Wrocław University of Science and Technology
Doctoral School

COURSE CARD

1. Basic information

Course name in English:	Supramolecular Photochemistry	
Course name in Polish:	Fotochemia supramolekularna	
Number of hours:	30	
Type of course:	Elective course	
Form of course:	lecture	
Code of course:		
Course leader:	Dr. Inz. Marco Deiana	
Faculty of the course leader:	W3 Faculty of Chemistry	
Email address of the course leader:	m.deiana@pwr.edu.pl	
Scientific discipline(s) assigned to the course (doctoral students representing the marked disciplines can participate in the course):	Architecture and urban planning	☐
	Automation, electronic, electrical engineering and space technologies	☐
	Information and communication technology	☐
	Biomedical engineering	☒
	Chemical engineering	☒
	Civil engineering, geodesy and transport	☐
	Materials engineering	☒
	Mechanical engineering	☐
	Environmental engineering, mining, and energy	☐
	Mathematics	☐
	Chemical sciences	☒
	Physical sciences	☒
	Management and quality studies	☐

2. Objectives

O1. To acquaint students with modern concepts of supramolecular chemistry and their impact on molecular organization, emission behavior, and functional material design.

O2. Acquiring the ability to understand and analyze photophysical phenomena such as aggregation-induced emission (AIE), aggregation-induced quenching (ACQ), disaggregation-induced emission (DIE), and excitonic interactions in supramolecular systems.

O3. Developing competence in quantitative analysis of molecular recognition and binding using spectroscopic techniques.

O4. Gaining insight into the principles of phototherapy (photodynamic and photothermal therapies) and supramolecular drug delivery, including the design of light-activated therapeutic systems and responsive molecular carriers.

O5. Enhancing literature comprehension and communication skills through critical analysis and individual project presentations.

3. Content

Detailed information about the course content, including topics and form of classes.

No.	Topic	Number of hours	Form of classes
1	**Supramolecular Foundations** ● Host–guest chemistry: crown ethers, cyclodextrins, calixarenes, cucurbiturils ● Molecular recognition: thermodynamics and cooperativity ● Supramolecular recognition in sensing	2	lecture
2	**Binding Analysis and Quantification** ● Analysis of supramolecular assemblies by spectroscopic methods ● Binding models: 1:1, 2:1, 1:2 ● Simulation of binding parameters by non-linear fitting procedures	2	lecture
3	**Photophysical and Excitonic Behavior** ● Photophysical origin of quenching ● Exciton theory: H-aggregates, J-aggregates, spectral shifts ● H-aggregates and J-aggregates morphological characterization ● H-aggregates and J-aggregates in sensing and imaging	2	lecture
4	**Aggregation-Caused Quenching (ACQ)** ● Photophysical origin and mechanistic understanding of ACQ ● Influence of aggregation on fluorescence in biomolecular environments ● Strategies to suppress or control ACQ in sensor design and drug carriers	2	lecture
5	**Aggregation-Induced Emission (AIE)** ● Design principles of AIE-active molecules: neutral *versus* charged groups ● Mechanisms: restriction of intramolecular motion (RIM) ● Applications as stimuli-responsive materials	2	lecture
6	**Disaggregation-Induced Emission (DIE)**	2	lecture

	● Concept and use of DIE in “turn-on/off” sensors ● Design of self-assembling/disassembling fluorogenic probes ● Case studies in cellular DNA, protein and lipid sensing		
7	**Supramolecular Imaging and Diagnostics** ● AIE and DIE based host–guest systems for biological imaging ● Cell permeability, organelle and molecular targeting	2	lecture
8	**Supramolecular Phototherapy Principles – Part I (Photodynamic Therapy, PDT)** ● Reactive oxygen species (ROS) generation ● Type I and Type II photodynamic mechanisms ● Light-responsive toxicity in cancer therapy	2	lecture
9	**Supramolecular Phototherapy Principles – Part II (Photothermal Therapy, PTT)** ● Principles of photothermal conversion and heat-induced cytotoxicity ● Supramolecular nanostructures as photothermal agents ● Combined PDT/PTT strategies and synergistic effects in cancer therapy	2	lecture
10	**Supramolecular Strategies for NIR Therapeutic Performance:** ● Biological Activation Windows: NIR-I (650–950 nm) and NIR-II (1000–1700 nm) ● Molecular strategies to tailor dyes for NIR-I and NIR-II emission: Extending π-conjugation, donor–acceptor (D–A) engineering, heteroatom substitution, supramolecular encapsulation and assembly	2	lecture
11	**Supramolecular Drug Delivery** ● Self-assembled nanocarriers: micelles, vesicles, cages ● Triggered drug release: pH, redox, and light-activated systems	2	lecture
12	**Supramolecular Theranostics** ● Dual sensor-therapy platforms (imaging + treatment)	2	lecture

