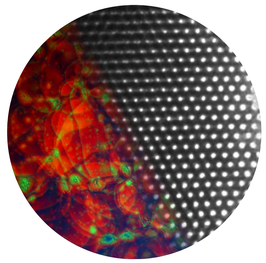

# Bruckner Group

# Hierarchically Structured Materials

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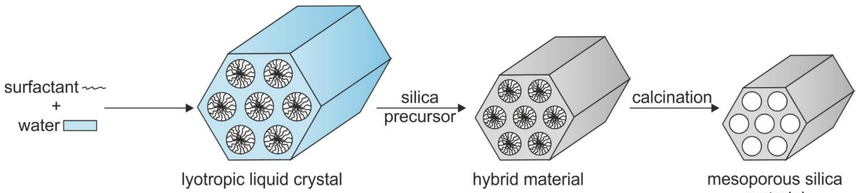
## About us

We use self-assembling systems, mainly lyotropic liquid crystals (LLCs), to fabricate hierarchically structured, functional materials. The long-range orientational order and sometimes also positional order of LLCs makes them an ideal starting ground for the production of nanostructures, while the fluidity of the LLCs allows for an easy handling and the manipulation of the produced material's macroscopic structure. Our research interests comprise the investigation of new LLC systems as starting materials, the synthesis of nanostructured materials and the analysis of their properties as well as functionalities.

## Ordered Mesoporous Materials



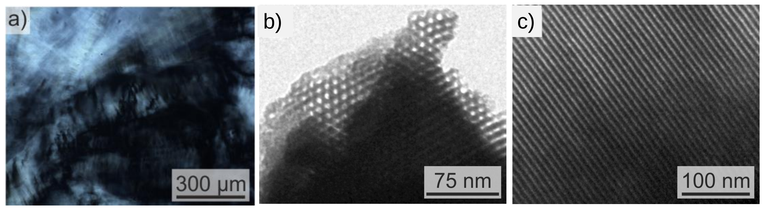

Simplified schematic of true liquid crystal templating (TLCT)

Polycondensation reaction of the silica precursor:

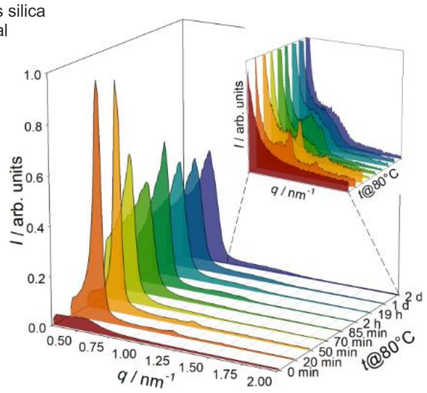
$$Si(OCH_3)_4 + 4\ H_2O \rightarrow Si(OH)_4 + 4\ CH_3OH$$

$$Si(OH)_4 \rightarrow SiO_2 + 2\ H_2O \quad (-\ CH_3OH,\ -\ H_2O)$$

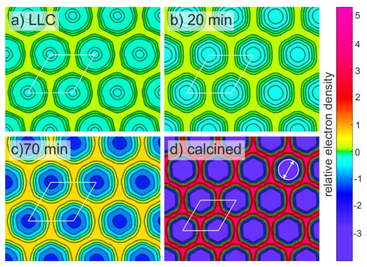
$$Si(OH)_4 \rightarrow Si(OH)_{4-x}(O)_{x/2} + x/2\ H_2O$$



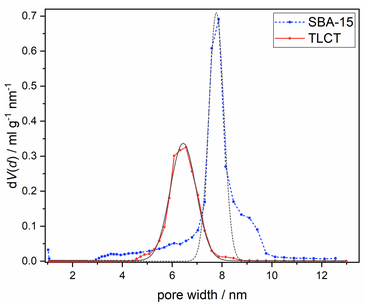

a) Texture of the hexagonal LLC phase as seen by POM. b) and c) mesopores of the ordered mesoporous silica observed by TEM.



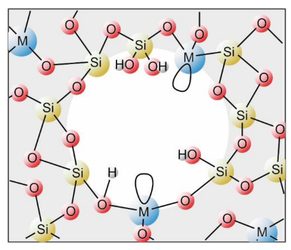

Structural changes throughout the TLCT process monitored by SAXS.




