

Nanocomposite thin films from cellulose – current state and challenges

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Cellulose, a major component of wood and lignocellulosic biomass, is a very versatile material that has provided many applications to mankind during the past centuries such as paper, textiles and housing. These classical applications are now being complemented with new materials where the length scale of the cellulosic materials has crossed the border from macroscopic bodies to enter the world of nanomaterials, where size effects start to play the decisive role for potential applications. In this context, a wealth of such nanocellulose based materials such as nanofibrils, nanocrystals, nanofibers, nanoparticles, aerogels as well as ultrathin cellulose films have recently been explored.¹

One of the main expertises in our group is a tailor made preparation of cellulose thin films by spin-coating. Our main motivation is (i) to learn more about basic interactions in cell wall components and (ii) to explore potential applications using different structuring approaches. However, the peculiarity for the preparation of cellulose thin films is the inherent insolubility of cellulose in common organic solvents making direct dissolution and processing tedious. An approach to circumvent these issues is to use soluble cellulose derivatives, which are converted back to cellulose after processing, a process commonly referred to as regeneration. We have recently developed a variety of methods to induce patterns in cellulose using photolithography, electron beam lithography and by microphase separation in films stemming from trimethylsilyl cellulose (TMSC).²

Further, we present an approach to replace semi-commercial TMSC by a large scale commodity, namely cellulose xanthate (CX) for thin film preparation.³ CX is a water soluble cellulose derivative and is produced in large quantities in the course of the viscose process. Functional nanocomposite multilayer film systems have been manufactured by alternate spin coating of CX and copper/indium xanthates, which were converted to cellulose and copper indium sulfide, respectively, after processing. In addition, the conversion step can also be performed while inducing micropatterns using UV illumination. First results showed that the Cu/In xanthates were converted to the copper indium sulfide while the CX was converted to cellulose. The film properties (structure, thickness, photoelectric activity) of the single and multilayer systems consisting of alternate layers of cellulose and copper indium sulfide were studied.

References

(1) (a) *Chem Rev* **2010**, *110*, 3479; (b) *Chem. Soc. Rev.* **2011**, *40*, 3941; (c) *Nat Nano* **2010**, *5*, 584; (d) *J. Mat. Sci.* **2009**, *45*, 1. (2) (a) *Scientific Reports* **2016**, *6*, 32451; (b) *Biomacromolecules* **2016**, *17*, 3743; (c) *Cellulose* **2015**, *22*, 717. (3) *Cellulose* **2018**, *25*, 711.

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Webpage: www.cell-rocks.com

Google Scholar Profile: <http://scholar.google.at/citations?user=k8INMckAAAAJ&hl=de>, h-index 20, i10 index 32.



Research interests: Biobased nanomaterials and nanocomposites, thin film formation, patterning and advanced characterization using SPR, QCM-D, GI-SWAXS, XRR; AFM, viscose process, energy storage materials, materials for new contrast agents in MRI

Education

10/2000: Karl-Franzens Universität Graz, Austria, Start of the studies in Chemistry, Main focus: synthetic chemistry

06/2002-05/2003: Interruption of the studies due to mandatory civilian service (Lebenshilfe Trofaiach, Austria: work with mentally and physically disabled people)

05/2005-02/2006: Diploma thesis: "Reaktivität sterisch gehinderter Trihalogensilane" with Dr. Rudolf Pietschnig (Dept. of Inorganic Chemistry, Universität Graz), with distinction

03/2006-04/2009: PhD-thesis: "Sterically demanding polyfunctional organosilicon compounds – synthetic and spectroscopic aspects" with Dr. Rudolf Pietschnig (Dept. of Inorganic Chemistry, Universität Graz), with distinction

04/2009-09/2009: Project coworker with Dr. Rudolf Pietschnig, Inorganic Chemistry, Universität Graz

10/2009-09/2010: Postdoc with Prof. Volker Ribitsch, Physical Chemistry, Universität Graz. Main topic: cellulose silane (nano)composites and surface modifications with silanes

10/2010-09/2011: Marie Curie Fellow with Prof. Norbert Mitzel, University of Bielefeld, Germany. Main topic: gas phase electron diffraction.

