Lodz University of Technology

Application of Nanostructured Materials in Chemical Engineering

Course description

Basic information

Study programme Industrial Process Engineering **Speciality/path** - **Organizational unit** Faculty of Process and Environmental Engineering **Study level** second-cycle programme (magister inżynier) **Study mode** full-time studies **Education profile** general academic	**Didactic cycle** 2026/27 **Course code** W09-IPP-3SF-01341-00 **Language of instruction** polish **Obligatory** Optional **Block** Directional subjects **Course related to scientific research** Yes

Course coordinator	Maciej Fronczak
Course instructor(s)	Maciej Fronczak, Piotr Owczarz, Anna Rył, Arkadiusz Selerowicz, Jacek Balcerzak

Period	**Form of verification**	**Total ECTS points**
Semester 1	Graded assignment **Classes and hours** • Lecture: 15 • Seminar: 15 • Project work: 40	6

Prerequisites

The student has knowledge of inorganic and organic chemistry as well as basic physics.

Learning outcomes

Code	Programme outcomes	Detailed outcomes indicators
2IPP2	Possesses advanced, including specialised, knowledge in material and energy balances, fluid mechanics, momentum transfer, heat and mass transfer, reaction kinetics, separation processes, process dynamics and control, equipment design, and product manufacturing technologies; analyses and evaluates the main development trends in chemical and biochemical engineering.	2IPP2.5 Integrates modern technologies, such as nanotechnology and advanced materials engineering, to create efficient and innovative process solutions in line with current industry trends.
2IPP4	Formulates and tests research tasks related to modelling and design; integrates knowledge from various areas of chemical engineering and allied disciplines; performs critical analysis and evaluation of results.	2IPP4.1 Defines a research problem in the field of chemical engineering, applying an interdisciplinary approach. 2IPP4.4 Verifies research results by comparing them with literature data and theoretical models. 2IPP4.5 Critically interprets results and formulates conclusions and recommendations for further research and implementation.

Course contents

Application of nanostructured materials in chemical and biochemical engineering, particularly in catalysis, separation processes, and environmental protection.

Complementary information

Contents - detailed selection

No.	Contents - detailed selection	Class type
1.	Introduction to nanomaterials. Nanoemulsions: definition, preparation, properties, and applications. Nanofillers: definition and types. Effect of nanofillers on material properties. Nanomaterials in medicine. Measurement of nanoparticle size and size distribution: DLS, laser diffraction, and zeta potential. Microrheology. Analysis of the physical stability of nanoparticle dispersions. Surface and interfacial tension. Environmental and safety aspects.	Lecture
2.	Students will present a presentation to the group on the latest achievements in the field of nanostructured materials and their applications in chemical engineering. Directions of development and the future of nanomaterials. Presentation topics will be selected from the scientific literature and/or patents from the last 5 years.	Seminar
3.	As part of the project, a hydrogel containing a nanofiller will be prepared; subsequently, its rheological properties and gelation point will be determined, and the sample will undergo gelation and freeze-drying, followed by surface and compositional characterization.	Project work

Teaching methods and techniques, passing conditions

Class type	Teaching methods and techniques	Passing conditions
Lecture	Lecture	The test consists of 18 single-choice questions, each with four possible answers, and is scored according to the following scheme: a correct answer +1 point, an incorrect answer −0.5 points, and no answer 0 points. To pass, a minimum of 11 points is required.
Seminar	Multimedia presentation, Discussion	The requirement for passing the seminar is the preparation of a presentation on the application of nanomaterials in chemical engineering, based on publications and/or patents from the last five years.
Project work	Discussion, Project execution, Demonstration, instruction, Team based learning	The project consists of multiple stages. Passing the project requires the preparation of a group multimedia presentation presenting the project objective, the applied methodology, the results, and the conclusions. Based on the discussion following the presentation, a final project report must be prepared.

Examination methods, weighed grades

Class type	Examination methods and weighed grades
Lecture	Final test: 30%
Seminar	Multimedia presentation: 20%
Project work	Multimedia presentation: 10% Design Project: 40%

Verification of learning outcomes

Detailed outcome indicators	Verification criteria	Assesment tool (class type)
2IPP2.5	Final exam - identifies and describes modern technologies used in chemical engineering, including nanotechnologies and advanced materials; - explains the mechanisms of action of nanomaterials in chemical engineering processes; - identifies application areas of innovative process materials; - relates technological solutions to current development trends in the chemical industry. Multimedia presentation - presents current technological solutions described in scientific literature and patents; - analyzes the innovativeness of the proposed process solutions; - evaluates the effectiveness of the application of nanotechnologies and advanced materials; - indicates the alignment of the presented solutions with current industry trends. Project - designs a process solution using nanotechnologies or advanced materials; - integrates material properties with the requirements of the technological process; - justifies the selection of applied technologies in terms of efficiency and innovativeness; - evaluates the implementation potential of the designed solution.	Design Project (Project work), Multimedia presentation (Seminar, Project work), Final test (Lecture)