	● Combination systems: PTT + chemotherapy, PDT + drug delivery		
13	**Molecular Targeting in Supramolecular Therapy** ● G-quadruplexes (G4s) as molecular targets ● Supramolecular strategies for targeting, sensing, and imaging overexpressed cancer-associated G4 DNA structures ● Design of supramolecular systems for structure-specific oxidative DNA damage induction ● Applications in *in cellulo* and *in vivo* cancer models	2	lecture
14	**Emerging Trends and Future Directions** ● Stimuli-responsive and adaptive supramolecular systems ● Reversible, self-healing, and programmable materials for soft robotics, electronics, and tissue engineering. ● Design of molecular machines, switchable nanosystems, and logic-based therapeutic delivery platforms. ● Machine learning and AI-assisted design of supramolecular systems	2	lecture
15	**Student Seminar & Discussion Session** ● Short student presentations on literature-selected supramolecular sensors/therapeutics.	2	lecture

4. Prerequisites

List of prerequisites relating to knowledge, skills and other competences for course participants.

1. Basic Organic Chemistry
2. General Physical Chemistry
3. Spectroscopy Fundamentals

5. Learning outcomes

List of learning outcomes at level 8 of the Polish Qualifications Framework assigned to the course (mark the learning outcomes in the last column).

Symbol	Learning outcome	
	KNOWLEDGE. Doctoral student knows and understands:	

SzD_W3	the main trends in the development of the scientific or artistic disciplines covered in the curricula;	☒
SzD_W4	research methodology;	☒
SzD_W5	the rules for the dissemination of scientific results, including in open access mode;	☐
SzD_W6	the fundamental dilemmas of modern civilization;	☐
SzD_W7	the legal and ethical conditions of scientific activity;	☐
SzD_W8	the economic and other relevant conditions of scientific activity;	☐
SzD_W9	basic principles of knowledge transfer to the economic and social spheres and commercialisation of results of scientific activity and know-how related to these results.	☐
	SKILLS. Doctoral student is able to:	
SzD_U2	use knowledge from different fields of science or art to creatively identify, formulate and innovatively solve complex problems or perform research tasks, in particular: - define the purpose and subject of scientific research, formulate a research hypothesis, - develop research methods, techniques and tools, and use them creatively, - draw conclusions on the basis of scientific research; critically analyse and evaluate the results of scientific research, expertise and other creative work and their contribution to knowledge development; transfer the results of scientific activities to the economic and social spheres;	☒
SzD_U3	communicate on specialised topics to the extent that they enable an active participation in the international scientific community;	☐
SzD_U4	disseminate research results, including in popular forms;	☐
SzD_U5	initiate debates and participate in a scientific discourse;	☒
SzD_U6	be able to speak a foreign language at B2 level of the Common European Framework of Reference for Languages to a level that enables them to participate in the international scientific and professional environment;	☐
SzD_U7	plan and implement an individual or collective research or creative activity, including in an international environment;	☐
SzD_U8	independently plan and act for one's own development and inspire and organize the development of others;	☐
SzD_U9	plan classes or groups of classes and implement them using modern methods and tools.	☐
	SOCIAL COMPETENCES. Doctoral student is ready to:	
SzD_K3	fulfilling the social obligations of researchers and creators, initiate public interest activities, thinking and acting in an entrepreneurial way;	☐
SzD_K4	maintaining and developing the ethos of research and creative environments, including: - carrying out scientific activities in an independent manner, - respecting the principle of public ownership of research results, taking into account the principles of intellectual property protection.	☐

6. