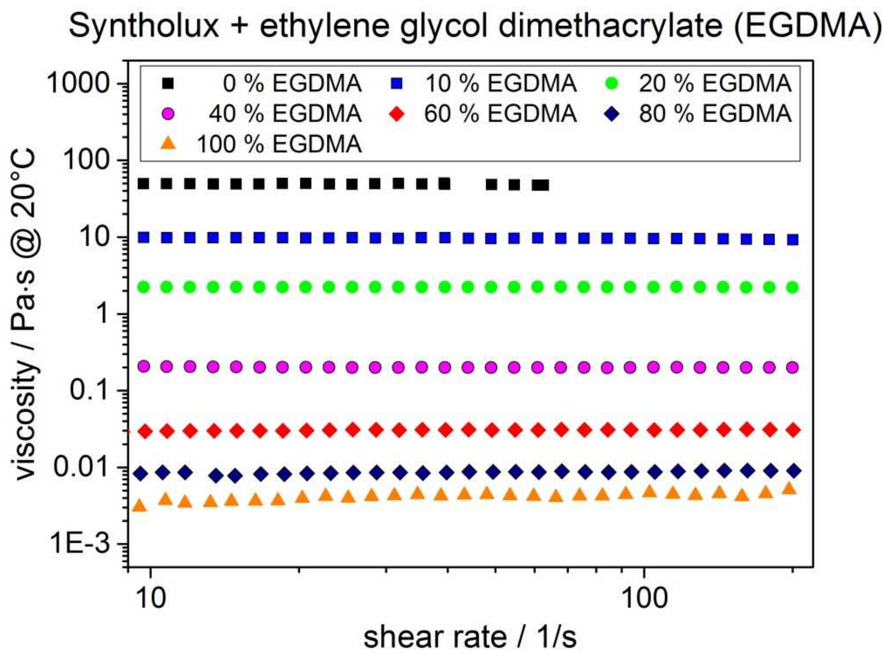
Viscosity Syntholux + EGDMA

- Temperature dependency
- Newtonian behavior





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