Lodz University of Technology

Physical Chemistry of Dispersed Systems

Course description

Basic information

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

Course coordinator	Piotr Owczarz
Course instructor(s)	Piotr Owczarz, Anna Rył, Bertrand Jóźwiak, Mariola Błaszczyk

Period Semester 6	**Form of verification** Graded assignment **Classes and hours** • Lecture: 25 • Seminar: 15 • Laboratory classes: 20	**Total ECTS points** 4

Prerequisites

Knowledge of Mathematics I, Physics I, Fluid Mechanics, Physical Chemistry, and Thermodynamics at an undergraduate level.

Learning outcomes

Code	Programme outcomes	Detailed outcomes indicators
1IPP2	Has knowledge of key chemical and process engineering processes, including: (1) momentum, heat and mass exchange mechanisms and their application in unit operations and process apparatus; (2) principles of mass, energy and momentum balancing in process engineering processes; (3) product separation, separation and purification processes; (4) fundamentals of chemical and biochemical reaction engineering.	1IPP2.1 Explain the mechanisms of momentum, heat and mass exchange and describe their role in basic unit operations and process apparatus.
1IPP4	Applies analytical and critical thinking to identify, formulate, and solve complex and atypical engineering problems related to industrial processes and process installations, selecting appropriate computational, technological, and organisational methods.	1IPP4.2 Selects and applies appropriate computational methods and engineering tools (e.g. balances, basic transport models, flow analyses) to assess process performance.

Course contents

Fundamentals of the chemical physics of dispersed systems, including colloids, emulsions, suspensions, and stabilization mechanisms. The course introduces the analysis of physicochemical properties and behaviour of dispersed systems in chemical and process engineering applications.

Complementary information

Contents - detailed selection

No.	Contents - detailed selection	Class type
1.	Thermodynamics of solutions and dispersed systems. Classification of dispersed systems according to the size of the dispersed phase. Thermodynamic conditions for the stability of dispersed systems. Physicochemical equilibria in solutions.	Lecture
2.	Soft matter – definitions; polymer and biopolymer dispersions; second-order phase transition – gelation; emulsions. Physicochemistry of interfacial surfaces and interactions of dispersed-phase particles with the solvent; zeta potential.	Lecture
3.	Physicochemistry of dispersed polymer chains, including the effect of electrolytes on chain expansion and conformation, radius of gyration, and hydrogels.	Lecture
4.	Rheological methods for the characterization of dispersed systems: rheological measurement techniques, structural deformation and recovery tests, determination of rheological properties, DLVO theory, etc.	Lecture

No.	Contents - detailed selection	Class type
5.	Characterization of dispersed systems using light-scattering image analysis. Theoretical foundations of light-scattering physics by dispersed particles; static light scattering (SLS), dynamic light scattering (DLS), small-angle light scattering (SALS), etc. Particle size determination; molecular weight determination – Zimm plot construction; turbidimetry – phase separation kinetics; optical microrheology for tracer mobility measurements; zeta potential measurement.	Lecture
6.	Investigation of the stability of dispersed systems and particle size at the nanoscale – zeta potential measurements	Laboratory classes
7.	Determination of the macroscopic rheological characteristics of viscoelastic systems – rotational and oscillatory measurements, variable amplitude or frequency sweep tests.	Laboratory classes
8.	Determination of intermolecular interaction energies in dispersed systems based on DLVO theory.	Laboratory classes
9.	Determination of the radius of gyration by Zimm plot construction based on SALS measurements.	Laboratory classes
10.	Determination of gel point parameters and gelation kinetics, phase separation kinetics based on DWS measurements, and mechanisms of destabilization of colloidal systems, suspensions, and emulsions.	Laboratory classes
11.	Industrial process analysis combined with the identification of dispersed systems occurring therein. Preparation of a presentation related to an industrial process, covering the stability of emulsions, gels and sols, phase transitions, and the methodology for determining key process parameters. Characterization of industrial products with consideration of standardization and quality assurance/quality control (QA/QC) aspects. Discussion during the seminar.	Seminar

