Biobased Materials

Core courses

BBM Core Courses

Sciences

Biobased Materials

Full course description

This course is more or less the mission course of the master programme. The course aims to make the students comprehend the importance of the transition from a petrol-based to a more sustainable biobased economy and society. The problems associated with this transition will be a central theme in this course. First the current state of biobased products, like bio-fuels, bio-plastics and biobased materials will be studied. Then the production strategies for these products will be considered in the context of sustainability. Furthermore, the problems associated with feed-stock and biobased building blocks are presented and will be discussed. Finally, the students will make a short study on the importance of a biobased material (or a group of biobased materials) for society and its future in a changing world economy.

Course objectives

To create a detailed understanding of the importance of biobased materials in the transition towards the biobased economy · To define what biobased materials are and how these can contribute to a more sustainable economy · To study different forms and sources of biomass and their processing technologies · To deepen the understanding and knowledge of biorefinery and cascading principles · To increase understanding about the current state of bio-fuels, bio- plastics, and other biobased materials · To create an understanding of the impact of bio-fuels, bio-plastics, and biobased materials on society and the environment and the methods to evaluate this impact (LCA) · To study and increase knowledge on the circular economy and its implications for society.

BBM1001

Period 1
2 Sep 2019
25 Oct 2019

Print course description
ECTS credits:
6.0
Coordinator:
Y. van der Meer

Sciences

Process Technology

Full course description

The first goal of this course is to enable you to develop a clear understanding of the fundamentals of chemical reaction engineering (CRE). To achieve the goal, the course has been structured to build skills in solving engineering problems through reasoning rather than through memorising and recalling mathematical equations. The fundamentals developed will be applied in reaction mechanisms and adopted pathways in the understanding of bioreactions and bioreactors. In this process you will be introduced to the rate of reaction, the general mole balance equation, batch reactors, industrial reactors, batch reactor design equations, design equations for flow reactors, reactors in series, rate laws, stoichiometry, catalysts in reactors, homogeneous and heterogeneous catalytic systems, enzymatic reaction fundamentals, enzyme reactions, bioreactors, physiologically based pharmacokinetic models. This course also has the ambition to develop your mathematical skills required for the follow up courses and your personal development. Description of skills training during the course: · The problem solving: Considering that the course is very much driven by mathematics it will be important to understand physical aspects of mathematical jargon and its use in examples. This skill will be build up by following extensive exercises given in the book. · The lab and pilot plant visits: To have practical insights on the reactors at different scales from micro to litres and mega-scale visits to the laboratories and pilot plants will be arranged. · The presentation: During the course a session with presentations will be held. In this you communicate your findings in modelling of the reactors.

Course objectives

To develop a clear understanding of the fundamentals of chemical reaction engineering - To be able to solve engineering problems focussed on reaction mechanisms of bioreactions and bioreactors - Develop mathematical skills required for process technology and reaction engineering - To apply mathematical skills for solving practical problems in chemical reaction engineering

BBM1005

Period 1
2 Sep 2019
25 Oct 2019

Print course description
ECTS credits:
6.0
Coordinator:
S. Rastogi

Sciences

Molecular Biology and Physiology of Plants and Microbes

Full course description

This mandatory course aims to introduce students with limited biological background into the biology of plants and microbes. A deepened understanding of the molecular mechanisms and metabolic routes in plants and microbes is the main aim of this course. Most biobased materials are of plant origin, and therefore students should expand their knowledge of plants, plant products and how these products are produced. In addition to study of natural plant materials and how the metabolic routes work, the possibility of genetically modified organisms in biobased materials or building block production will be studied. The molecular biology of microbes will in part concentrate on the isolation of building blocks from these organisms. Another focus will be the microbial enzymes that can be used to synthesize interesting building blocks. These enzymes can be used in vitro to produce novel biobased building blocks and/or materials. Description of skills training during the course: The course will be divided up into weekly topics which are introduced in the lecture and further analysed in the tutorial sessions using PBL and RBL. The laboratory sessions will be used to make the students familiar with plant and microbial biology techniques. Isolation, purification, enzyme characterization will be included in the practical sessions.