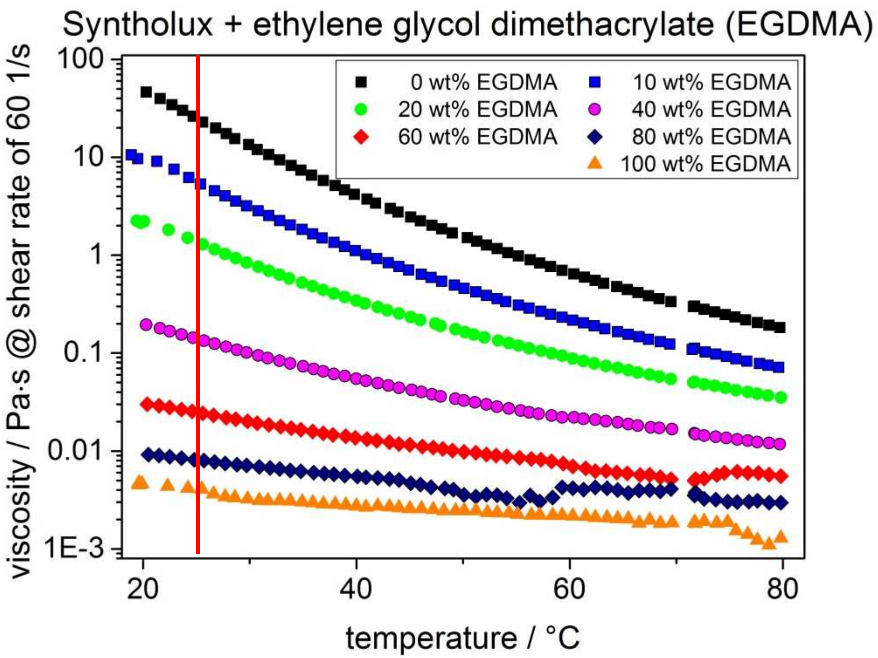
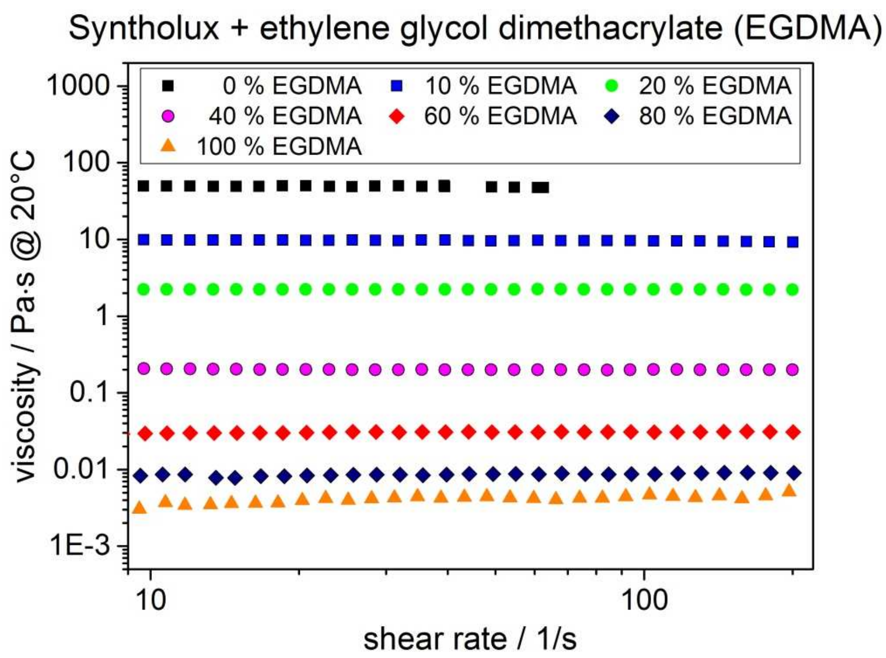
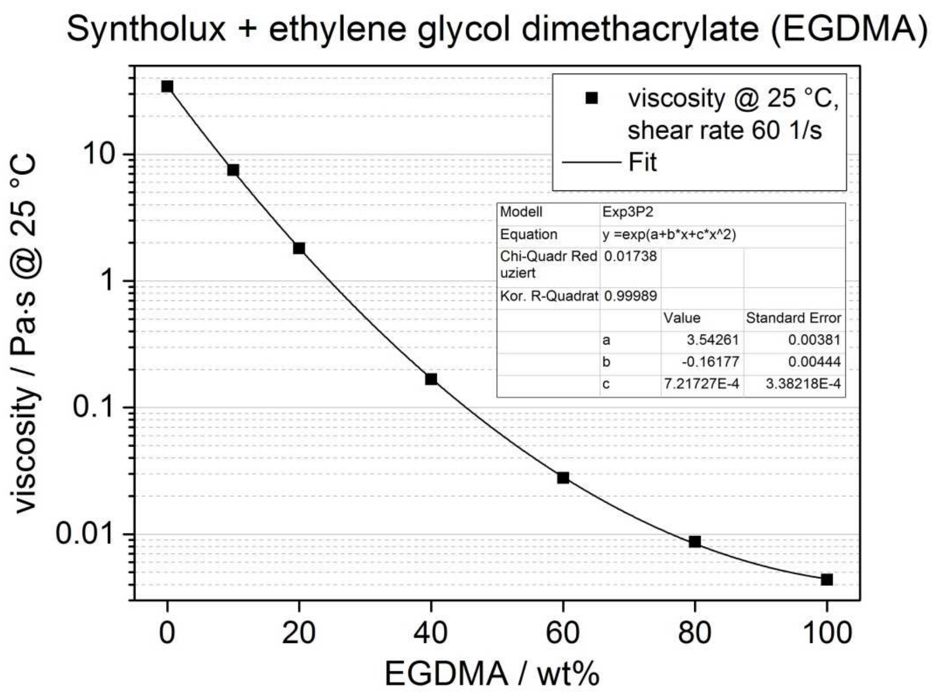




