EPNOE Newsletter - November 2022

Connecting the international polysaccharides community

Editorial

Dear Readers,

We are happy to invite you to the launch event of the *EPNOE Research Roadmap 2040*!

The **Research Roadmap** is the result of the contributions of more than 20 high-level scientists from 13 European countries working with the common focus on materials and engineering, food and nutrition, biomedical applications and chemistry, physics, and biology of polysaccharides. **The launch event will take place in Leuven, Belgium, on 31 January 2023.** More information about the agenda will follow soon.

It will be anticipated and followed by some online events and social media activities. Our aim is to **engage the international polysaccharide community to deliver our message about the relevance of polysaccharides for a sustainable future of our planet.**

EPNOE is a strong and vibrant association, and we are now expanding our collaborations with more and more associations. This is opening new horizons for interdisciplinary research and innovation, that will certainly be in support to the achievement of the United Nations' Sustainable Development Goals.

With this aim, we are also collaborating with some organisations in view of the **EPNOE2023 Conference in Graz, Austria**. Notably, we are working on a series of targeted workshops and joint events with partner associations in 2023.

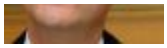
The transition to a carbon neutral society requires a combination of efforts coming from different sectors and an open dialogue with clear and concrete goals. We are aware that polysaccharides are resourceful materials with structure-property relationships tailored by evolution during millions of years. **Our mission is to raise awareness on polysaccharides, especially among the general public and policy-makers.**

We will continue to take all the necessary steps to better display the great opportunities that polysaccharides can offer.

Looking forward to meeting you in EPNOE,

Pedro Fardim
*President of EPNOE***d us on**

Follow us



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News & Announcements

Launch of the EPNOE Research Roadmap 2040

The EPNOE Research Roadmap 2040 is ready!

We are proud of the final result and grateful to all the contributors for the hard work that they put into it.

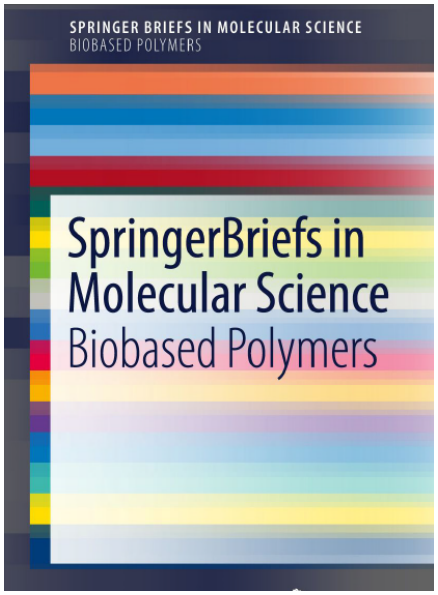
The Research Roadmap is a timely and necessary action we decided to take, with which we aim to address the most relevant scientific questions around sustainable solutions of biomass and polysaccharides.

We are currently working on the official launch event, as well as on other dissemination activities.

Read more about the Research Roadmap on this **webpage,** and follow us on our Social Media channels.

Read more about the Research Roadmap

The book "*Function-oriented bioengineered skin equivalents - continuous development towards complete skin replication*" is online!



The book *"Function-oriented bioengineered skin equivalents - continuous development towards complete skin replication"* aims to provide readers with a comprehensive summary of the available information on various in vitro skin models, from historical background to different modeling approaches and their applications.

Read more **here.**

Springer

Workshop: "Polysaccharides in drug delivery – On the road to innovation"

The workshop on **"Drug Delivery – On the Road to Innovation"** held in Rome, on 27 and 28 October 2022 was a great success!

Organised in cooperation with the **La Sapienza University of Rome**, the workshop was insightful and powerful, being **the perfect occasion to bring together scientists involved in pharmaceutical applications of polysaccharides, thus exchanging experiences and perspectives.**

All the talks, spanning form nanotechology to biohydrogels, were extremely interesting and the resulting discussions allowed all the participants to be an active part of the drug delivery community.