Detailed outcome indicators	Verification criteria	Assesment tool (class type)
2IPP4.1	- clearly and precisely formulates a research problem in the field of chemical engineering; - justifies the choice of the research approach in the context of the current state of knowledge.	Design Project (Project work)
2IPP4.4	- compares the obtained results with data from current scientific literature; - analyzes the agreement and discrepancies between own results and reference data; - identifies possible causes of the observed differences.	Design Project (Project work)
2IPP4.5	- critically interprets the obtained results in the context of the research assumptions; - formulates logical and coherent conclusions supported by data analysis; - evaluates the application potential of the research results; - proposes directions for further research or potential implementation pathways.	Design Project (Project work)

Literature

Compulsory reading

1. Nanotechnologia w praktyce : praca zbiorowa, PWN 2016
2. Andrzejczuk, Nanomateriały inżynierskie : konstrukcyjne i funkcjonalne, PWN, 2015
3. Huczko, Nanorurki węglowe : otrzymywanie, charakterystyka, zastosowania, WUW 2014
4. Huczko, Synteza spaleniowa materiałów nanostrukturalnych, WUW 2011
5. Huczko, Grafen : otrzymywanie, charakterystyka, zastosowania, WUW, 2016
6. Kelsall, Hamley, Geoghegan (red.), Nanotechnologie, PWN, 2008.

Other reference materials

1. Torrente-Murciano, L., Dunn, J.B., Christofides, P.D., Keasling, J.D., Glotzer, S.C., Lee, S.Y., Van Geem, K.M., Tom, J., He, G., 2024. The forefront of chemical engineering research. Nat. Chem. Eng. 1, 18–27. https://doi.org/10.1038/s44286-023-00017-x

Research and publications

M. Fronczak, A. Kasprzak, M. Bystrzejewski, Carbon-encapsulated iron nanoparticles with deposited Pd: A high-performance catalyst for hydrogenation of nitro compounds, Journal of Environmental Chemical Engineering, 2021, 9(1), 104673
Kierzkowska-Pawlak H., Ryba M., Fronczak M., Kapica R., Sielski J., Sitarz M., Zając P., Łyszczarz K., Tyczkowski J. Enhancing CO2 conversion to CO over plasma-deposited composites based on mixed Co and Fe oxides Catalysts 2021, 11(8), 883
M. Fronczak, A.M. Keszler, M. Mohai, B. Jezso, A. Farkas, Z. Karoly, Facile and continuous synthesis of graphene nanoflakes in RF thermal plasma, Carbon, 2022, 193, 51-67
Šalipur H., Manojlović D., Milošević K., Fronczak M., Silva A.G., Lončarević D., Dostanić J., Unraveling the solar and visible light-induced deactivation mechanism of Pt-decorated carbon/TiO2 nanocomposite in photocatalytic hydrogen production, Journal of Environmental Chemical Engineering, 2024, 13(3), 112862
Šalipur H., Fronczak M., Prašnikar A., Kamal K.M., Mudrinić T., Hadnađev-Kostić M., Likozar B., Dostanić J., Lončarević D., Metal doped TiO2 decorated carbon nanostructured materials as an emerging photocatalysts for solar fuels production, Catalysis Today, 2024, 436, 114724

Student workload

Activity type	Average number of hours* needed to complete an activity

Lecture	15
Seminar	15
Project work	40
Preparation of a multimedia presentation	20
Preparation of a report	20
Preparation for the final exam	20
Participation in academic consultations	20
pk: Research and academic laboratories	10
Total student workload	**No. of hours** 160
Workload involving teacher	**No. of hours** 80
Total ECTS points	**ECTS** 6

* activity hour equals to 45 minutes

Directional learning outcomes

Code	Content
2IPP2.5	Integrates modern technologies, such as nanotechnology and advanced materials engineering, to create efficient and innovative process solutions in line with current industry trends.
2IPP4.1	Defines a research problem in the field of chemical engineering, applying an interdisciplinary approach.
2IPP4.4	Verifies research results by comparing them with literature data and theoretical models.
2IPP4.5	Critically interprets results and formulates conclusions and recommendations for further research and implementation.