Planar Optronic Systems

Viscosity Syntholux + EGDMA

- Temperature dependency
- Newtonian behavior
- Fitting curve for easy lookup



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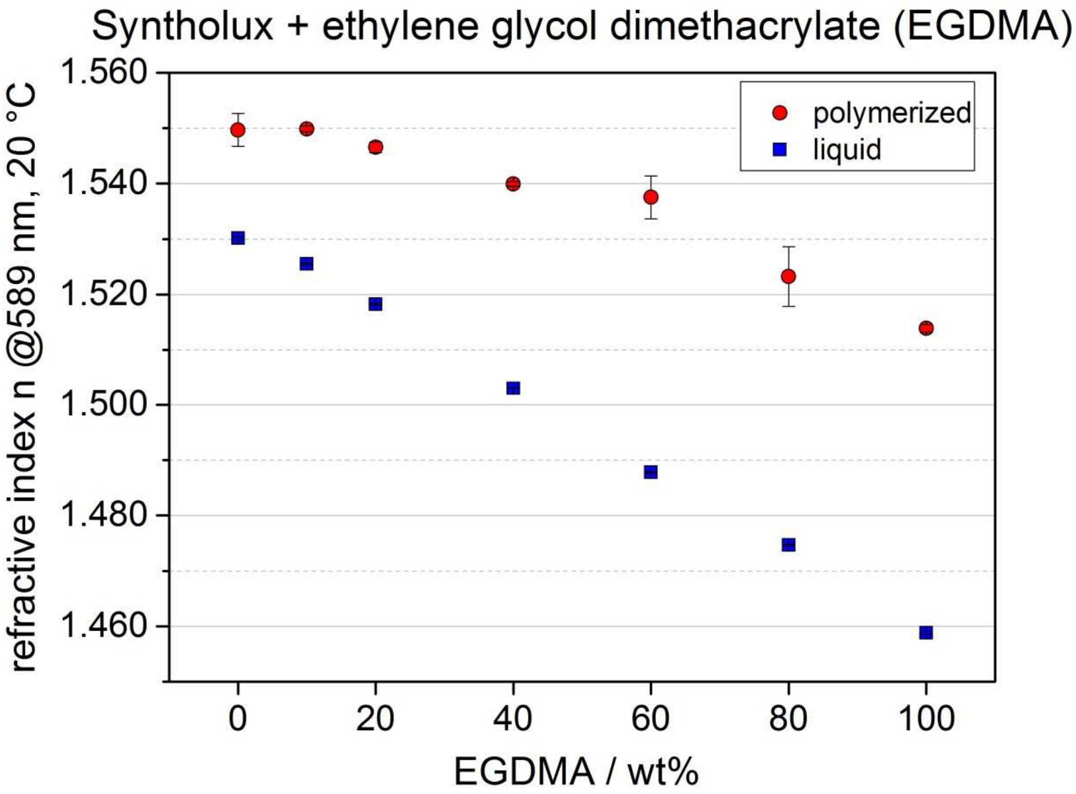
Refractive index

- Liquid
- Polymerized
  - 1.55 > n > 1.515
  - Shift increases



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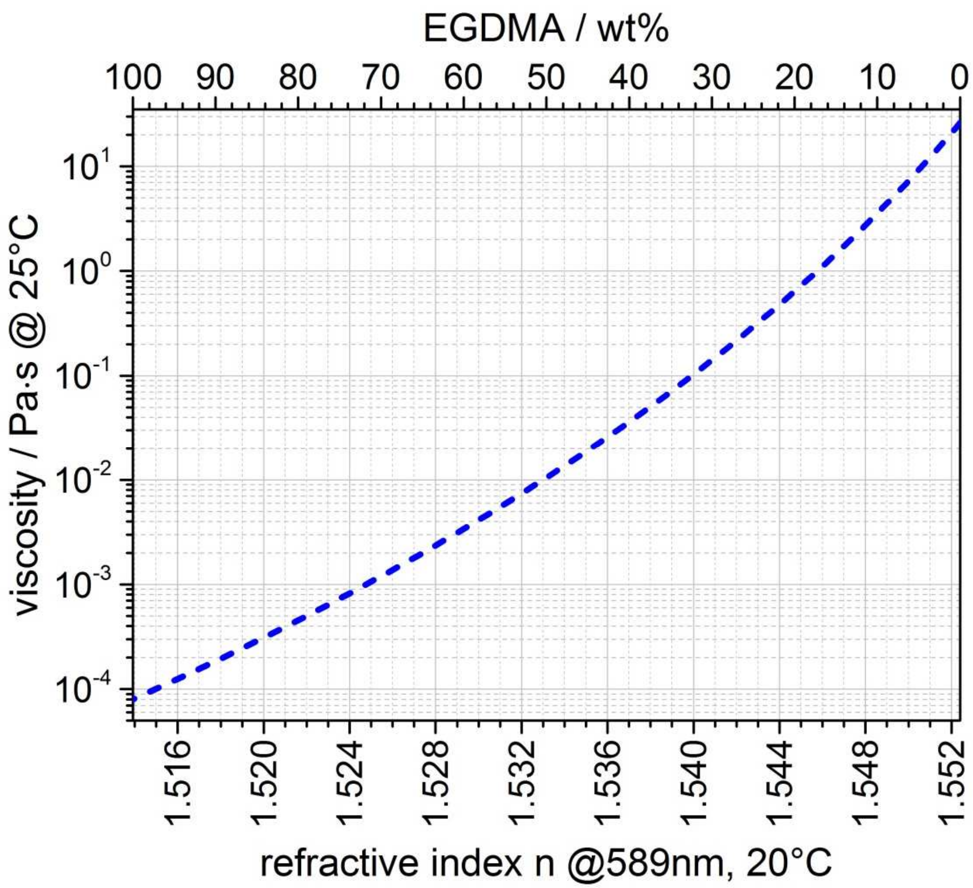
Data combined