Course objectives

In this mandatory course the students will be familiarized with the way in which plants and microbes function at a molecular level. To achieve this, the students will deepen their knowledge of: - The morphology and structure of plants, plant cells and bacteria; - The conditions under which plants and microbes grow and how growth can be optimized in the laboratory(microbes) on in the field (plants) - The relation between the structure and function of the biomacromolecules that are found in the bacterial and plant cells; - The major metabolic routes in bacteria and plant cells, including the routes leading to biobased building blocks - Enzymes involved in metabolic routes and how these can be used for in vitro synthesis

BBM1002

Period 2
28 Oct 2019
20 Dec 2019

Print course description
ECTS credits:
6.0
Coordinator:
L. Bortesi

Sciences

Principles of Materials Science

Full course description

The course is mandatory for students who enter the master program without being trained in materials science, and in particular polymer science, and the physico-chemical nature of polymeric materials. As such the underpinning science of the multidisciplinary elements of polymeric material science, covering mainly synthesis, characterization and properties, is generated; a prerequisite to allocate the contents of the advanced, most often elective, courses of the program. Four pillars establish the contents of the course, being (i) chemical structure (microscopic); identification and synthesis; (ii) characterization of polymers; (iii) phase structure and morphology; (iv) macroscopic properties of bulk polymers. Description of skills training during the course: Besides the theory encompassed in the lectures, students will be trained in lab and presentation skills. Furthermore, students will learn to methodologically design experiments, select and use the right analytical tools, and assess scientific papers and each other critically.

Course objectives

To create a molecular understanding of micro- and macroscopic polymer structures, architectures and assembly · Thermodynamics and kinetics of phase transitions for glassy and semi- crystalline polymers · To generate a molecular and theoretical understanding of polymer dynamics; rubber-elasticity and visco-elasticity · To understand variations in mechanical behaviour of polymer systems from a theoretical and practical perspective; durability, stability, plasticity, elasticity, etc. · To gain detailed insight In and hands-on experience with polymer characterization and analyses techniques · To correlate molecular design-structure-property relationships to technology development and applications.

BBM1003

Period 2
28 Oct 2019
20 Dec 2019

Print course description
ECTS credits:
6.0
Coordinator:
J.A.W. Harings

Sciences

Plant Derived Materials and Building Blocks

Full course description

This course aims at providing students with insights about drivers and know-how on how to convert our fossil-based organic chemical industry towards a more sustainable biobased industry. Future materials will contain other building blocks than we are using today, giving materials with substituted or outperforming (combinations of) functionalities. The framework of our current chemical practice, combined with our growing needs to make this practice more sustainable in the near future, will set the scene to design mankind’s sustainable materials of the future. This transitional evolution will be illustrated and highlighted both from scientific and business angles. The drivers for this transition are manifold: scientific challenges and limits are surrounded with many other influential parameters. But the outcome is evident: biobased is not a hype. This course prepares the student to boost his/her know-how and skills in a more sustainable chemical word.

Course objectives

- Overview of fossil raw materials used to serve our current needs
- Identify and understand the main fossil-based sources
- Overview of existing and future renewable plant-derived sources
- Identify and understand the main biobased sources
- Scientific and business dynamics in the evaluation of the new sources
- Identify and quantify the criteria for a successful building block

- Overview of some commercially available renewable biobased products
- Understand the success of the commercially available examples
- Overview of the main renewable building blocks and case studies
- Chemical conversions of the main building blocks from renewable sources

Recommended reading

Industrial Organic Chemistry, 5th Edition, Hans-Jurgen Arpe, Stephen Hawkins (Translator) ISBN: 978-3-527-32002-8, 525 pages, September 2010. Additional references are included in the course material.

BBM1004

Period 2

28 Oct 2019

20 Dec 2019

Print course description

ECTS credits:

6.0

Elective courses

BBM Courses

Sciences

Advanced Macromolecular Chemistry: Biopolymers Synthesis, Modification and Characterization

Full course description

Different polymerization mechanisms: radical polymerization, ionic polymerization, coordinative polymerization, ringopening polymerization, step growth polymerizations and also polymer modification; - Copolymers and copolymerization curves; - Polymerization techniques: bulk, solution, dispersion, emulsion; - Polymer architectures: linear, block copolymer, graft copolymer, star shaped polymers, supramolecular polymers; - Polymer classes and their application fields: thermoplasts and thermosets; - Polymers in solution and phase separation; - Molecular weight determination of polymers: gel permeation chromatography with different detectors, viscometry, ...; - Application of the knowledge on biobased polymers. Description of skills training during the course: - Lab skills on polymer synthesis and molecular characterization; - Presentations skills; - Understanding publications in the field and discuss about it; - Student can search relevant information in literature and on Scifinder; - Analyze and solve problems in the field; - Student is able to choose the most appropriate polymer mechanism to make the desired polymers; - Student can choose the right molecular characterization technique(s) for the polymer under consideration; - Critical evaluation of publications and lab results.

