Use of Microcrystalline Cellulose as a Matrix for Functional Coatings

S. Segel[1], F. Gähr[1], M. R. Buchmeiser [1,2]

[1] German Institutes of Textile and Fiber Research (DITF), Körschtalstraße 26, D-73770 Denkendorf

[2] Institute of Polymer Chemistry, University Stuttgart, Pfaffenwaldring 55, D-70550 Stuttgart

DEUTSCHE INSTITUTE FÜR TEXTIL+FASERFORSCHUNG

Introduction

- Conventional textile finishing and coatings are primarily based on fossil-derived polymer binders used to fix water-insoluble pigments and functional additives. As a renewable raw material, cellulose offers a sustainable alternative; however, its use has been hindered by the limited processability and insufficient wash fastness of existing cellulose-based coating systems.
- Microcrystalline cellulose (MCC) is a promising raw material due to its commercial availability, relatively simple production and processability in aqueous dispersion systems. Compared to microfibrillated cellulose (MFC) and other nanocelluloses, MCC can offer advantages in terms of handling and rheological control. However, there is currently a lack of cellulose-based coating systems that combine good processability with common application methods and high wash resistance.

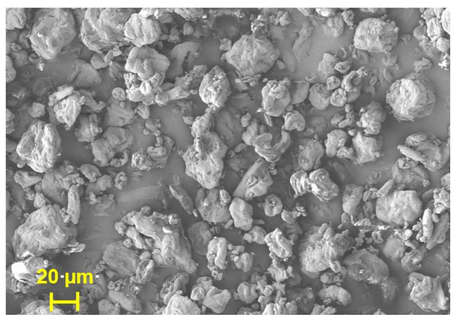
Objectives

Development of sustainable MCC-based coating/finishing formulations for permanent fixation of functional additives and pigments on textiles.

- Use of aqueous MCC gels (MCGs).
- Identification of suitable crosslinkers for efficient crosslinking and long-term stabilization of the cellulose layer.
- Homogeneous, color-neutral coatings with minimal impact on fabric flexibility and handle.
- Compatibility with established textile finishing processes.
- Integration of functional additives and pigments for the permanent functionalization and dyeing of textiles.
- Preservation of textile comfort and flexibility while ensuring durable adhesion and high wash fastness of the additives.

Microcrystalline Cellulose Gels

- MCGs are synergistic, co-processed composites of MCC and sodium carboxymethylcellulose (Na-CMC). Their properties can be tailored by varying the Na-CMC content.

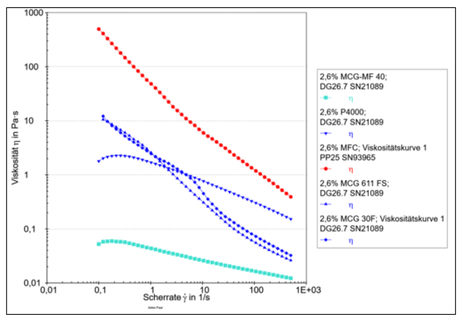


SEM: MCG powder with average particle size of about 10 µm

- Upon high-shear activation in water, MCC particles disperse while solvated CMC acts as a spacer, preventing agglomeration.
- The resulting thixotropic colloidal gels are stable over a pH range of 4.3–11 and exhibit film-forming properties.

Results

Rheology



Rotational measurement: Flow curves, comparison of MCG and MFC, c= 2,6 wt.%

Rheological and formulation benefits of MCGs vs. MFC:

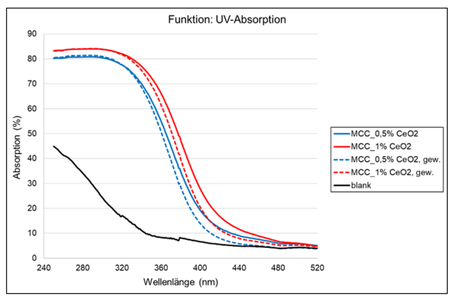
- Lower viscosity η < 0.1 Pa·s at 2 wt.% (typical use level)
  → easier processing
- Moderate shear-thinning & good structural recovery
  → reliable coating application
- Effective suspension stabilization via a particulate network
- Less interconnected network
  → improved additive distribution and formulation flexibility
- Better process control & scale-up potential

