Module Catalog
Faculty of Applied Natural Sciences
Cologne University of Applied Sciences | Campus Leverkusen
for the Study Program
Applied Chemistry
(Master of Science)

01.12.2014

Courses in English

Master Program „Applied Chemistry“

	Module	Subject	Credits	SWS	Language
First Term					
	1.1	Applied transition metal chemistry and modern synthetic methods	3 of 6	2	English
	1.2	Process analytical technology and process development	6	4	English
	1.3	Practical lab-training modern chemical technologies	2 of 4	2	German
	1.4	Green chemistry, water and environmental chemistry	6	4	German
	1.5	Practical lab-training green chemistry	2 of 4	2	German
	1.6	Physical chemistry of polymers and inorganic materials	6	4	English
	1.7	Practical lab-training materials chemistry	3 of 5	2	German
	2.3	Open module	3 of 6	2	Ger/Eng
		Sum	30	22	
Second Term					
	2.1	Biotechnology and biorefineries	6	4	English
	2.2	Polymer materials and polymer colloids	6	4	German
	2.3	Open module	3 of 6	2	Ger/Eng
	2.4	Project study	5	4	Ger/Eng
	1.1	Applied transition metal chemistry and modern synthetic methods	3 of 6	2	English
	1.3	Practical lab-training modern chemical technologies	2 of 4	2	German
	1.5	Practical lab-training green chemistry	2 of 4	2	German
	1.7	Practical lab-training materials chemistry	2 of 5	2	German
		Sum	30	22	
Third Term					
	3.1	Master`s thesis	24		Ger/Eng
	3.2	Master seminar	3	2	Ger/Eng
	3.3	Master colloquium	3		Ger/Eng
		Sum	30		

Applied transition metal chemistry and modern synthetic methods

course number	workload	credits	integration in the curriculum	frequency of occurrence	duration
1.1	180 h	6 CP	1. or 2. semester	summer and winter	2 semester

type of lecture	contact time	self-study	planned group size
1) applied transition metal chemistry a) seminar 2 SWS 2) modern synthetic methods a) seminar 2 SWS	60 h (4 SWS)	120 h (preparation and review)	24 students

1 **learning outcomes / course objective**

After completing the course students will be able to

- describe and explain the synthesis, chemical bonding, and chemical and physical properties of selected archetypal and/or industrially relevant coordination compounds.
- analyze and compare the mechanisms of transition metal reactions.
- describe the principles of bioinorganic reactions and explain their importance for natural and biomimetic processes.
- discuss and compare typical catalyzed as well as uncatalyzed chemical reaction, their mechanisms and their importance for modern synthetic and industrial processes.
- describe and discuss the synthesis of selected, industrially important natural products.

2 **course content**

1) applied transition metal chemistry

- principles of coordination chemistry (valence bond theory, ligand field theory, molecular orbital theory)
- structure of coordination compounds (coordination number and molecular symmetry, isomerism / organometallic and bioinorganic compounds)
- characterization of transition metal compounds (e.g. infrared and electron absorption spectroscopy, magnetic properties)
- kinetics and mechanism of transition metal reactions (ligand exchange, electron transfer and photoreactions)
- supramolecular compounds, host-guest complexes
- selected bioinorganic and biomimetic, transition metal catalyzed processes (redox, hydrolytic and polymerization processes)
- principles of organic chemistry (analysis of industrially important reaction mechanisms)

2) modern synthetic methods

- importance and examples of industrially important catalytic processes (e.g. enantioselective syntheses, C-C coupling reactions)
- synthesis of natural products (e.g. odorants, flavourings, pharmacologically active compounds)
- synthesis and properties of crop protective compounds