All the abstracts are published **on our website!**

Read the abstracts

IBIOSYS of Graz University of Technology (Austria), was presented at the AUSTRIA NIGHT - reveals BOLD @WebSummit 2022 in Lisbon Portugal on 2nd of November 2022

Our colleagues *Florian Lackner* and *Rupert Johann Kargl* presented our technology on 3D printed biomimetic aorta models at the AUSTRIA NIGHT – reveals BOLD.

We are grateful for this opportunity and invitation from the Austrian Federal Economic Chamber (WKO), the BOLD community and Advantage Austria.

A big thank you to our collaboration partners from Ludwig-Maximilians-Universität München, Prof. Dr. Nikolaos Tsilimparis, Jan Stana, MD, PhD, and Maximilian Grab, MSc, for contributing state-of-the-art vascular 3D models and EVAR implants.

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Events

Next EPNOE Webinar

The next EPNOE Webinar will take place on **2 February 2023, from 13:00 to 14:30, CET.**

Save the date and keep an eye on our website and social media channels for more information coming in the next few weeks!

More information

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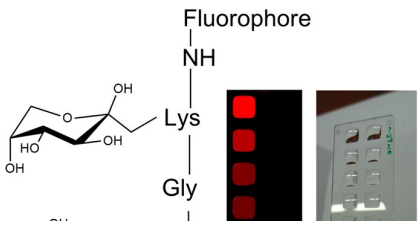
Research

The potential of polysaccharides in biomaterial science - A perspective of IBIOSYS at Graz University of Technology

Natural polymers form the basis of life and understanding and modifying their properties can lead to new applications. From hyaluronic acid in connective tissue to cellulose in plants and peptidoglycans in bacteria, polysaccharides are one of the important components of living things. Up to now, we are far from completely understanding the organizational principles of life. The use of naturally occurring or chemically modified polysaccharides in material science, or in contact with living tissue is therefore our main research interest at the Institute of Biobased Systems (Head Prof. Karin Stana Kleinschek). This requires a highly interdisciplinary expertise, which we are trying to create together with collaborators within and outside TU Graz, Austria.

Two examples are given of how IBIOSYS attempts to utilize polysaccharides in advanced (bio-)material science.

Figure 1 shows a general concept of how polysaccharide nanofibers with a diameter of 10 - 500 nm and a length of several hundred micrometers are used in the manufacturing of extrudable inks that can be 3D printed[1] into macroscopic shapes of advanced materials. The basis for our nanofibers form plants, but more interestingly bacteria, that might be capable of delivering well defined polymeric sequences and supramolecular structures. Chemical modification of the components and the addition of living cells to our inks can be used to create tissue mimetics that could find application in regenerative medicine for skin or in the vascular system. The chemical modification is driven by our endeavor to find new ways to construct defined and complex polysaccharide peptide co-polymers that can be crosslinked into stable gels through enzymatic or non-covalent means.[2, 3] We are also interested in the biomechanical properties of these materials in collaboration with Prof. Gerhard Holzapfel and team, at the Institute of Biomechanics, TU Graz, Austria. We could show in preliminary studies that water and pressure resistant tubes comprising hydrophilic components can be manufactured (**Figure 1**) and that these tubes have similar tensile strength and elongation when compared to porcine tissue. The aim is to imitate the fibrous structure of native vascular or connective tissue which is comprised of collagen and elastin fibrils surrounded by proteoglycans. Cell tests and growth studies are planned in collaboration with Prof. Dr. Petra Kotzbeck and team, at the COREMED facilities of Joanneum Research, Graz, Austria.



