Preparation and Characterization of Nanocellulose

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Motivation

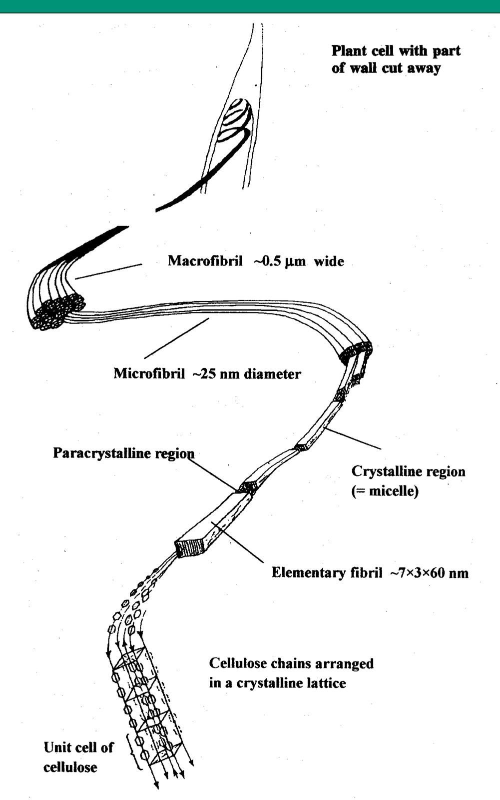
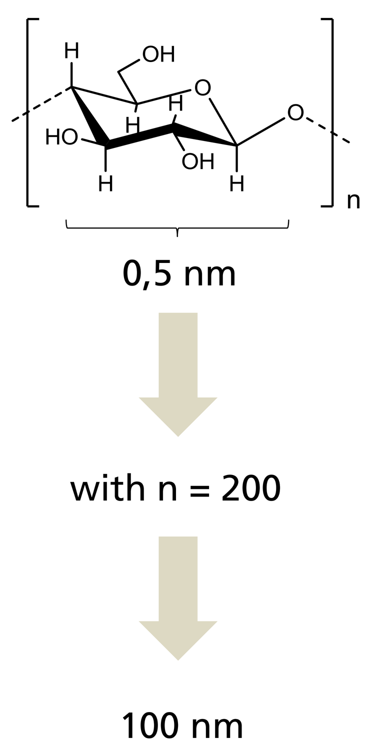


Fig. 1:
Build-up of the plant cell from from macrofibril to microfibril to the elementary fibril down to the cellulose units (adapted from Roberts 1996)



As the most abundant organic and renewable polymer, cellulose is used in a wide variety of industrial products and applications (Kennedy et al. 1985; Klemm et al. 2005). In the recent past novel and interesting cellulosic materials were developed which were obtained by disintegrating cellulosic or lignocellulosic fibres using mechanical (Iwamoto et al. 2008; Abe et al. 2007), chemical (Moran et al. 2008) and enzymatic approaches (Rambo et al. 2008; Xing et al. 2007) or combinations thereof (Henrikkson et al. 2007; Paeaekkoe et al. 2007; Siró and Plackett 2010; Eichhorn 2011).
The aim of the project was the preparation of spherical cellulose particles with diameters in the nanometer range. We combine cellulose pre-treatment by grinding, dissolution and precipitation, hydrolysis or chemical derivatization of different pulps with subsequent mechanical treatment of aqueous suspensions of pre-treated or derivatized cellulose with a Microfluidizer® processor.

Project

Sample		DP (Cuen)
Spruce pulp	starting material	803
WAM 1/04	amorphization in NMMNO	725
R05/99	MF treatment	650
Cotton linters	starting material	1316
WAM 2/04	amorphization in NMMNO	1146
R05/98	MF treatment	864
R05/103	Hydrolysis and MF treatment	60

The preparation of the nanoparticles was carried out by different pre-treatments as grinding, amorphization (decrystallisation), hydrolysis or chemical derivatization of different pulps with subsequent mechanical treatment of aqueous suspensions of pre-treated or derivatized cellulose with a Microfluidizer® processor. As an example the results of amorphization from cellulose in combination with the mechanic treatment are shown following.