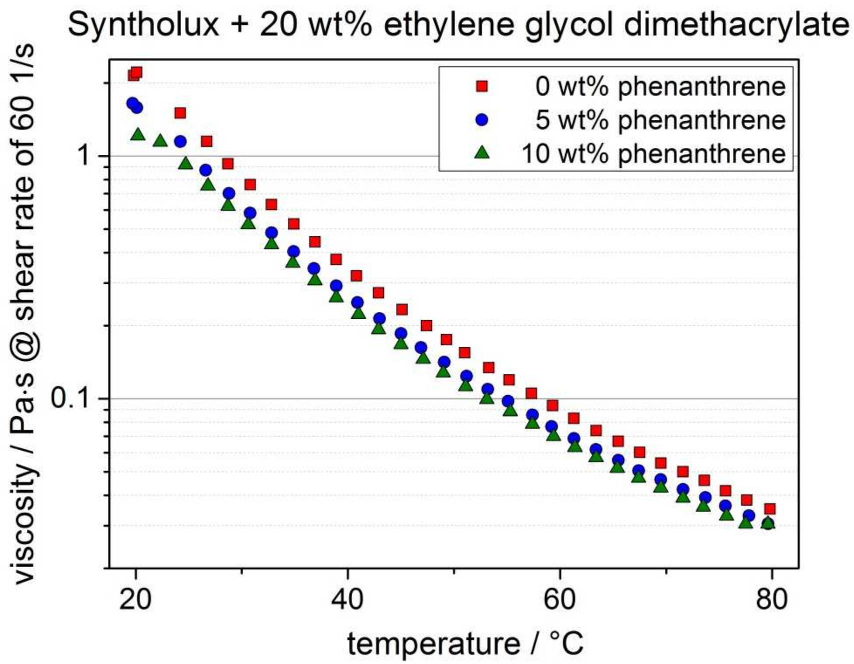
- Viscosity
  - Refractive index
- Refractive index
  - Viscosity
- Easy lookup