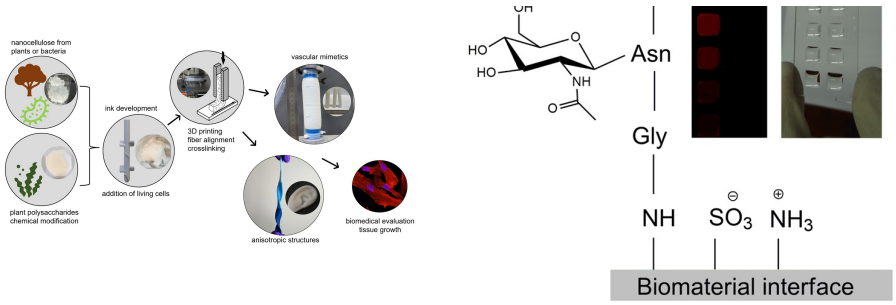


Figure 1: workflow of exemplary biomaterial research at IBIOSYS. Nanofibers are formulated into 3D printable inks with chemically modified polysaccharides optionally containing living cells. Extrusion is used to align nanofibers into desired directions. Various shapes are produced and evaluated for mechanical and biological properties. Parts of the work are funded by FoE Advanced Material Science (Anschubfinanzierung) and performed within the doctoral studies of DI Florian Lackner. Our colleague Dr. Tamilselvan Mohan is highly acknowledged for his contributions.

(Poly)saccharide interfaces are decisive when biological molecules and living cells interact with solids. To elucidate basic mechanisms of semi-synthetic carbohydrate interactions, another interest is in the manufacture and study of defined and novel carbohydrate solid-liquid interfaces on a range of substrates[4] (Figure 2). These can be gold, silicon, polystyrene, polyesters, and others. Chemical methods are devised to synthesize and couple unusual carbohydrates to surfaces in collaboration with the Glycogroup of Prof. Tanja Wrodnigg at IBIOSYS. These surfaces are evaluated with respect to their interaction with proteins and living cells and conclusions are drawn from irreversible binding, cell layer formation, enzymatic activity, or antimicrobial action. Layers and coating methods can find use in biosensors, for drug screening, for enzyme immobilization or again in tissue growth. Integration into fluidic systems and cell culture plates are parts of the planned work.

Figure 2: Glycosylated peptides on amino group containing biomaterial surfaces. The glycosides can be naturally occurring or chosen from a very large library of saccharides including (pseudo-) C-glycosides. The aim is to investigate surface interactions with biomolecules or cells. The inset shows microscope glass arrays of fluorescently labelled biomolecular surfaces. Ongoing work in collaboration with DI Tobias Dorn, currently performing his doctoral studies at IBIOSYS.

Overall, we are convinced that biopolymers and carbohydrates have a significant potential to be used as biomaterials due to their very large structural variability and biological origin to which living cells respond. New chemical and physical methods are still needed to better understand, and to finally utilize the beneficial properties of such materials. In any case a network of strong collaborators and openness to disruptive ideas are necessary to reach the aims described.

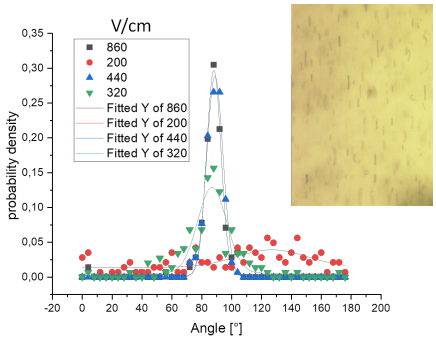
1. Mohan, T.; Dobaj Štiglic, A.; Beaumont, M.; Konnerth, J.; Gürer, F.; Makuc, D.; Maver, U.; Gradišnik, L.; Plavec, J.; Kargl, R.; Stana Kleinschek, K., Generic Method for Designing Self-Standing and Dual Porous 3D Bioscaffolds from Cellulosic Nanomaterials for Tissue Engineering Applications. *ACS Applied Bio Materials* **2020,** 3, (2), 1197-1209.
2. Mohan, T.; Kleinschek, K. S.; Kargl, R., Polysaccharide peptide conjugates: Chemistry, properties and applications. *Carbohydr. Polym.* **2022,** 280, 118875.
3. Bratuša, A.; Elschner, T.; Heinze, T.; Fröhlich, E.; Hribernik, S.; Božič, M.; Žagar, E.; Kleinschek, K. S.; Thonhofer, M.; Kargl, R., Functional dextran amino acid ester particles derived from N-protected S-trityl-L-cysteine. *Colloids Surf., B* **2019,** 181, 561-566.
4. Katan, T.; Kargl, R.; Mohan, T.; Steindorfer, T.; Mozetič, M.; Kovač, J.; Stana Kleinschek, K., Solid Phase Peptide Synthesis on Chitosan Thin Films. *Biomacromolecules* **2022,** 23, (3), 731-742.