Course objectives

- Student gains theoretical knowledge in the field of polymer synthesis and molecular characterization of polymers; - Student learns to read and understand publications in the field; - Student gains practical lab experience in polymer synthesis and molecular characterization; - Student learns to work problem solving, to evaluate work (own lab work, publications in the field) in a critical way and to search more in depth information in literature.

BBM1007

Period 4
3 Feb 2020
3 Apr 2020

Print course description
ECTS credits:
6.0
Coordinator:
K.V. Bernaerts

Sciences
Applied Materials Science and Engineering

Full course description

Description of the course: The elective course provides students with (pre-requisite) background in the field of polymer materials science extended insights to physical properties and advanced characterisation methods. Specifically for biobased polymer materials the listed subjects from the multidisciplinary field of Soft Matter science are addressed. Description of skills training during the course: Further to lectures on the background with available data and theories also lab training, discussion skills, and presentation skills will be imparted. The students will learn about fundamentals of materials physics and mechanics as well as state-of-the-art analytical tools for evaluating scientific methods and results.

Course objectives

· Communicate on the role of polymers in materials science and engineering in general discussions · Be able to identify advantages and disadvantages between processing and the processed products of polymers, metals, and ceramics · Be aware of different structure–property relations for biobased polymeric materials with relation to: o Molecular structure. The students are able to identify the role of molecular conformations and configurations on general thermal behavior, phase behavior and potential processing routes o Crystallization. The students know the differences between the formation of 1) chain-folded crystals, 2) non-periodic layer crystals, and 3) extended chain crystals, and are able to translate these concepts to the thermal and mechanical properties. o Morphology. The students are able to predict polymer morphologies under quiescent and defined flow conditions in homopolymers and polymers blends. o Additives. The students are able to identify the effect of the introduction of various additives on the thermal behavior and mechanical performance in polymers. o Mechanical performance. The students are able employ their knowledge regarding molecular structure, morphology, and additives to predict their effects on the mechanical performance of processed polymers. · Know the basic theory relating to Flory Huggins Lattice Model, and being able to use it to read solution phase diagrams, identify polymer miscibility, phase stability, and the thermodynamics and kinetics of phase transitions. · Have theoretical insight and practical experience with microscopy, rheometry, thermal analysis, spectroscopy and scattering analysis techniques

BBM1008

Period 4

3 Feb 2020

3 Apr 2020

Print course description

ECTS credits:

6.0

Coordinator:

J.A.W. Harings

Sciences

Biomedical Materials

Full course description

This course aims to introduce the students to the field of biomedical materials. Biobased materials have not been applied widely in a medical context, but there are example like poly(lactic acid) (PLA). The currently used biomedical materials include: metals (skeletal implants), ceramic materials (dental/orthopaedic), hydrogels (coatings, drug delivery), fibres (surgical patches, wound dressings), and high-grade polymers (tubings, catheters, etc.). The introduction of novel materials in biomedical applications has proven to be complicated and slow. The requirements for the materials and their synthesis are very strict to reduce the risk for the patient. Furthermore, the materials have to possess specific properties that ensure the biocompatibility of the material. This does not mean lack of toxicity, but also prolonged functionality over the intended period of use. The course also aims to teach the students the basic principles of effective communication between materials scientists and medical doctors. The translation of material development into a usable implant in the clinic is the ultimate goal of biomedical material development. With this course we will set a first step in that direction by teaching the required "biomedical" language for a (biobased) materials specialist Description of skills training during the course: The skills trainings in this course will be a combination of laboratory sessions and a case study. This case will be distributed at the start of the course. The research problem will be translated into a research question and possible experiments to be performed in the laboratory. The results of this case study will be presented at the end of the course in a small symposium.