Electron density maps calculated from SAXS data.

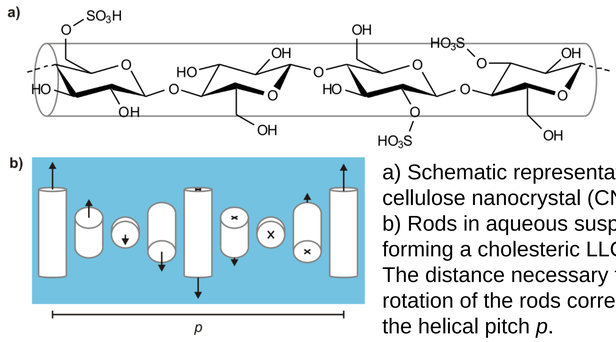



Pore width distribution of a material produced by TLCT and a commercial SBA-15.

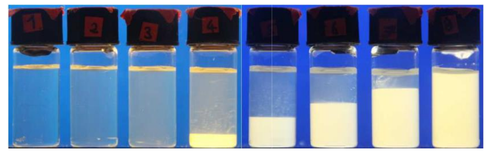


Sketch of a mesoporous metallosilicate with tailored electronic properties

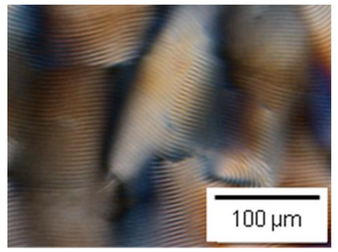
## Polysaccharide Nanocrystals



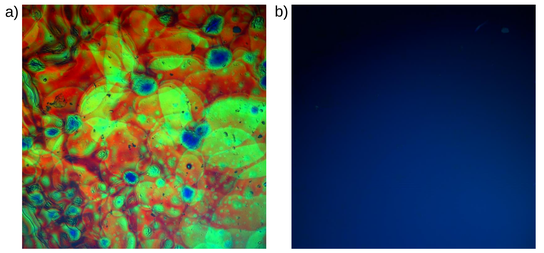

a) Schematic representation of a cellulose nanocrystal (CNC) as rod. b) Rods in aqueous suspension forming a cholesteric LLC phase. The distance necessary for a full rotation of the rods corresponds to the helical pitch *p*.



Suspensions with 1 to 9 wt% of CNCs, exhibiting an upper isotropic and a lower LLC phase viewed between crossed polarizers




Fingerprint texture of a cholesteric LLC as seen by POM




Dried CNC film viewed under a) left-handed circular porlarized light and b) right-handed circular polarized light.

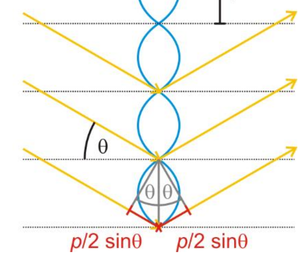



Illustration of the Bragg reflection ($N \cdot \lambda = p \cdot \bar{n} \cdot \sin\theta$)

## Possible Theses' Topics

**LLC phases of block-copolymers:**

- Screen amphiphilic polymers designed by the Adams group for their LLC properties
- Record LLC phase diagram(s) by means of POM and DSC
- Characterize structures of LLC phases by SAXS

**Macro/mesoporous silica materials:**

- Prepare silica materials which contain both macro- and mesopores by combining TLCT and polystyrene particles
- Investigate structure by SAXS, TEM and SEM
- Explore possibilities for selective functionalization and continuous flow processes

**Silification of CNC-films:**

- Fabricate silica/CNC composite films
- Investigate selective reflection by POM, UV-Vis and IR spectroscopy
- Correlate helical pitch to the silica content and preparation conditions

## Characterization Methods

- Polarizing optical microscopy (POM)
- Small-angle X-ray scattering (SAXS)
- Wide-angle X-ray scattering (WAXS)
- IR and UV-Vis spectroscopy
- Zeta potential measurements
- Dynamic light scattering
- Differential scanning calorimetry (DSC)
- Scanning electron microscopy (SEM)
- Transmission electron microscopy (TEM)

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