Technology Offer
In-situ alignment of dielectric fibers using electric fields in extrusion processes

Precise control of fiber orientation in composites is critical to the mechanical, electrical, optical, and biological properties of many materials. Our technology enables in-situ alignment of dielectric micro- and nanofibers during extrusion of any type of non-conductive polymer matrix. Fiber alignment is possible in all three spatial dimensions, it can be dynamically changed during extrusion, and it can be used to produce 3D objects with unprecedented and enhanced anisotropic properties.

BACKGROUND

The superior specific mechanical strength and toughness of naturally evolved composites originates from precise orientation of reinforcing fibers or particles in a matrix. While living organisms grow these anisotropic reinforcement architectures out of themselves, fiber alignment in polymer processing and especially in 3D printing requires external forces such as shear force or magnetic fields. Moreover, it is often limited to specific application scenarios. In contrast, strong electric fields could control the alignment of a wide range of different dielectric fiber materials. This will lead to novel mechanical, electrical, optical and biological properties.



TECHNOLOGY

Herein we provide a technology that allows for the targeted orientation of fibers in polymer melts, solutions or gels during an extrusion or a 3D printing process. This is achieved by specially designed extrusion nozzles containing multiple electrodes and a control over electric fields in these nozzles. It is combined with fiber alignment due to the extrusion shear forces. The alignment direction can further be changed and controlled during the continuous extrusion process, allowing for a precise fabrication of anisotropic 3D printed objects with novel mechanical, electrical, optical and biological properties.

ADVANTAGES

Our technology has several advantages and new potential applications:

- Wide material spectrum e.g. natural fibers (cellulose, chitin,…) and synthetic fibers (PTFE, carbon nanotubes, metals, ceramics,…)
- Easy integration into existing extrusion devices
- Precise control of fiber orientation in every spatial dimension
- Change of fiber alignment within a continuous extrusion e.g. corners in 3D printing
- Enhanced or new material properties e.g. local control of mechanical strength or electrical conductivity.

REF. Number: E_0991
Keywords: Electric fields, Extrusion, Dielectric Material, Ansiotropic Solids
Inventors: Florian Lackner, Karin Stana Kleinschek, Rupert Kargl
Cooperation Options: Licensing, Sale, Technical Cooperation
Development Status: Proof of Concept
Status of Patents: EP Application field
Contact: Alexander Muhr, Graz University of Technology - Research & Technology House, Mandellstraße 9/11, 8010 Graz, T: +43-(0)316-873 6924, alexander.muhr@tugraz.at, www.tugraz.at/go/ft-haus

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Projects

Upcycling Organic Waste into Carbon-based Functional Inks for Environmental Sensing and Smart Textiles (UPCYCLING-NOW)

Grant number: TED2021-130819B-I00
Funding agency: Spanish Ministry of Science and Innovation
Start date: December 2022
End date: November 2024

Low-cost, large-surface printing technologies to fabricate all sorts of electronic devices is an extremely dynamic field with many prospects in the mid-term. A current barrier to the materialization of mass-consumer applications is the excessive cost of conductive inks based on metals or carbon nanomaterials. A strategy for solving this problem which is in line with the shift to a circular economy is using inexpensive waste feedstocks while trying to reduce the energetic budget in the ink production processes.

The vision of UPCYCLING-NOW is to exploit environmentally-friendly approaches to develop innovative inks for printed electronics by upcycling biopolymer waste. The aim is to transform biopolymers into carbon materials by means of energy-efficient processes. In particular, we focus on cotton, a natural fiber widely used in textiles and woody biomass, which is another biopolymer waste of relevance in the Spanish context.