Course objectives

· To create a detailed understanding of the application of different materials in medical profession; i.e. implanted or in contact with the human body or organs · To define what are the precise material properties required for medical application for(biobased) materials · To study the effects of (biobased) materials on the human body and tissues (biocompatibility) · To create an understanding of the impact of materials development on treatment of patients and vice versa: · To get insight into the requirements and regulations governing the synthesis and application of biomedical materials

BBM1009

Period 4
3 Feb 2020
3 Apr 2020

Print course description
ECTS credits:
6.0
Coordinator:
K. Saralidze

Sciences

Surfaces and Interfaces: Modification and Spectroscopical Analysis

Full course description

The surface of the material therefore can determine how the reaction towards the material will be. Careful design, modification, manipulation and characterization of surfacesis an important part of application of BioBased Materials, and will be discussed in this course:

- fundamentals in surface and interface science;
- binder chemistry and film formation for e.g. water based, solvent based, radiation curable and powder coatings;
- coating formulation;film formation;
- surface characterization: contact angle, spectroscopy (e.g. IR), microscopy (optical, SEM, TEM, AFM), application properties (gloss, color, adhesion and mechanical properties)
- traditional and new application fields of (biobased) coatings: inks and paints, antifouling, wear resistant, antimicrobial, self-cleaning, self-repairing, etc;

Description of skills training during the course:

- coating formulation and film formation;
- gain insights in the advantages/disadvantages of different types of binder chemistries and film formation mechanisms;
- interpretation of coating formulation and surface characterization results;
- reading and understanding relevant scientific papers in the field;
- solving problems in the field;
- critical thinking.

Course objectives

- The student is able to apply the gained knowledge to tackle the surface chemistry of (biobased) materials;
- At the end of the course, the students should be able to quickly catch and discuss, in the frame of a scientific publication, what the research approach has been, which means have been used and why, to solve a question in the field. The student must be able to present this to a broad audience and prove his critical attitude;

- The student knows how to change surface properties to gain the desired properties;
- The student learns to have an helicopter view over (lab) results of himself and his colleagues and is able to present (oral presentation) those different lab experiments as well as the corresponding results in a systematic way;
- The students learn to plan their lab work as efficient as possible;
- The students learn to make notes during lectures and when things are explained to them e.g. during tutorials.

BBM1011

Period 5
6 Apr 2020
5 Jun 2020

Print course description
ECTS credits:
6.0
Coordinator:
K.V. Bernaerts

Sciences

Nano-Science and Nano-Technology: (Bio)Polymers and (Bio)Composites

Full course description

This course will focus on the study of materials on the nano-meter scale, i.e. materials with dimensions in the range of 10-9m. The properties of materials change when applied in this nano-scale. In nanotechnology structures of nano-meter precision are fabricated, elucidating functionalities at micro- and macroscopic length scales. Especially in (bio)composites nanoparticles can be used to modify the properties of materials. Therefore it is of interest to study natural occurring bio-nano-structures and composites, to understand their fabrication paths and consequential physical, chemical and mechanical properties at micro- and macroscopic length scale. Characterization tools elucidating the nano-sized structures comprise for example X-ray and neutron diffraction/ scattering techniques, transmission electron microscopy, environmental scanning electron microscopy and atomic force microscopy. The next step in the course is to translate this knowledge into synthetic, bio-inspired materials that can lead to industrial or medical (in-vivo) application of nanomaterials like organic semi-conductors, antimicrobial coatings and bio-sensoring. Description of skills training during the course: Part of the skills training will be devoted to intense literature study, which will lead to a small research plan. The students will have to make a set of novel composite materials and determine the chemical, physical and/or mechanical properties of their materials.