3	**teaching methods** • seminar • self-studies and group work
4	**language of instruction** • English
5	**qualification for attendance** • none
6	**method of examination** • part 1(applied transition metal chemistry, graded, grade contributes with 50% to the overall module grade):written exam, oral exam • part 2 (modern synthetic methods, graded, grade contributes with 50% to the overall module grade): written exam, oral exam In exceptional cases alternative methods of examination may be defined. Method and duration of the examination will be defined at the beginning of the course.
7	**prerequisites for earning credit points** • passed exam
8	**significance of the module for other study programs** • none
9	**weight for the overall grade** • grade contributes unweight to the average of module grades that define 60% of the overall grade
10	**name of lecturer** • Prof. Dr. D. Burdinski, Prof. Dr. M. Eisenacher
11	**further information / Recommended Reading** • pdf-files of the course will be deposited in the WWW in ILIAS *recommended reading (latest edition):* 1) applied transition metal chemistry • C. E. Housecroft, A. G. Sharpe, Inorganic Chemistry, Prentice Hall • J. Huheey, E. Keiter, R. Keiter, O.K.Medhi: Inorganic Chemistry; Pearson Education India. • J. Ribas Gispert, Coordination Chemistry, Wiley-VCH • H.-B. Kraatz, N. Metzler-Nolte, Concepts and Models in Bioinorganic Chemistry; Wiley-VCH 2) modern synthetic methods • K. P. C. Vollhardt, N. E. Schore: Organic Chemistry; W. H. Freeman • R. Brückner: Reaktionsmechanismen: Organische Reaktionen, Stereochemie, Moderne Synthesemethoden; Spektrum • R. A. Sheldon, I. Arends, U. Hanefeld: Green Chemistry and Catalysis; Wiley-VCH • G. Rothenberg: Catalysis; Wiley-VCH • M. M. Green, H. A. Wittcoff: Organic Chemistry Principles and Industrial Practice; Wiley-VCH • B. Schäfer: Naturstoffe der chemischen Industrie; Spektrum

Process analytical technology and process development

course number	workload	credits	integration in the curriculum	frequency of occurrence	duration
1.2	180 h	6 CP	1. or 2. semester	every summer term	1 semester

type of lecture	contact time	self-study	planned group size
1) process analytical technology a) seminar 2 SWS 2) process development a) seminar 2 SWS	60 h (4 SWS)	120 h (preparation and review)	24 students

1 **learning outcomes / course objective**

After completing the course students will be able to

- formulate industrially important or environmentally relevant chemical and process engineering issues as process analytical problems and propose appropriate solutions.
- interpret and develop process flow sheets of their process analytical components using their knowledge in instrumental analytics.
- identify and justify suitable substance-specific measurement parameters beyond sum parameters for a given chemical or biotechnological production process.
- suggest appropriate methods of analysis and process integration for the determination of the measured parameters and evaluate them with respect to efficiency, safety and practicality.
- simulate complex chemical engineering processes with modern software, interpret the simulation results and, derived from this, come up with and justify proposals for process optimization.
- taking into account economic and environmental considerations suggest and justify suitable combinations of fundamental process operations for process optimization.

2 **course content**

1) process analytical technology

- industrial ecology: basic principles of sustainability
  - carrying capacity: capacity and limits of natural systems such as the hydrosphere and atmosphere
  - opportunities and limits of control of material flows and material cycles
  - resources and energy efficiency
- strategies for knowledge-based products and processes
  - product-Features-Design
  - project management for knowledge-based products and processes
  - process analytical chemistry for quality control
- economic Assessment of Process Analytics
  - investment environment
  - combined methods of economic evaluation
- application of spectroscopy as a process analytical technology
  - spectroscopy in reaction and process monitoring
  - on-line and in-line optical spectroscopy in gases, liquids, solids and surfaces

	o mass spectroscopy in reaction and process monitoring o imaging optical and spectroscopic methods o process analysis with ultrasound and sonochemistry o process variables and sensors • concepts and system integration of process gas and liquid chromatography o continuous analytical and preparative chromatography o chromatographic reactors • process analytical chemistry and case studies of sustainable process analytics o examples of application o chemical and pharmaceutical industry (PAT initiative of the FDA) o biotechnology and food industry o plastics industry and manufacturing industry o PAT and micro process engineering 2) process development • fundamentals of Project Management o project organization and planning o use of Microsoft Project o operational project management • solvent-free and energy-saving separation processes o aqueous two-phase extraction o membrane: gas -liquid and liquid-liquid extraction o pervaporative separation o osmotic distillation • introduction to Aspen One o establishment of computational models o static and dynamic simulations o independent project implementation in teams
3	**teaching methods** • seminar • self-studies and group work
4	**language of instruction** • English
5	**qualification for attendance** • none