Permanent functionalization of fiber materials

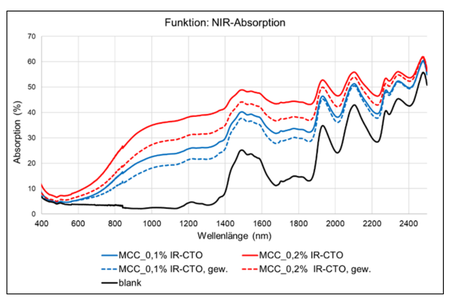
- Substrate: 100% cotton fabric
- Crosslinker: blocked isocyanate, non-ionic, butanoxime free
- Washing Procedures: DIN EN ISO 6330: 2013-02 (up to 10 cycles)

UV or NIR absorption effects

- Functional additives: Nanobyk 3810, CeO_2 - dispersion in water (18%) (BYK) and Perilen IR CTO, $Cs_{0.33}WO_3$ - dispersion (20%) (Dr. Petry)



Absorption spectra: 250 nm to 400 nm (UV A+B range)
Black curve: 2% MCG
Red curves: 2% MCG, 2% blocked NCO, 0,5% /1% CeO_2
Blue curves: 2% MCG, 2% blocked NCO, 0,5% /1% CeO_2, washed

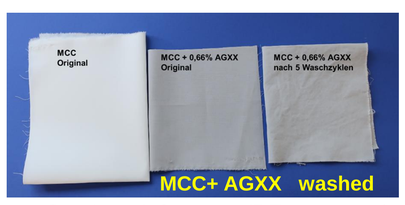


Absorption spectra: 250 nm to 2400 nm (UV-VIS-NIR)
Black curve: 2% MCG
Solid red/blue curves: 2% MCG, 2% blocked NCO, 0,1% or 0,2% IR CTO
Dashed red/blue curves: 2% MCG, 2% blocked NCO, 0,1% or 0,2 % IR CTO, washed

The modified textiles can block 80% UV resp. up to 35% of NIR light depending on the concentration used.

Antimicrobial, fluorescence and coloring effects

- Functional additives: AGXX dispersion, 22 wt% (Heraeus), invisible UV phosphors (Perilen UV Red FL Nano (Dr. Petry), Tailorlux)
- Coloring: Vat-pigment dyeing on m-aramid (DITF process)

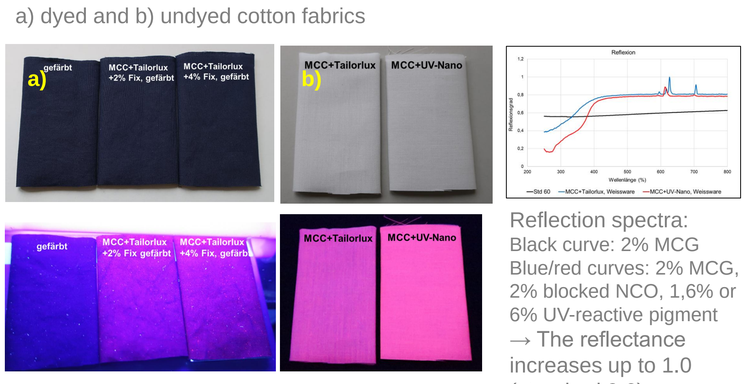


→ Good wash fastness (DE cmc = 1.4)



→ Improvement of washing/rubbing fastness and visual properties (warmer shade)

Invisible marking of the fabric using MCC and UV-reactive pigments
Visual effect before and after UV excitation:
a) dyed and b) undyed cotton fabrics



Reflection spectra:
Black curve: 2% MCG
Blue/red curves: 2% MCG, 2% blocked NCO, 1,6% or 6% UV-reactive pigment
→ The reflectance increases up to 1.0 (standard 0.6)

Conclusions and Outlook

- The developed technology enabled the formation of stable cellulose coatings with good wash durability on textile substrates.
- Special crosslinkers based on blocked isocyanates were identified as particularly suitable for achieving permanent coating performance. Furthermore, the cellulose layers allowed the stable incorporation of a wide variety of functional additives and color pigments underlining their potential as a sustainable replacement for fossil-based textile coating materials.

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Contact: frank.gaehr@ditf.de