With the upcycled carbon materials we will prepare inks that will be assessed in specific applications such as single-use biodegradable electrodes for monitoring water contamination with simple onsite electrochemical sensing techniques. Finally, we will use these sensors for analyzing water eutrophication as an educational tool to set the basis for a communication and outreach initiative to be fully developed beyond the scope of the project.

Biobased Soft Functional Nanocomposites For Tissue Regeneration (Biosoft-Rege)

Grant number: PID2021-122645OB-I00
Funding agency: Spanish Ministry of Science and Innovation
Start date: September 2022
End date: August 2025

Tissue engineering and regeneration medicine aim to repair and regenerate damaged or diseased tissues and organs by converging multidisciplinary efforts from materials science, biomedicine, cell therapies, and clinical methodologies.

A promising approach is through the implantation of engineered smart biomaterials and the latest advances at the forefront of healthcare research are gradually transitioning from inert structural supports to biomimetic and bioactive platforms where natural polymers are well-positioned ensuring a more sustainable approach while securing equal or improved performances.

Soft nanocomposites using natural polymers with fine-tuned mechanical and functional properties are propitious alternatives to allografts, autografts, and synthetic polymers in the development of biomedical implants. In the foreseeable future, we expect that the programmability of soft nanocomposites using natural polymers is going to push the narrative from proof-of-concept scenarios to realistic functional biomedical platforms underpinning regenerative medicine.

In this context, the main objective of BIOSOFT-REGE is to enlarge the natural polymers landscape of soft nanocomposite implants by combining natural polymers and nanoparticles toward sophisticated hydrogels displaying a variety of shapes, topographies, and porosities while also encompassing features such as biocompatibility, biointegrability, mechanical compliance, stimuli responsiveness, or programmed biodegradation profiles.

ENERGISE: "Improving tolerance for FODMAPs using modified celluloses: defining the role of gelation in reducing gas production in vitro and in vivo"

Grant number: MR/W026295/1
Funding agency: UKRI / MRC (Medical Research Council)
Start date: June 2022
End date: March 2026
Link to project: https://www.nottingham.ac.uk/research/groups/gi-mri/energise.aspx

Low FODMAP (fermentable, oligo-di-mono-saccharides and polyhydric alcohols) diets have revolutionised management of irritable bowel syndrome (IBS). FODMAPs cause abdominal discomfort, bloating and flatulence by their rapid colonic fermentation which produces gas and distends the colon.

Low FODMAP diets, although widely adopted, are expensive, inconvenient and may have negative effects on health by excluding high fibre foods (HFF) that protect against obesity-related diseases and colon cancer.

This project aims to use modified celluloses to trap FODMAPs in a gel, thereby limiting bacterial access and modifying fermentation to produce less gas. We have shown this in IBS patients by co-administered psyllium, a viscous and gel forming fibre, with the FODMAP, inulin.

Biophysical defence in the mammalian gut: Unlocking the molecular mechanisms of dietary fibre interaction with mucin glycoproteins.

Grant number: BB/T006404/1
Funding agency: UKRI / BBSRC (Biotechnology and Biological Sciences Research Council)
Start date: September 2020
End date:September 2023
Link to project: https://www.nottingham.ac.uk/research/groups/food-structure-and-biomaterials/

Mucus plays pivotal role in gut health, including its role in maintaining healthy microbiota. Despite the importance of mucus biofluids to human health and well-being, there is a limited knowledge about how dietary fibre interact with mucus. The emerging evidence suggests that fibre-rich diet can support mucus integrity and boost its barrier function.

This project considers the effect of dietary fibre on biophysical properties of mucus, such as rheology (flow, viscoelasticity), hydration, lubrication and permeability. The key scientific question is to uncover the interaction mechanisms between dietary fibre polymers / fibre assemblies (e.g., plant cell walls) and mucus. Common dietary fibre with proven health benefits (e.g., oat b-glucan) display no mucoadhesive properties when tested using instrumental techniques commonly employed in drug delivery research.

