Cellulosic nanomaterials with preferred orientation

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Benefits of orientation

Higher fibre volume fraction

~ 50% with nonwovens, theoretical maximum 91% in UD composite

Anisotropy

At the same Vf, E-random is at best 1/3 of E1-UD

More design options
Ways to quantify orientation in cellulose

Orientation of crystalline domains by WAXS

Beam size from several 100 µm down to 200 nm

X-ray beam

fibre

2D detector

10 µm tencel fibre

Position (step 500nm)
Ways to quantify orientation in cellulose

Average orientation from birefringence measurement using polarized light microscopy

Transmission  Crossed polarisers  Compensated

Polarized Raman microscopy => average orientation

Microscopy + image analysis for discrete objects
Overview of possible approaches

Strong magnetic field (7T)

Strong AC field (1kHz, 1kV/cm)

Shear
Dugan et al. *Biomacromolecules* 2010

- Fibre spinning
- Spinning disc
- Rotating drum
- Post-drawing
Orientation by an AC electric field

Gindl et al. Biomacromolecules 2009
Spun cellulose fibres

Take-up speed > extrusion speed

High fc; fa improved by post-drawing

Wet-drawn cellulose II films with undissolved cellulose I crystals

E: 10 => 32 Gpa
σ: 200 => 400 Mpa
ε: 16 => 3 %

Oriented sheets of MFC

Rotating drum method: rotation speed, fibril content, entanglement of fibrils, …..

Post drawing: Strong interfibril bonds in once consolidated films – network formation

No results so far
TEMPO-oxidated cellulose

TEMPO: (2,2,6,6-tetramethylpiperidine-1-oxyl)
Stretched TEMPO-oxidated cellulose

MOE (GPa)

\[ \cos^2\theta \]

MFC
tMFC
tMFC 15%
tMFC 30%

Veigel et al. 2011
Conclusions

Magnetic and electric fields interesting for small-scale applications

Post-drawing of consolidated films plasticised by moisture is feasible for regenerated cellulose and for surface-modified MFC

Need for a method to obtain orientation during film formation!