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**Modulbezeichnung:** **Schwerpunktfach Advanced Processes (AP focal)** **15.0 ECTS**  
 (Focal subject Advanced Processes)

Modulverantwortliche/r: Tanja Franken

Lehrende: Hannsjörg Freund, Hans-Joachim Egelhaaf, Malte Kaspereit, Andreas Bück, Tanja Franken, Matthias Thommes

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|------------------------|------------------------|------------------------------|
| Startsemester: SS 2021 | Dauer: 2 Semester      | Turnus: halbjährlich (WS+SS) |
| Präsenzzeit: 150 Std.  | Eigenstudium: 300 Std. | Sprache: Englisch            |

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**Lehrveranstaltungen:**

In the third MAP semester (WS), the lecture "Catalysis" is obligatory.

In addition, one of the following two lectures with the respective exercises has to be chosen:

Adsorption: Fundamentals and Application

or

Drying Technology

Thin films: processing, characterization and functionalities. (SS 2021, Vorlesung, 1 SWS, Hans-Joachim Egelhaaf)

Process Technologies (SS 2021, Vorlesung, 2 SWS, Hannsjörg Freund et al.)

Process Technologies Exercises (SS 2021, Übung, 1 SWS, Markus Kaiser et al.)

Catalysis (WS 2021/2022, Vorlesung, 2 SWS, Tanja Franken)

Adsorption: Fundamentals and Applications (WS 2021/2022, optional, Vorlesung, 2 SWS, Matthias Thommes)

Trocknungstechnik/Drying Technology (WS 2021/2022, optional, Vorlesung, Andreas Bück)

Sustainable Technologies (SS 2021, Vorlesung, 1 SWS, Tanja Franken)

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**Empfohlene Voraussetzungen:**

basics in physical chemistry

**Es wird empfohlen, folgende Module zu absolvieren, bevor dieses Modul belegt wird:**

Basics in Advanced Processes 1+2: Unit Operations and Reactor Design, Chemical Analysis and Structure Determination

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**Inhalt:**

Sustainable Technologies:

1. Definition of sustainability and measures
2. Current and future Energy mix
3. Exhaust Gas Catalysis
4. Sustainable Feedstocks
5. Biorefinery
6. CO<sub>2</sub> as C1 Source
7. Chemical Energy Storage
8. H<sub>2</sub> Production & Fuel Cells
9. Batteries
10. Solar Cells

Process Technologies:

The course "Process Technologies" gives an overview on important processes in the chemical process industries. The processes are treated in a holistic approach and the interaction of individual process steps and their feedback to the overall process are discussed in more detail. In particular, the relationship between the physical/chemical basics of the processes, process development and process design will be discussed. The presented processes are selected based on their importance in the fields of raw materials, intermediates and consumer products of the chemical process industries. In the sense of process engineering, apart from the reaction steps, the separation operations are also part of the considerations. The evaluation of the methods with regard to their cost-effectiveness and sustainability complete the description of the processes. In detail, the following aspects will be treated:

- Raw materials (crude oil, fuels, natural gas, technical gases)
- Organic base chemicals (syngas, alkanes, alkenes, aromatics)

- Organic intermediates (C1-C4 alcohols, cyclic alcohols, ether, epoxides, organic acids)
- Renewable raw materials
- Organic end products (surfactants, pigments, polymers)
- Inorganic base chemicals and intermediates (sulfuric acid, ammonia, sodium hydroxide)
- Inorganic end products (fertilizers, ceramics, glass)
- Process development (technologies, economic evaluation)

Thin films:

- overview on passive materials in organic electronics (substrates, dielectrics, packaging and encapsulation materials)
- dielectric properties, barrier properties, optical properties
- major thin film fabrication processes (gas phase and solution based)
- printing (gravure, ink-jet, doctor blading) techniques and conditions
- composition of inks, thin film homogeneity and thickness control
- deposition of patterned features
- molecular self-assembly (molecular scale fabrication, applications).