The emerging hypothesis is that interactions are mediated by the bound water and are physical in nature amplified by polymer entanglement. By bringing key capabilities in analytical centrifugation, rheology, micromechanical testing and advanced microscopy, the project aims to tackle this fundamental problem by addressing three specific research questions: (a) uncover the role of DF molecular architecture on hydration, viscoelasticity, and responsiveness of mucus/dietary fibre complexes; (b) by controlling the molecular architecture of fibre polymers, unlock the potential of fibre to control mucus rheological properties; and (c) design dietary fibre composites to tune and modulate mucus barrier functionality.

Visualisation and motion analysis of in mouth processes and oral behaviours associated with wearing dentures

Grant number: BB/V509553/1

Funding agency: UKRI / BBSRC (Biotechnology and Biological Sciences Research Council)
Start date: September 2020
End date:September 2024
Link to project: https://highlights.cdt.horizon.ac.uk/students/psxms20

Investigating the applications of machine learning in observing, mapping, and modelling the movements of the vocal organs for applications within dental healthcare. The research explores the development of novel computer vision algorithm for constructing a representation of the mouth's internal elements by mapping the 2D/3D view or action (i.e. time domain) of the external elements.

Sustainable Chemistry: Atoms-2-Products.
Effect the configuration of cellulose synthase complex in microalgae on the properties of cellulose-derived films.

Grant number: EP/S022236/1
Funding agency: UKRI / EPSRC (Engineering and Physical Sciences Research Council)
Start date: September 2021
End date:September 2025
Link to project: https://www.nottingham.ac.uk/research/groups/food-structure-and-biomaterials/

Micro-algae are species with different cellulose structures that may provide unique properties to the extracted cellulose. The structure in which the cellulose is formed depends on the position of the cellulose synthase complexes (Terminal Complexes). In higher plants, these are arranged in a hexagonal structure called a rosette structure. In microalgae, they can also be arranged as single rows, multiple rows, or diagonal rows.

This difference in structure could impart different physicochemical properties, which would help create bioplastics for varying applications or combine for multiple purposes. Research into algal cellulose and its creation into algal films could therefore provide multiple benefits and help solve the current plastic crisis.

Sustainable Future Foods: Mechano-Enzymatic Assembly of Complex Food Structures

Grant number: BB/T008369/1 - 2604202
Funding agency: UKRI / BBSRC (Biotechnology and Biological Sciences Research Council)
Start date: September 2021
End date:September 2025
Link to project: https://www.nottingham.ac.uk/research/groups/food-structure-and-biomaterials/

This project seeks to discover and develop new methods for controlling enzymatic cross-linking during extensional flow and characterise ordered structures using small angle scattering and nuclear magnetic resonance imaging, as well as diving into understanding fibre's mechanical and functional properties, focusing on applications in foods.

Nanoscale Characterisation of Biological and Bioinspired Materials using Integrated Fluidic Force - High-Resolution Confocal Microscopy

Grant number: BB/W019639/1
Funding agency: UKRI / BBSRC (Biotechnology and Biological Sciences Research Council)
Start date: July 2022
End date: July 2023
Link to project: https://www.nottingham.ac.uk/nmrc/

We propose a new imaging platform that combines ultra-fast confocal imaging with the the nano-fluidic functionality delivered by an integrated Fluidic Force microscope (FluidFM-UFCLSM). The proposed capability opens a new phase of exploration of biological systems by enabling characterisation of localised biochemical and physiological processes. The proposed capability provides new avenues for specific applications such as new antimicrobial agents, functional genetics

and the development of sustainable crops.

The unique design of FluidFM-UFCLSM enables accommodating an array of complex biological samples to perform quantitative and predictive characterisation of biofilms, tissues, whole plants, small animals, insects, mucosal membranes, food systems and tissue scaffold hydrogels.