Teaching methods and techniques, passing conditions

Class type	Teaching methods and techniques	Passing conditions
Lecture	Lecture	Written examination based on the lecture content. A prerequisite for passing the course is obtaining a positive grade, i.e. achieving at least 60% of the total available points
Seminar	Multimedia presentation, Discussion, Peer assessment, Work with source text	Obtaining a positive grade requires: • delivery of a multimedia presentation / seminar paper on an assigned topic – 60% of the seminar grade; • active participation in the discussion of other students' presentations, assessed by the academic instructor – 40% of the seminar grade.
Laboratory classes	Work with source text, Laboratory/computer-based exercises	A prerequisite for passing the course is obtaining a positive grade: • in the oral assessment for all laboratory exercises performed. The average grade from oral quizzes constitutes 20% of the final course grade (66% of the laboratory grade); • obtaining a positive grade for the substantive laboratory report prepared in laboratory groups – 10% of the final course grade (34% of the laboratory grade). The course instructor may differentiate the final report grades taking into account the ongoing observation of the student's performance during laboratory classes, including, among others, active participation in laboratory work and involvement in data analysis and result interpretation.

Examination methods, weighed grades

Class type	Examination methods and weighed grades
Lecture	Written assignment: 40%
Seminar	Multimedia presentation: 30%
Laboratory classes	Report: 10% Speaking assignment: 20%

Verification of learning outcomes

Detailed outcome indicators	Verification criteria	Assesment tool (class type)
1IPP2.1	Obtaining a positive grade requires that the student is able to: • define basic thermodynamic quantities and concepts of solutions, is familiar with the classification of dispersed systems and the conditions for their stability; • define fundamental concepts of soft matter, classify phase transition processes, including gelation as a phase transition; • characterize interfacial surface concepts and interactions between dispersed-phase particles and the solvent, including zeta potential, as well as polymer chain dispersions, the dependence of chain expansion on the presence of electrolytes, radius of gyration, and hydrogels; • demonstrate knowledge of basic rheology and rheometry concepts, as well as rheological measurement techniques and interpretation of rheological data; • define, describe, and present fundamental methods for the characterization of dispersed systems using image analysis based on monochromatic light scattering techniques.	Written assignment (Lecture), Report (Laboratory classes), Multimedia presentation (Seminar)
1IPP4.2	A positive grade is awarded if the student: • is able to work effectively in a group and, through collective discussion, interprets the results with reference to the research objective and hypothesis, as well as indicates their significance; • takes an active part in conducting laboratory experiments and in the analysis of the obtained results and preparation of the report, as assessed on the basis of the instructor’s observation.	Speaking assignment (Laboratory classes), Report (Laboratory classes)

Literature

Compulsory reading

1. P. Owczarz, Inżynieria układów chitozanowych wrażliwych na zmianę temperatury, Politechnika Łodzka, 2019
2. Literatura przedmiotu i instrukcje do ćwiczeń laboratoryjnych

Other reference materials

1. De Kee D., Chhabra R.P., Transport processes in bubble, drops and particles, Taylor&Francis, London 2002
2. Faghri A., Zhang Y., Transport phenomena in multiphase system, Elsevier, Amsterdam 2006

Research and publications

1. P. Owczarz, Inżynieria układów chitozanowych wrażliwych na zmianę temperatury, Politechnika Łodzka, 2019
2. Owczarz, P., Ziółkowski, P., Modrzejewska, Z., Kuberski, S., & Dziubiński, M. (2018). Rheo-kinetic study of sol-gel phase transition of chitosan colloidal systems. Polymers, 10(1), 47.
3. Rył, A., & Owczarz, P. (2020). Injectability of thermosensitive, low-concentrated chitosan colloids as flow phenomenon through the capillary under high shear rate conditions. Polymers, 12(10), 2260.
4. Rył, A., & Owczarz, P. (2021). Thermoinduced aggegation of chitosan systems in perikinetic and orthokinetic regimes. Carbohydrate polymers, 255, 117377.

Student workload

Activity type	Average number of hours* needed to complete an activity
Lecture	25
Seminar	15
Laboratory classes	20
Preparation of the paper	15
Participation in written or practical forms of verification	2
Literature analysis	15
Preparation for the laboratory	10
Preparation for test	10
Participation in academic consultations	5
Total student workload	**No. of hours** 117
Workload involving teacher	**No. of hours** 60
Total ECTS points	**ECTS** 4

* activity hour equals to 45 minutes

Directional learning outcomes

Code	Content
1IPP2.1	Explain the mechanisms of momentum, heat and mass exchange and describe their role in basic unit operations and process apparatus.
1IPP4.2	Selects and applies appropriate computational methods and engineering tools (e.g. balances, basic transport models, flow analyses) to assess process performance.