Course objectives

On the completion of the course you will master: · the main fabrication strategies in making nanoscale materials; synthetic, natural and bio-inspired · the concepts of molecular self-assembly, its thermodynamics and kinetics, and the role of non-covalent inter- and intramolecular interactions · the principles and (dis)advantages of characterization methods resolving questions at the nano-meter length scale · understand the relationships between nano-structures and functional properties in both natural, in-vivo and technological applications

BBM1012

Period 5
6 Apr 2020
5 Jun 2020

Print course description
ECTS credits:
6.0
Coordinator:
J.A.W. Harings

Sciences
Sustainability of Biobased Materials

Full course description

An important characteristic of biobased materials will be their sustainability. The first difference with fossil based materials is the use of renewable resources. The use of plant and/or microbial sources can avoid this problem, as long as the life cycle of the biobased material can be closed. Fossil based materials are dumped in land-fills or burnt to generate CO2 and water. This means that eventually the source for most currently used polymers will be depleted. Moreover, dumping leads to catastrophic waste problems and burning fossil carbon leads to CO2 emissions that cause (further) global climate change. Circular economy developments try to reduce the waste problem by introducing re-use and recycling strategies. Biobased materials however, have additional potential for further waste prevention strategies, like biodegradation to inputs for future processes. Biobased materials are however not intrinsically sustainable. The biomass feedstock, manufacturing process, interdependency with other product value chains, recycling and waste scenarios play an important role in the level of sustainability. Therefore, it is important to assess the sustainability of the current materials and the biobased alternatives to truly contribute to a more sustainable world by developing biobased materials. Finally the course will highlight the environmental policies and in particular those of importance to biobased products. Description of skills training during the course: During the practical skills sessions of this course, the students will work on a sustainability topic for a presentation. In a small symposium at the end of the course these presentations will be assessed by peer review and by the teaching staff. During the skills, practical sessions will be devoted to presentation techniques, writing and reviewing competences.

Course objectives

In this course the following topics will be studied and discussed in detail: · Sustainability: concepts and theories · Ecosystems and climate change · Methods to assess and measure sustainability · Life cycle assessment theory · Life cycle assessment case study: biobased vs. fossil based materials · Sustainable energy · Waste scenarios and their impact on sustainability · Closing the loop: cradle to cradle and circular economy · Environmental policy

BBM1013

Period 5
6 Apr 2020

5 Jun 2020

Print course description

ECTS credits:

6.0

Coordinator:

Y. van der Meer

Sciences

Carbohydrates: Monomers amd Polymers

Full course description

The course aims at providing a detailed overview of carbohydrates as biobased materials. There are many obvious materials that are already in industrial use, like hemicellulose, cellulose and starch. These polysaccharide materials are widely used for a large number of applications. However, there is also another large field of carbohydrate research that uses lactic- and/or glycolic acid. These can be used to produce polymers of which the properties can be fine-tuned by using different techniques and technologies. In this course an expert from this field will introduce the industrial use and application of poly-lactides. Also the design and synthesis routes for new carbohydrate building blocks will be studied. Description of skills training during the course: During the course there will be laboratory sessions on the isolation and production of different carbohydrate biobased materials. The students will work together with an external expert in designing their own experiments on structure-function relations of synthetic carbohydrate polymers, i.e. poly-lactic acid, poly-glycolic acid and/or synthesis of new blends (using for instance starch, chitosan, etc.).

Course objectives

· To get detailed insight into the complex structures of carbohydrates and polysaccharides; · To study the different carbohydrate materials, i.e. cellulose, starch, hemicelluloses, chitins, etc. and their applications · To create an understanding on the relation between structure and functional properties of carbohydrates and materials based on carbohydrates (vide supra); · To study the details of isolation, production and polymerization of lactic- and glycolic-acid and derived materials · To understand the synthesis and applications of poly-lactides, poly- glycosides and derived materials;

BBM1015

Period 1

2 Sep 2019

25 Oct 2019

Print course description

ECTS credits:

6.0

Coordinator:

K. Saralidze

Sciences

Materials Molecular Engineering: Structure-Function Relationships

Course objectives

· Competences in Materials Design: how to link polymer materials structure at multiple length- and time-scales to analysis, processing and product application, e.g. for solids, melts, solutions, bio-/hydro- gels, (nano-)composites, and rubbers · Insights to Fundamental Concepts and Theories: Chains Dimensions and Gaussian Coil, Continuum Mechanics, Constitutive Modelling, (Computational) Polymer and Fluid Dynamics, Rubber- and Viscoelasticity, Percolation Network, Time-Temperature Equivalence, Universal Calibrations · Expertise in Advanced Analysis Techniques: e.g. Shear and Elongational Rheometry with Light or X-ray Scattering and Spectroscopy, (Flow- Induced) Birefringence Imaging, Polarimetry, Velocimetry, Solution Chromatography · Communication Ability: with colleagues, (non)scientists, (non)experts, and public

