Theme 1: Recycling for a Sustainable Society

1. **'Recovery of extracellular polymers from wastewater treatment residuals as a new circular biopolymer (REThiNk)', DKK 54,829,600 over 6 years**

   Main applicant: Per Halkjær Nielsen, Department of Chemistry and Bioscience, Aalborg University

   Co-applicants:
   Thomas Seviour, Department of Biological and Chemical Engineering, Aarhus University

   Mark van Loosdrecht, Environmental Biotechnology, Delft University of Technology

   Morten Kam Dahl Dueholm, Department of Chemistry and Bioscience, Aalborg University

   Brief description:
   Activated sludge is the most widely used biological treatment process for wastewater, and it produces >10% of all biowaste in the western world. We present a new strategy for turning these biosolids into valuable biopolymers via extraction of extracellular polymeric substances (EPS) that are secreted from bacteria in the activated sludge. The EPS has high intrinsic value and can be recycled into new sustainable biomaterials and replace oil-based polymers. There is a lack of understanding of the microorganisms that produce the EPS and their relevant properties. We will establish a predictive model for declaration of extracted EPS by linking the bacterial physiology, overall community composition, and properties of extracted EPS. The EPS will be formulated into biomaterials and create an entry point for activated sludge into the global biopolymer market, with the goal to develop a new resource recovery strategy and increase the sustainability and profitability of wastewater treatment.

2. **‘SUgar Beet REvolution: Enzymatic Biorefining of Sugar Beet Pulp to Nutraceuticals and Recyclable Materials (SURE)’, DKK 57,051,850 over 6 years**

Main applicant: Anne Meyer, Department of Biotechnology and Biomedicine, Technical University of Denmark

Co-applicants:
Gustav Nyström, Cellulose & Wood Materials Laboratory, EMPA Switzerland

Susanne Brix Pedersen, Department of Biotechnology & Biomedicine, Technical University of Denmark

Peter Ulvskov, Department of Plant and Environmental Sciences, University of Copenhagen

Brief decription:
Sugar beet is one of the highest yielding crops in the Northern Hemisphere, with 2.5 million tons/year produced in Denmark alone. It is grown to produce sugar, but the fibrous pulp is rich in functional cellulose fibers and unique bioactive polysaccharides. Now, our vision is to convert sugar beet into a biorefinery crop and a leading example of how to shift from one product to sustainable production of several beneficial products via side-stream bioprocessing. We propose to meet this challenge by an interdisciplinary research effort providing the scientific foundation for achieving entirely biotechnology based fiber disassembly and optimal product functionalities. We will employ microbial expansins to loosen structural cell wall assemblies, explore enzymatic separation of bioactive pectin elements and cellulose microfibrils, optimize enzymatic lignin removal and focus on cleaving lignin-hemicellulose linkages, assess anti-inflammatory bioactivity mechanisms of particular pectin polysaccharides, and aim to understand how assembly, disassembly, and reassembly of biocomposites work.

3. **'Center for enzymatic deconstruction of thermoset plastics for a sustainable society (En'Zync)', DKK 57,003,755 over 6 years**

Main applicant: Daniel Otzen, Interdisciplinary Nanoscience Center (iNANO), Aarhus University

Co-applicants:
Peter Westh, Department of Biotechnology and Biomedicine, Technical University of Denmark

Maria Ramos, Computational Biochemistry, University of Porto

Anders Lindhart, Environmental Technology, Danish Technological Institute

Brief description:
Among the strongest and most durable plastics exist a group called thermosets, used for wind turbines, airplanes, and insulation foams.Common for these plastics are that they cannot be melted, and thus, not recycled through conventional means. However, unlike regular plastics, most thermosets consist of chemical linkages reminiscent of nature's own linkages as found in food sources such as sugar or protein. Using nature's own approach of degradation, En'Zync will attempt to develop enzymes, found in fungi, which are able to break down thermosets into molecular units in a controlled manner. These molecular units, called monomers, can be used in the production of new thermosets and will offer an unprecedented method for thermoset recycling. This ambitious goal is made possible only through interdisciplinary collaboration between material specialists, molecular biologists, and computational experts.