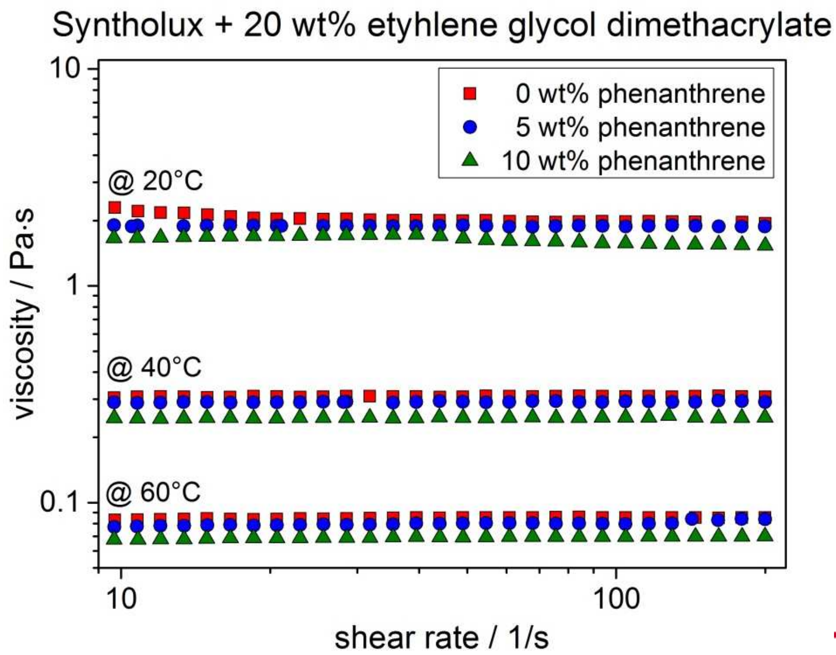


Planar Optronic Systems

Viscosity Syntholux + EGDMA + phenanthrene

- Temperature dependency
- Newtonian behavior
- Low influence of phenanthrene

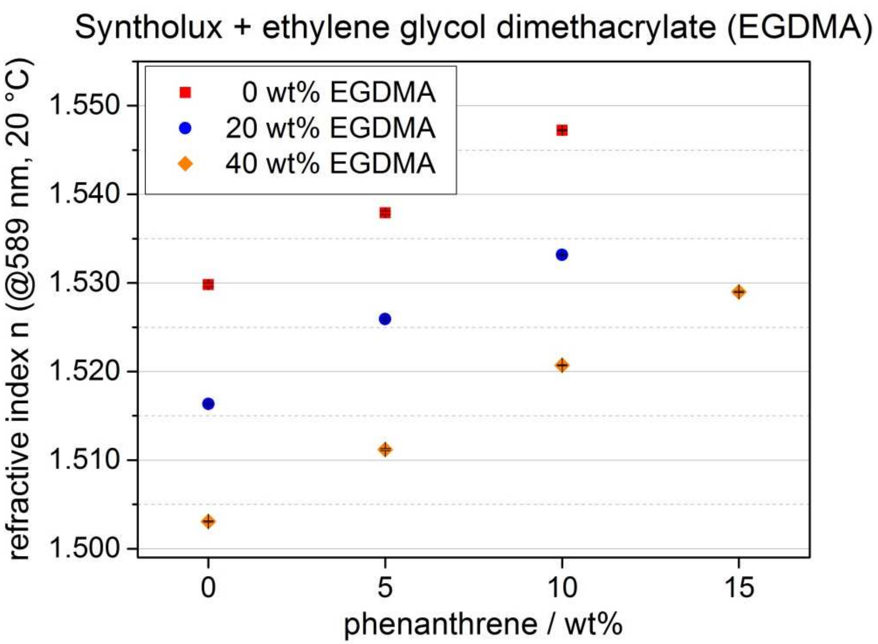


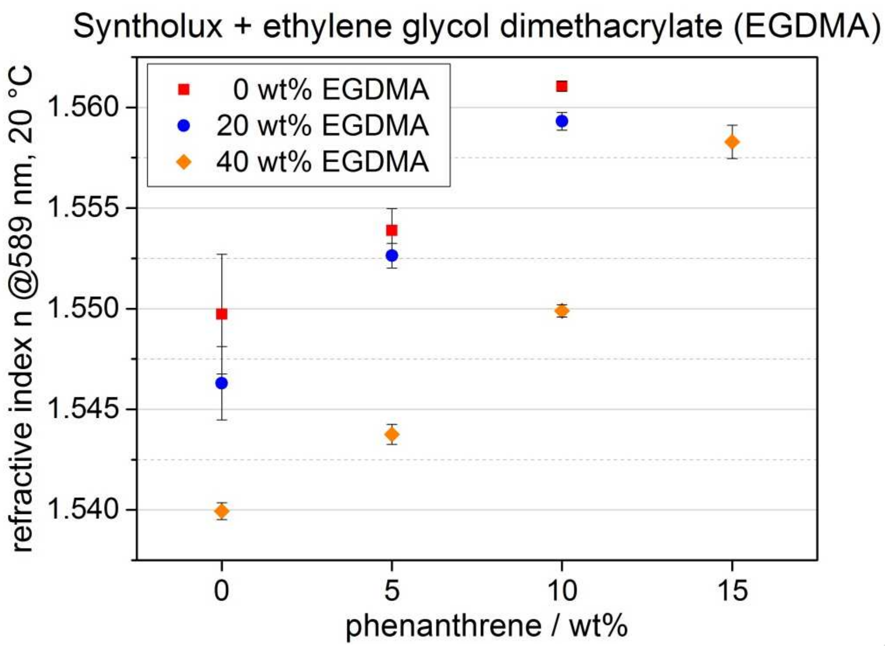


Planar Optronic Systems

Refractive indices Syntholux + EGDMA + phenanthrene

- Phenanthrene increases refractive index
- Maximum phenanthrene content increases with EGDMA content
- Phenanthrene compensates EGDMA influence

