Cellulose-based Nanoparticles Precipitated from Ionic Liquids by a Continuous Emulsification Technique

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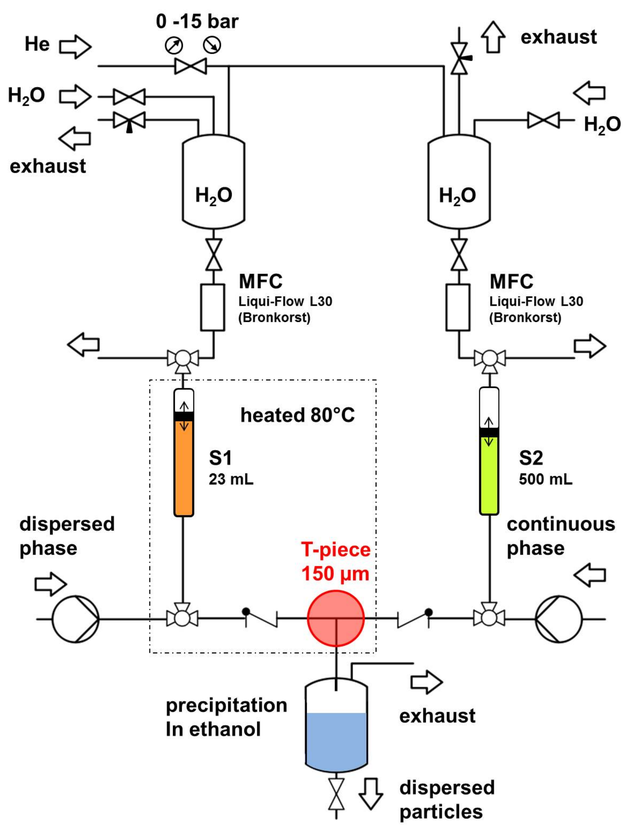
Introduction

The polysaccharide cellulose is the most abundant renewable polymeric raw material in the world. Particular advantageous properties are biodegradability, hydrophilicity, chirality and the broad chemical modifying capacity. Because of these advantages, cellulose research and product development has considerably increased over the past decade worldwide.[1] The efficient dissolution of cellulose has been a long-standing goal and has been complicated by a limited number of common solvents [2,3] Crystalline cellulose is dissolved in different ionic liquids *(*disperse phase) and subsequently dispersed continuously by two consecutive orifices (left row) or a T-piece (right row) into kerosene (continuous phase). As ionic liquids 1-benzyl-3-methylimidazolium-dicyanamide ([BzMIM][DCA]), 1,3-dimethylimidazolium-dimethylphosphate ([MMIM][Me_2PO_4]), and 1,3-dimethylimidazolium-acetat ([DMIM][OAc]) are used to achieve clear cellulose solutions. The resulting emulsions are precipitated with ethanol to obtain cellulose micro- and nanoparticles.

Setup with T-piece



Continuous phase:

Cerosine with

0.8 wt% Tween 80
3.2 wt% Span 80

Mass flow rate: 10 g min^{-1}

Disperse phases with 2.5 wt% cellulose:

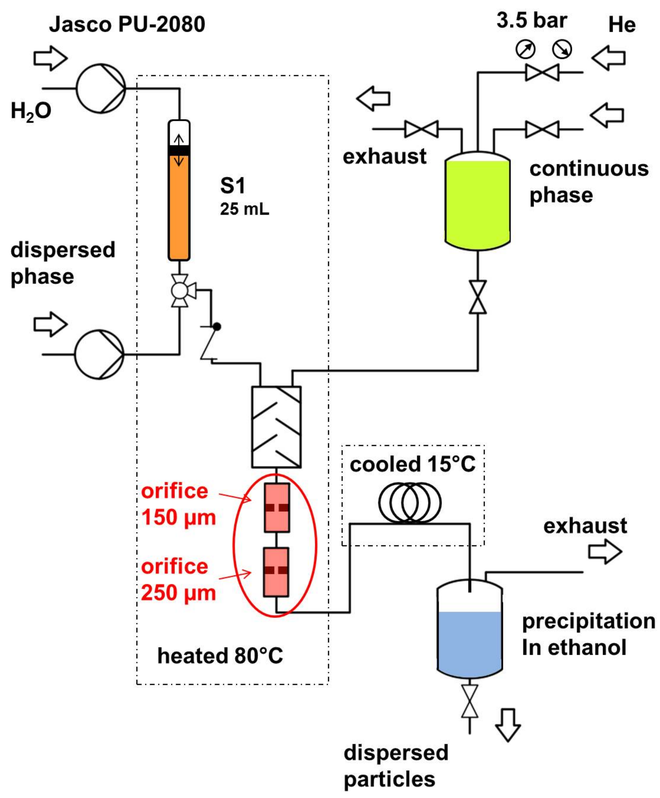
A: dissolved in [DMIM][OAc]
130°C > 12 h