Theme 2: Energy Materials with Biological Applications

1. **'EMGUT - Energy Materials for the GUT', DKK 59,963,788 over 6 years**

   Main applicant: Anja Boisen, Department of Health Technology, Technical University of Denmark

   Co-applicants:
   En-Te Hwu, Department of Health Technology, Technical University of Denmark

   Fatemeh Ajalloueian, Department of Health Technology, Technical University of Denmark

   Nikolaj Gadegaard, James Watt School of Engineering, University of Glasgow

   Brief description:
   There is a growing interest in the influence of our gut condition on our general health. The microorganisms in our gut (microbiota) are for example anticipated to have profound impact on progress and development of major human diseases, which include obesity, hypertension, cardiovascular disease, diabetes, cancer, Inflammatory Bowel Disease and depression. At the same time we lack tools for studying, detecting and treating conditions in the gut in a minimum invasive matter. In EMGUT, we will develop and apply so called 'energy materials' that can transform e.g. mechanical movement into electrical energy for minimal invasive ways of 1) sampling, 2) drug delivery and 3) sensing in the gut. Our vision is to both analyze and act upon local gut conditions – for example dispensing local medication.

2. **‘Soft wearables with high energy density: merging chemical biology and silicone chemistry with compliant active devices (WeArAble)’, DKK 47,987,527 over 5 years**

Main applicant: Anne Ladegaard Skov, Department of Chemical Engineering, Technical University of Denmark

Co-applicants:
Herbert Shea, Department of Mechanical Engineering, École Polytechnique Fédérale de Lausanne

Neel Joshi, Department of Chemistry and Chemical Biology, Northeastern University

Brief description:
Wearables, e.g. smartwatches and trackers of various types, are increasingly becoming a more natural part of our lives, yet soft and compliant wearables in the shape of prosthetics and soft exoskeletons are far from being available as commodity products. This is mainly due to many scientific challenges with respect to construction of inherently soft materials that are still robust and have high energy densities, such that e.g. a limb can be activated. The vision of the WeArAble project is to build the scientific foundation for future development of soft wearables that are mechanically transparent in the sense that the wearables are worn without the wearer noticing them, and not hindering motion nor even the sense of touch. The WeArAble centre proposes to do this by combing tissue-resembling soft silicone elastomers for stability and integrity, biologically tailored materials for high energy density and functionality, and smart device design for full benefit of the developed materials.

challenge

Theme 3: Immunity at Mucosal Surfaces

1. **‘Center for intestinal immune regulation (CIIR)’, DKK 59,997,987 over 6 years**

   Main applicant: William Winston Agace, Department of Health Technology, Technical University of Denmark

   Co-applicants:
   Lars Rønn Olsen, Department of Health Technology, Technical University of Denmark

   Kathy McCoy, Department of Physiology and Pharmacology, University of Calgary

   Flemming Bendtsen, GastroUnit, Hvidovre Hospital

   Brief description:
   Crosstalk between immune cells and environmental signals from our diet and intestinal bacteria is essential for intestinal health. Alterations in this crosstalk can rewire immune cell function, contributing to the inflammatory bowel diseases (IBD). There are few effective therapies for IBD and many IBD patients do not respond to therapy or loose therapeutic responses over time, highlighting the need for new directions and approaches to disease management and treatment. Intestinal mesenchymal stromal cells (iMSC) represent a diverse population of tissue resident non-immune cells that lie in immediate proximity to intestinal immune cells. Here we will assess the importance of iMSC-immune cell interactions in intestinal homeostasis and the initiation and maintenance of IBD. We anticipate identifying novel iMSC-centric targets for promoting/restoring intestinal immune homeostasis, for the treatment of IBD and use as predictive biomarkers of disease status and therapeutic responsiveness.