Australia Partnering Award: Delving down-under using advanced plant phenotyping to uncover how roots grown in hard soils

Grant number: BB/V018124/1
Funding agency: UKRI / BBSRC (Biotechnology and Biological Sciences Research Council)
Start date: July 2021
End date: July 2025
Link to project: https://www.nottingham.ac.uk/research/beacons-of-excellence/future-food/index.aspx

The overarching aim of this project is to share UK-Australian expertise in plant phenotyping with the goal to improve compaction tolerance and global food security (supporting Bioscience for Sustainable Agriculture and Food from the BBSRC Delivery Plan and the BBSRC Agriculture and Food Security Strategic Priority Area and the priority areas of Food, Soil and Water of the Australia Research Council.

Cellulose from waste and bacteria in electro-spinning for continuous fibre reinforced 3D printed composites

Funding agency: M-ERA.NET 3, Horizon 2020 program
Start date: November 2022
End date: October 2025
Link to project: https://www.list.lu/en/research/project/biocel3d/?tx_listprojects_listprojectdisplay%5Barchive%5D=&cHash=c9c1488ae45bf58b5781f1b7c4689af1

Natural fibre potential as reinforcement in composites is restricted by their inherent properties (e.g. moisture sorption) and variability (mechanical properties are different even for same species). Continuous reinforcing yarn is used in 3D printing, providing more strength and stiffness.

For continuous natural fibre reinforced filaments, fibres must be twisted to keep the yarn integrity, reducing the mechanical properties of the composite due to fibre misalignment. BioCell3D proposes the incorporation of an aligned cellulose based reinforcement for continuous fibre 3D printing by creating our own technical natural fibre with hierarchical organization and enhanced physical properties. Continuous reinforcement will be obtained by electrospinning of cellulose derivatives as well as bacterial cellulose.

Assessment of permeation and toxicity of nanoparticles on polysaccharide-based 3D bioprinted bilayered skin substitute

Funding agency: Federal Ministry Republic of Austria (Oead)
Start date: November 2022
End date: November 2024

3D bioprinting of polysaccharide-based bioink containing human derived skin fibroblast and human epidermal keratinocytes for the fabrication of dermal and epidermal skin layers.

Porous Materials @ Work for Sustainability

Funding agency: Lead projects - Graz University of Technology
Start date: September 2022

End date: September 2025
Link to project: https://www.tugraz.at/projekte/pmws/sub-projects

Porous Materials@Work for Sustainability is divided into a set of 12 sub-projects (P1-P12), which typically bundle hitherto unconnected research lines at TU Graz. These sub-projects pursue at least two of the following four overarching targets: Clean energy, Green chemistry, Recycling and Monitoring.
Project 5: Azobenzene Crosslinked Carbohydrates for the Selective Uptake/Release of Biologically Active Species.

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Education

Welcome to new students and researchers!

- New Ph.D. students

"Petru Poni" Institute of Macromolecular Chemistry Iasi, Romania:

- **Alexandra Lupu**, Bio-inspired hybrid materials with biomedical and therapeutic applications (Chemistry); Supervisor: **Dr. Maria BERCEA**
- **Melinda-Maria Bazarghideanu**, Environmentally friendly polymer composites containing polysaccharides or their derivatives (Chemistry); Supervisor: **Dr. Marcela MIHAI**

Open Positions

Postdoctoral researcher Life cycle assessment of electrochemical conversion of CO2
Utrecht University, Faculty of Geosciences

Are you interested in finding out whether CO2 utilisation can lead to net zero? How to define and to assess circularity in carbon capture and utilization? Can electrochemical technology play an important role?

We are looking for an LCA expert with chemical engineering background to join our team!

- Start Date: As soon as possible
- Deadline to apply: 1 December 2022
- Contact email: Dr. Li Shen, L.Shen@uu.nl

For more information, please **visit this webpage**.

Professorship in the area of "Chemical Engineering: Design and Processing of Functional Products by Physico-Chemical Treatment of Natural Compounds from Side/Waste Streams" at Ghent Technology Campus

This vacancy is embedded in the "Soft Matter, Rheology and Technology" division (SMaRT) of the Department of Chemical Engineering, KU Leuven.

For more information, please **visit this webpage.**

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