B: dissolved in [MMIM]Me2PO4]
80°C > 12 h

C: dissolved in [BzMIM][DCA]
80°C, 1 h

Mass flow rate: 1.0 g min^{-1}

Setup with consecutive orifices



Continuous phase:

Cerosine with

0.8 wt% Tween 80
3.2 wt% Span 80

Disperse phases with 2.5 wt% cellulose:

D: dissolved in [DMIM][OAc]
- continuous phase: 24.2 g min^{-1}
- disperse phase: 1.0 g min^{-1}

E: dissolved in [BzMIM][DCA]
- continuous phase: 20.5 g min^{-1}
- disperse phase: 1.0 g min^{-1}

Results: T-piece

A: dissolved in] [MMIM]Me_2PO_4]:

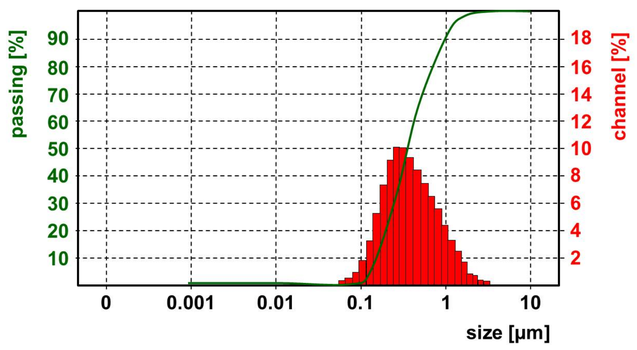
- highly viscous fluid,
- no droplet rupture,
- brittle cellulose filaments

B: dissolved in [DMIM][OAc]:

- viscous fluid
- disturbed droplet rupture
- beads with diameter size in the millimeters range

C: dissolved in [BzMIM][DCA]:

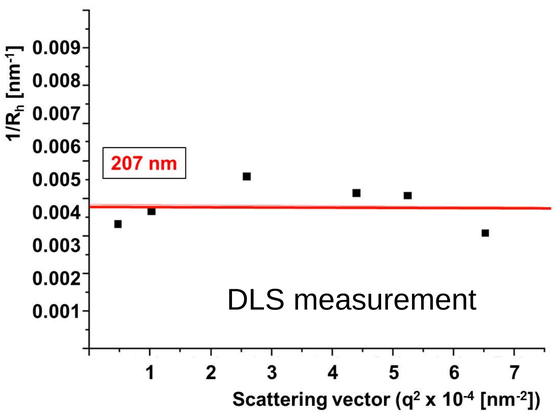
- achieved particle size ranges from 1.5 µm down to 80 nm.
- mean diameter approx. 500 nm
- agglomeration



Results: consecutive orifices

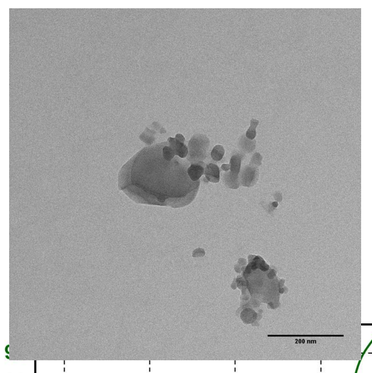
D: dissolved in [DMIM][OAc]:

- particles with a hydrodynamic radius of 207 nm were obtained



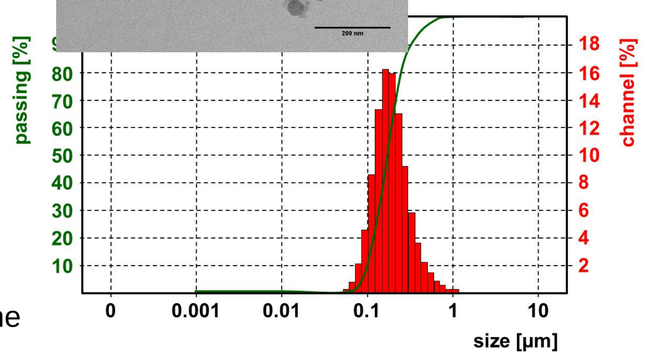
E: dissolved in [BzMIM][DCA]

- particle size ranges from 80 nm to 1µm,
- mean diameter approx. 250 nm,



- Cellulose dissolved in [MMIM]Me_2PO_4]:

  could not be processed due to the high viscosity of the solution



Summary

The full potential of dissolution of cellulose with ionic liquids has not yet been fully exploited, as well as the generation of cellulose particles.

Both [DMIM][OAc] and [MMIM][Me_2PO_4] deliver do not deliver cellulose nanoparticles.

Generation of Particle depends on used ionic liquid.

This uncomplicated procedure is interesting and furthermore extends the possibilities for the generation of cellulose nanoparticles.

Acknowledgment

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References

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