The Catalysis lecture covers

- Homogeneous catalysis
- Fluid/fluid biphasic catalysis
- Hatta number and enhancement
- Advanced solvents for catalyst immobilization
- Heterogeneous catalysis
- Deriving reaction rate approaches for surface catalyzed reactions
- Reactors to determine kinetics of reaction and mass transfer
- Mass transfer coefficient correlations
- Mass transfer influences on selectivity
- Mass transfer in fluidized beds
- Models to describe residence time distributions
- Catalyst characterization
- Chemical energy storage

Adsorption: Fundamentals and Applications

1. Introduction and terminology
2. Gas adsorptions basics and adsorbent materials
3. Physisorption mechanisms
4. Surface area determination
5. Porosity and pore structure analysis of nanoporous materials
  - 5.1 Micropore analysis
  - 5.2 Mesopore analysis
  - 5.3 Macropore analysis : adsorption and liquid intrusion methods
  - 5.4. Characterization of hierarchically structured porous materials
6. High pressure adsorption
7. Surface chemistry effects on adsorption
8. Adsorption and characterization in the liquid phase
8. Adsorption of mixtures
9. Adsorption applications in gas storage and separation

### **Lernziele und Kompetenzen:**

Students who successfully participate in this module can

- define different types of chemical reaction and reactor
- differentiate between steady-state and transient reactor operation
- evaluate the differences between idea and real reactors
- assess aspects of safety of chemical reactors
- define challenges and solutions for multiphase reactors
- describe the importance of thin film technologies to modern (opto)electronic devices
- define principal gas and solution-based thin film fabrication technologies, especially printing techniques
- evaluate the composition of printing inks and characteristics and quality of printed layers
- explain how thin films can be patterned
- understand the role of emerging thin film technologies such as molecular self-assembly

Students who successfully participate in this module can  
explain the material, technological and developmental aspects of chemical processes  
understand the fundamentals of both homogeneous and heterogeneous catalysis  
analyze and evaluate the general mechanisms in catalysis  
describe and critically assess the interplay between mass transport and chemical reaction  
apply immobilization techniques for homogeneous catalysts  
transfer their knowledge about chemical reactors regarding influences on catalytic processes

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### **Studien-/Prüfungsleistungen:**

Advanced Processes 2a: Catalysis and Adsorption und Advanced Processes (Prüfungsnummer: 1802)  
(englische Bezeichnung: Advanced Processes 2: Process Technology and Catalysis)

Prüfungsleistung, schriftlich oder mündlich

Anteil an der Berechnung der Modulnote: 50%

weitere Erläuterungen:

either oral exam 45 minutes or written exam 120 minutes

Prüfungssprache: Englisch

Erstablingung: WS 2021/2022, 1. Wdh.: SS 2022

1. Prüfer: Tanja Franken

Advanced Processes 2b: Catalysis and Drying Technology (Prüfungsnummer: 1803)

(englische Bezeichnung: Advanced Processes 1: Separation Processes, Reactors and Thin Films)

Prüfungsleistung, schriftlich oder mündlich

Anteil an der Berechnung der Modulnote: 50%

weitere Erläuterungen:

either oral exam 45 minutes or written exam 120 minutes

Prüfungssprache: Englisch

Erstablingung: WS 2021/2022, 1. Wdh.: SS 2022

1. Prüfer: Tanja Franken

Advanced Processes 1: Process Technologies, Sustainable Technologies, and Thin Films (Prüfungsnummer: 1804)

Prüfungsleistung, schriftlich oder mündlich, Dauer (in Minuten): K 120 min, m 45 min

Anteil an der Berechnung der Modulnote: 50%

weitere Erläuterungen:

either oral exam 45 minutes or written exam 120 minutes

Prüfungssprache: Englisch

Erstablingung: SS 2021, 1. Wdh.: WS 2021/2022

1. Prüfer: Tanja Franken

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### **Organisatorisches:**

Please register on StudOn for the respective courses