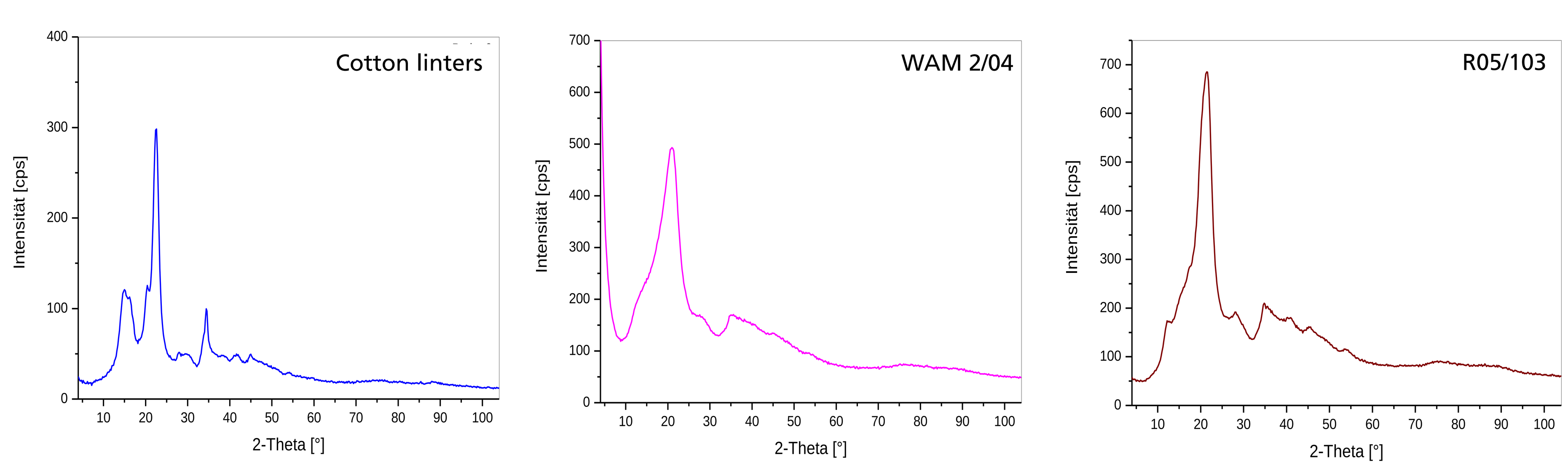


Fig. 2: Investigation of the decrystallized samples by WAXS

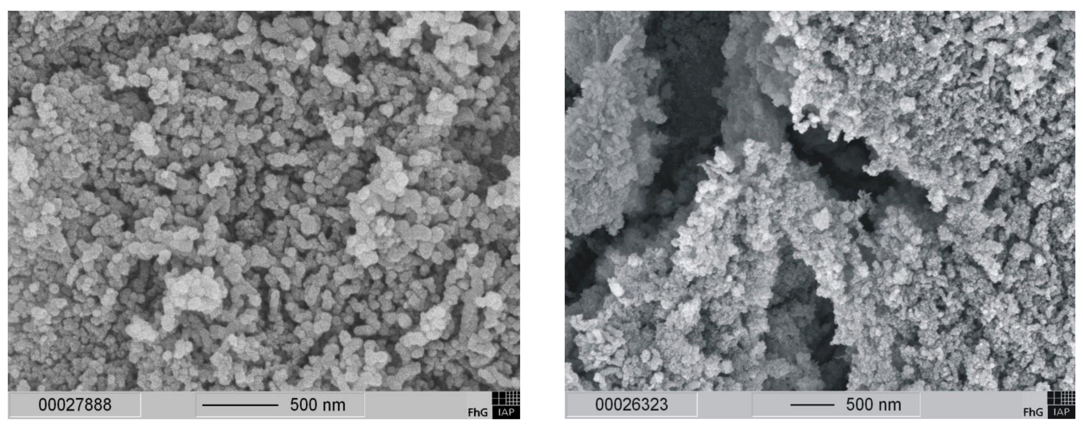


Fig. 3: SEM images of R05/98 and R05/103

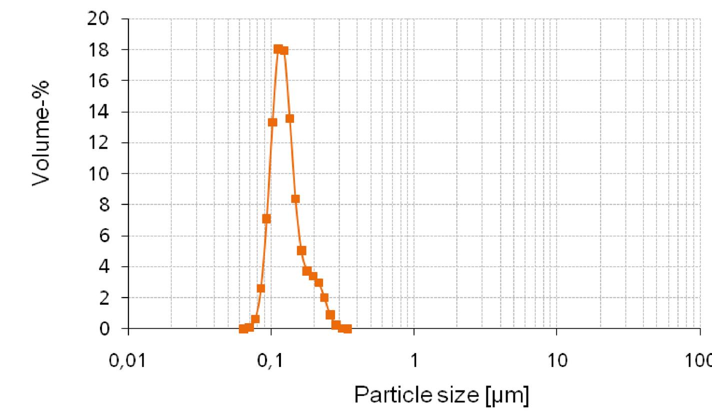


Fig. 4: Particle size distribution by dynamic light scattering (D_{90} = 193 nm; D_{50} = 128 nm)

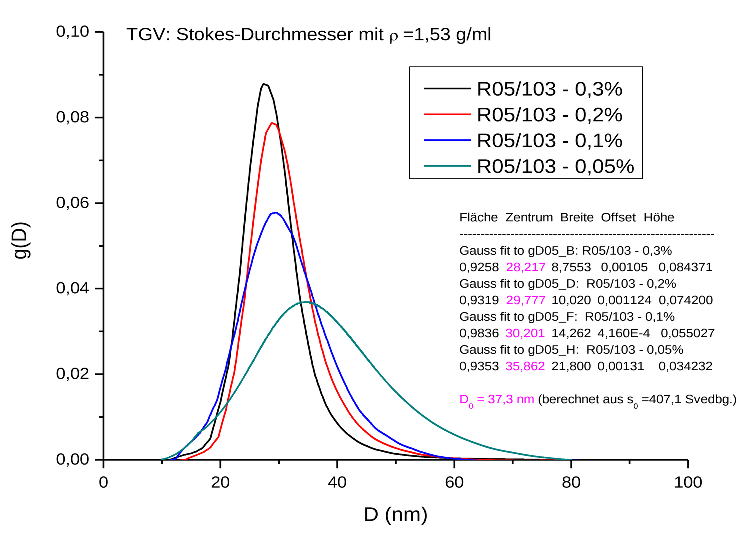


Fig. 5: Particles size distribution with ultracentrifugation

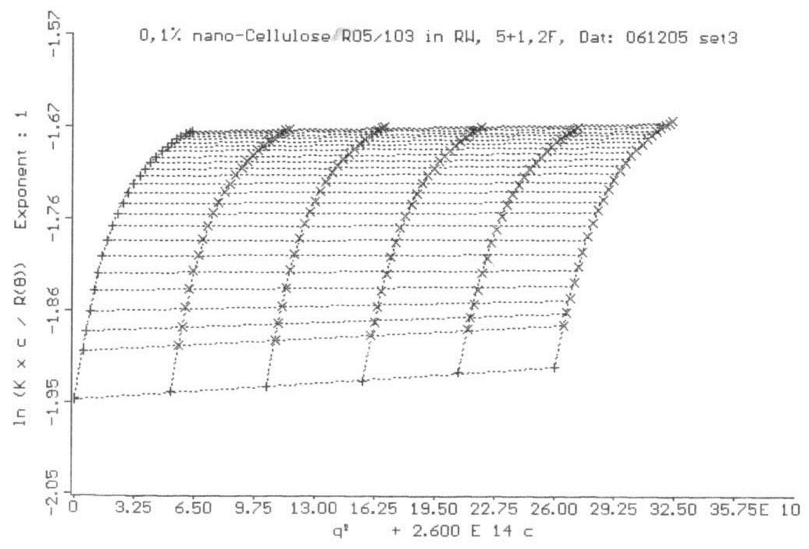


Fig. 6: Particles size distribution with static light scattering

Comparison of the particle sizes in dependence of the methods

Method	Particle size [nm]	Advantages	Disadvantages
SEM	<< 500	optical analysis	only small regions
Static light scattering	195	direct and exact method	time-consuming, only monomodal systems
Dynamic light scattering	193	direct and fast method	not applicable for shear thinning samples
Ultracentrifugation	120-190	direct and exact method	limited applicable for charged samples

Summary

- Stable cellulose nanodispersion can be formed by an adequate pretreatment followed by a mechanical treatment with a Microfluidizer® processor
- Amorphization of cellulose as pretreatment is suited for preparation of nanocellulose
- Characterization of nanocellulose dispersion with different analytical tools result to similar particle size distributions

References

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