10/2011-09/2012: Marie Curie Fellow with Prof. Karin Stana-Kleinschek, University of Maribor, Slovenia. Main topics: polysaccharide interfaces, hybrid materials, processing of polysaccharides

10/2012-01/2013: Research associate with Prof. Karin Stana-Kleinschek, University of Maribor, Slovenia

02/2013-07/2016: Assistant professor (non-tenure) at the Institute for Chemistry and Technology, Graz University of Technology, Austria

09/2013-08/2016: Marie Curie Fellow holding a Career Integration Grant at TU Graz

From 08/2016: Assistant professor (tenure) at the Institute for Paper, Pulp and Fiber Technology, Graz University of Technology, Austria

08/2017: Habilitation (*venia docendi*) in the field of Chemistry and Technology of Biomaterials

12/2018: Promotion to Associate Professor

Awards/Major Projects (>75kEuro)

Marie-Curie Intraeuropean Fellowship 2010-2011 (EU)
FWF Schrödinger Fellowship, J3426-N28, not taken
Marie-Curie Fellowship, Career integration grant, 2013-2016 (EU)
Coordinator of the **FFG project** Cello-H₂O-4papers, 2014-2017 (FFG)
Work package leader in the **Research Studios Austria** 'Advanced and Innovative Materials for Electrochemical Energy Storage', 2014-2018 (FFG)
Work Package Leader and co-coordinator in the **H2020-FET-open CONQUER**, 2015-2018 (EU)
Steirer des Tages (Styrian of the day, selected by federal newspaper *Kleine Zeitung* for people making an impact on society, 20.4.2015)
Coordinator in the **Thermoup** project (2017-2018), direct industrial project
Coordinator in the **Barrieren** project (2017-2018), direct industrial project
Coordinator of the **FFG Lignobatt** project 2017-2020
Coordinator of the **Stärke+** project 2018-2020

Involvement in projects/cooperation

CD-Laboratory for Fiber Swelling (2015-2022)
COMET K-project FLIPPR² (2017-2021)
BioEnergyTrain (2017-2021, EU)

Major international cooperation partners (common papers/student exchanges/projects)

K. Stana-Kleinschek (Maribor/SLO), E. Kontturi (Aalto, FI), W. Thielemans (Leuven, BE), E. Belamie/B. Alonso (Montpellier, FRA), T. Heinze (Jena, DE), T. Nypelö (Gothenburg, SE), M. Biesalski (Darmstadt), B. Volkert (Fraunhofer IAP, DE), K. Zhang (Göttingen, DE), S. Fischer (Dresden; DE), S. Coseri, L.Sacarescu (Iasi, RO), N. Krstulovic (Zagreb, CRO), P. Vilaro (Montevideo, URU), A. Rao (Clemson, USA), D. Kruk (Olsztyn, POL).

Memberships

Austrian Chemical Society (GÖCH)
American Chemical Society (ACS)
Austrian Marie Curie Chapter (founding member)

Editorial Board Member of the open access journal *Fibers*
Guest Editor for *Frontiers in Chemistry*

Board member of EPNOE Junior Scientist network

Reviewing activities for international journals 2014-2018(selection)

Nature Communications, Biomacromolecules, Cellulose, Langmuir, Carbohydrate Polymers, Scientific Reports, ACS Sustainable Chemistry and Engineering, Nanoscale, Journal Colloid Interface Science, Holzforschung, Wood Chemistry and Technology, Polymers...

Reviewing activities for projects (selection)

Evaluator in the H2020-FETopen-2015-1 and H2020-FETopen-2015-2
Vice Chair in the FETopen 2016-1 and in the FETopen 2017-2
Evaluator in the H2020-Marie Curie Sklodowska IF 2015, 2016, 2017, 2018
FWO (Belgium)
Knowledge Foundation (Sweden)

Publications

70 publications in peer reviewed journals, 2 books, 3 book chapters, two EU patents, more than 145 oral presentations at conferences, more than 25 invited talks, one interview in the Austrian radio (Ö1)

Invited Talks (Selection)

- 257th ACS national meeting (Anselme Payen Award session), Orlando, USA, 2019
- 253rd ACS national meeting (Anselme Payen Award session), San Francisco, USA, 2017
- 251st ACS national meeting, San Diego, USA, 2016.
- Keynote Speaker at EPNOE 2015 conference in Warsaw, Poland, 2015.
- 249th ACS national meeting Denver, USA, 2015.
- ANALYTIX-2015, Nanjing, China, 2015.

Conference organization

- European Workshop on Smart Inorganic Polymers, Maribor 2014
- Co-Organizer of the Lignocellulosics and Nanotechnology Symposium at the ACS meeting 2015 in Denver, USA.
- Co-Organizer of Lignocellulosics and Nanotechnology Symposium at the ACS Spring meeting in San Diego 2016.
- Organizer of the EPNOE-Junior Minisymposium, Graz, Austria, 2016.
- Co-Organizer of the 2nd EPNOE-Junior Scientist Conference in Sophia Antipolis 2016.
- Co-Organizer of Lignocellulosics and Nanotechnology Symposium at the ACS Spring meeting in San Francisco 2017.