BBM1016

Period 1
2 Sep 2019
25 Oct 2019

Print course description
ECTS credits:
6.0
Coordinator:
S. Rastogi

Sciences

Commercialization and Entrepreneurship

Full course description

A key role of corporate R & D is to investigate novel products and technologies and translate these into new business. In the case of biobased materials, the transition towards increased sustainability and green technology can trigger new business development. Imagining how a novel product or technology can lead to new business is an inherently creative process that should also be mastered by scientists. In this course the focus lies on developing important competences in the process of business development: 1) discovering opportunities and 2) developing business concepts.

Important characteristics for a scientist in developing business opportunities are creativity and persistence. These are important in problem solving during the process of business development.

In this course your entrepreneurship competences will be tested, and where possible improved. You will have to actively participate and take a creative attitude. A business model will have to be made, using all the information and help you can obtain during this course from the experts.

Course objectives

• To understand how science and technology can be transferred from the lab to start-ups and established companies
• To create a detailed understanding of science and technology commercialization modes: licensing, spin-offs, spinning out, new business development
• To understand the process and regulations concerning intellectual property, patenting and licensing, etc.
• To create and foster a entrepreneurial spirit

BBM1017

Period 1
2 Sep 2019
25 Oct 2019

Print course description
ECTS credits:
6.0
Instruction language:
English
Coordinator:
J.M. Sewall
Teaching methods:
Lecture(s), PBL

Projects

BBM Projects

Sciences
Research Project 1

Full course description

The projects are based on research based model (RBL). In this model, you are challenged with a real-life problem and have to come up with a creative solution to this problem. You have to take ownership and responsibility to make it a worthwhile learning experience. Not only will you learn how to perform a number of techniques but you will also gain an understanding of how to think like a scientist. Throughout the project period, you will learn what it is like to work, think, and learn in an actual laboratory setting. It is common to you experience that “science by doing” is challenging, sometimes a bit frustrating, but above all fun. This way of working is very challenging, but It also offers opportunity to learn work in team sharing responsibilities, which is very important not only in your future careers, but in your lives in general. Furthermore, in the projects, you have to use all knowledge and skills gathered in the programme up to that point. Only when you work together and use all information, you can truly excel, propose and execute a project that surpasses the regular master level. Especially innovation and creativity are important, as well as solid scientific method and proper argumentation and discussion. This way of organizing projects means that you not only execute the project, but also design it. The success of the project depends on your enthusiasm and motivation.

PRJ4001

Period 3
6 Jan 2020
31 Jan 2020

Print course description
ECTS credits:
6.0
Coordinator:
K. Saralidze

Sciences
Research Project 2

Full course description

The projects are based on research based model (RBL). In this model, you are challenged with a real-life problem and have to come up with a creative solution to this problem. You have to take ownership and responsibility to make it a worthwhile learning experience. Not only will you learn how to perform a number of techniques but you will also gain an understanding of how to think like a scientist. Throughout the project period, you will learn what it is like to work, think, and learn in an actual laboratory setting. It is common to you experience that "science by doing" is challenging, sometimes a bit frustrating, but above all fun. This way of working is very challenging, but It also offers opportunity to learn work in team sharing responsibilities, which is very important not only in your future careers, but in your lives in general. Furthermore, in the projects, you have to use all knowledge and skills gathered in the programme up to that point. Only when you work together and use all information, you can truly excel, propose and execute a project that surpasses the regular master level. Especially innovation and creativity are important, as well as solid scientific method and proper argumentation and discussion. This way of organizing projects means that you not only execute the project, but also design it. The success of the project depends on your enthusiasm and motivation.

PRJ4002

Period 6
8 Jun 2020
3 Jul 2020

Print course description
ECTS credits:
6.0
Coordinator:
K. Saralidze

Thesis

BBM Thesis

Sciences

Master Thesis Biobased Materials

BBM5000

Semester 2

3 Feb 2020

3 Jul 2020

Print course description

ECTS credits:

48.0

Instruction language:

English

Coordinator:

K. Saralidze