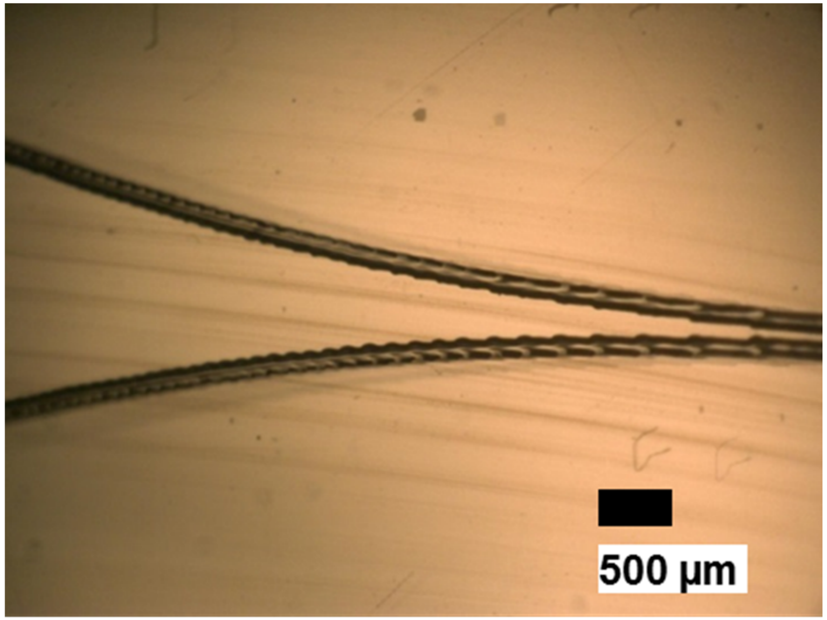


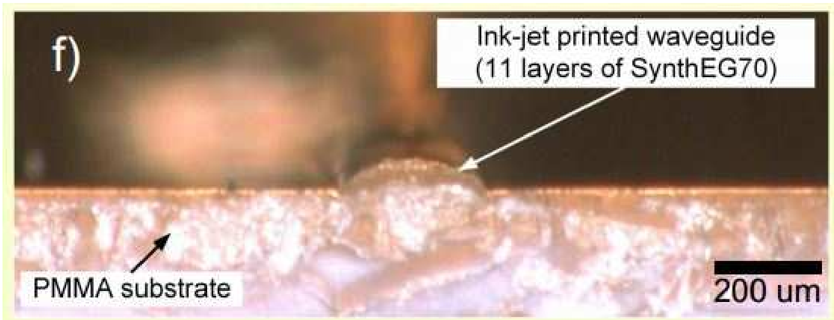


Planar Optronic Systems

Printed “waveguides”

- Ink-jet
  - width appr. 180 µm
  - height appr. 40 µm



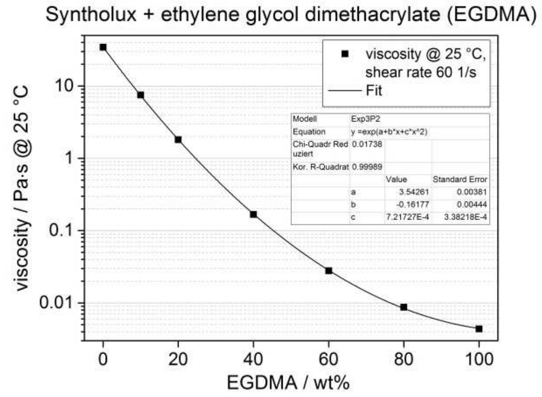


Ink-jet printed waveguides

[Bollgrün, University of Freiburg 2013]