6	**method of examination** • Written exam, presentation and/or oral exam. In exceptional cases alternative methods of examination may be defined. Method and duration of the examination will be defined at the beginning of the course.
7	**prerequisites for earning credit points** • passed exam
8	**significance of the module for other study programs** • none
9	**weight for the overall grade** • grade contributes unweight to the average of module grades that define 60% of the overall grade
10	**name of lecturer** • Prof. Dr. A. Rehorek, Prof. Dr. S. Barbe
11	**further information / recommended reading** • pdf-files of the course will be deposited in the WWW in ILIAS *recommended reading (latest edition):* 1) process analytical technology • K. H. Koch: Process Analytical Chemistry - Control, Optimization, Quality, Economy, Springer • R. W. Kessler: Prozessanalytik – Strategien und Fallbeispiele aus der industriellen Praxis, Wiley-VCH • W. Kessler: Multivariate Datenanalyse - Pharma-, Bio- und Prozessanalytik, Wiley-VCH • A. von Gleich, St. Gößling-Reisemann: Industrial Ecology – Erfolgreiche Wege zu nachhaltigen industriellen Systemen, Vieweg und Teubner • T. J. Mason, J. P. Lorimer: Applied Sonochemistry- The Use of Power Ultrasound in Chemistry and Processing, Wiley-VCH 2) process development • Towler, Sinnot, Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design; Butterworth-Heinemann • Vauck, Wilhelm; Müller, Hermann: Grundoperationen chemischer Verfahrenstechnik; Wiley-VCH • Müller, Walter: Mechanische Grundoperationen und ihre Gesetzmäßigkeiten; Oldenbourg • B. Lohrengel, Einführung in der thermischen Trennverfahren; Oldenbourg

Physical chemistry of polymers and inorganic materials

course number	workload	credits	integration in the curriculum	frequency of occurrence	duration
1.6	180 h	6 CP	1. or 2. semester	every summer term	1 semester

type of lecture	contact time	self-study	planned group size
a) seminar	60 h (4 SWS)	120 h (preparation and review)	24 students

1 **learning outcomes / course objectives**

After completing the course students will be able to

- describe structure-property-relationships of polymeric materials, assess their importance for given applications and use them to recommend well-founded structural changes to obtain specific material characteristics.
- name technically important materials and explain their structure and their way of function.
- select an adequate substance out of a variety of given materials to solve a technical problem and scientifically motivate their choice.
- investigate scientific questions and present them to and discuss them with a trained audience in adequate form and in a given timeframe.

2 **course content**

- introduction to polymers
  - classification, nomenclature, degree of polymerization, molecular weight, constitution, configuration, conformation
- physical-chemical properties of polymeric systems:
  - glass transition and crystallization, structure, dynamic-mechanical properties, viscoelasticity,
  - properties in solution, polymer-surfactant interactions
  - electric, optic and electro-optic properties
  - polymer surfaces
- inorganic materials
  - solid state structure of important inorganic materials, metal-organic framework materials, synthesis and properties of nanostructured materials and nanoparticles
  - important technical materials, such as iron-based alloys (steel), non-iron metals, carbon modifications, silicon-containing materials, inorganic fibers, glasses, ceramic materials, vitreous/porcelain enamels, composite materials, construction materials

3 **teaching methods**

- seminar
- self-studies and group work

4 **language of instruction**

- English

5	**qualification for attendance** • none
6	**method of examination** • Written exam, presentation and/or oral exam. In exceptional cases alternative methods of examination may be defined. Method and duration of the examination will be defined at the beginning of the course.
7	**prerequisites for earning credit points** • passed exam
8	**significance of the module for other study programs** • none
9	**weight for the overall grade** • grade contributes unweight to the average of module grades that define 60% of the overall grade
10	**name of lecturer** • Prof. Dr. D. Burdinski, Prof. Dr. B. Glüsen
11	**further information / recommended reading** • pdf-files of the course will be deposited in the WWW in ILIAS *recommended reading (latest edition):* • G. Strobl: The Physics of Polymers; Springer • M.D. Lechner et al.: Makromolekulare Chemie; Birkhäuser • J.M.G. Cowie Polymers: Chemistry & Physics of Modern Materials; CRC Press • B. Tieke: Makromolekulare Chemie; Wiley-VCH • H.G. Elias Makromoleküle Band 2 - Physikalische Strukturen und Eigenschaften; Wiley-VCH • C. Janiak, H.-J. Meyer, D. Gudat, R. Alsfasser, Moderne Anorganische Chemie, W. de Gruyter • L. Cademartiri, G. A. Ozin, Concepts of Nanochemistry, Wiley-VCH

Biotechnology and biorefineries

course number	workload	credits	integration in the curriculum	frequency of occurrence	duration
2.1	180 h	6 CP	2. or 1. semester	every winter term	1 semester

type of lecture	contact time	self-study	planned group size
a) seminar 4 SWS	60 h (4 SWS)	120 h (preparation and review)	24 students

1 **learning outcomes / course objective**

After completing the course students will be able to

- explain the basic techniques of biotechnology and molecular biology and recognize their importance for the development of modern biotechnological processes.
- describe and compare the most important industrial processes utilizing biotechnology.
- explain and analyze the utilization of renewable resources as raw material for the production of platform chemicals and biofuels
- depict the state of the art in biorefinery technologies.
- conduct literature surveys in the field of biotechnology, summarize the results and present to an audience.

2 **course content**

1) biotechnology

- historical developments in biotechnology
  - o the „color code“ of biotechnology with focus on industrial biotechnology
- molecular biology methods
  - o isolation and modification of DNA and RNA
  - o polymerase chain reaction (PCR) and DNA sequencing
  - o recombinant protein / enzyme expression with microbial host organisms
- molecular biotechnology
  - o Genome sequencing
  - o Introduction into bioinformatics and respective databanks
  - o Metabolic engineering

2) biorefineries

- renewable resources
  - o sources, agriculture, isolation, processing, transport
  - o biomass as raw material for fuels, chemicals, plastics and materials
  - o renewable resources in Germany and on a global perspective
- Biofuels and biorefinery concepts
  - o bioethanol, biodiesel, biogas: production technologies, capacities, sources of biomass and future perspectives
  - o „2nd generation Biofuels“ and current trends

	o raw material situation, algae technology o thermo-chemical conversion: syngas processes o industrial sugar and starch platforms o ligno-cellulosic based pulping and production processes o lipid-biorefinery: oleochemicals from fats and oils
3	**teaching methods** • seminar • self-studies and group work
4	**language of instruction** • English
5	**qualification for attendance** • none
6	**method of examination** • Written exam, presentation and/or oral exam. In exceptional cases alternative methods of examination may be defined. Method and duration of the examination will be defined at the beginning of the course.
7	**prerequisites for earning credit points** • passed exam
8	**significance of the module for other study programs** • none
9	**weight for the overall grade** • grade contributes unweight to the average of module grades that define 60% of the overall grade
10	**name of lecturer** • Prof. Dr. U. Schörken

11	**further information / recommended reading** • pdf-files of the course will be deposited in the WWW in ILIAS *recommended reading (latest edition):* • G. Antranikian: Angewandte Mikrobiologie; Springer • R. Renneberg, D. Süßbier: Biotechnologie für Einsteiger; Spektrum • R. D. Schmid: Pocket Guide to Biotechnology and Genetic Engineering; Wiley-VCH • M. C. Flickinger: Upstream & Downstream Industrial Biotechnology (3 volumes); Wiley • H. Sahm, G. Antranikian, K.-P. Stahmann, R. Takors: Industrielle Mikrobiologie; Springer Spektrum • M. Wink: An Introduction to Molecular Biotechnology: Fundamentals, Methods and Applications; Wiley-VCH • F. Cavani, G. Centi, S. Perathoner, F. Trifiro: Sustainable Industrial Chemistry; Wiley-VCH • B. Kamm, P. R. Gruber, M. Kamm: Biorefineries – Industrial Processes and Products; Wiley-VCH • Biorefineries Roadmap; published by BMELV, BMBF, BMU & BMWI • R. Höfer: Sustainable Solutions for Modern Economies; RSC Publishing • W. Soetaert, E. Vandamme: Biofuels; Wiley