Summary & Outlook

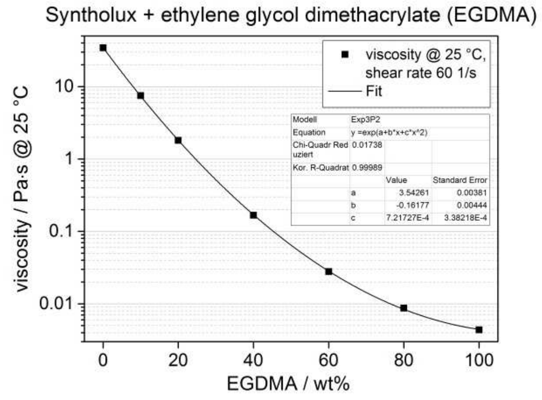
- Viscosity adjustable in a wide range
  - 48 Pa·s > η > 4 mPa·s (@ 20 ℃)
  - Suitable for different shaping methods

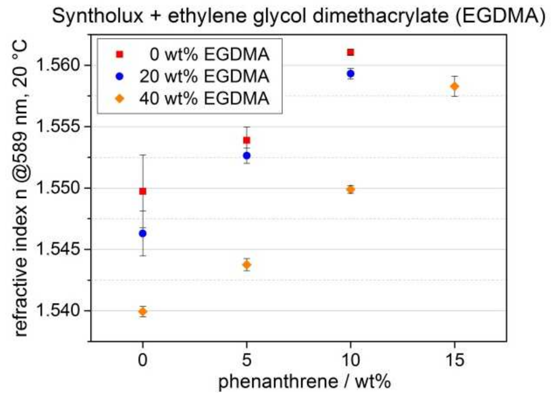


Planar Optronic Systems

Summary & Outlook

- Viscosity adjustable in a wide range
  - 48 Pa·s > η > 4 mPa·s (@ 20 ℃)
  - Suitable for different shaping methods
- Refractive index tunable
  - 1.51 < n < 1.56 (@ 20 ℃, 589 nm)
  - Phenanthrene can compensate influence of EGDMA





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Summary & Outlook

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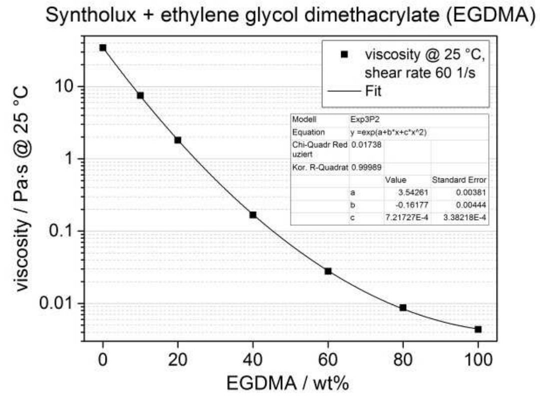
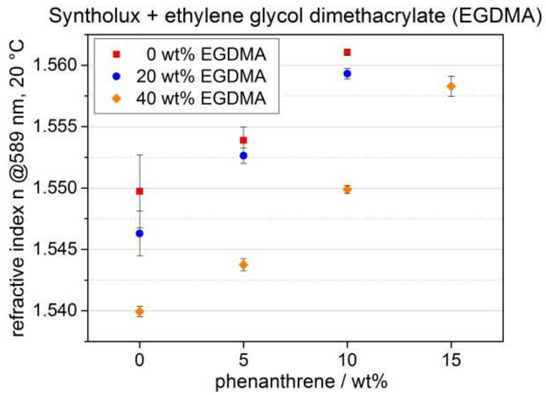
- Refractive index tunable
  - 1.51 < n < 1.56 (@ 20 ℃, 589 nm)
  - Phenanthrene can compensate influence of EGDMA
- Dispersion
  - Abbe number
- Optical damping
- Glass transition temperature





Acknowledgements

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Kort	Bremer	Martin	Körner	Maik	Rahlves	Stanislav	Shermann
Boris	Chichkov	Jan Gerrit	Korvink	Holger	Reinecke	Yixiao	Wang
Ayhan	Demircan	Wolfgang	Kowalsky	Carsten	Reinhardt	Nan	Wang
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Sebastian	Döhring	Uwe	Morgner	Maher	Rezem	Tim	Wolfer
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Ludmila	Eisner	Gregor	Osterwinter	Detlef	Ristau	Marc	Wurz
Melanie	Gauch	Torsten	Otto	Bernhard	Roth	Yanfen	Xiao
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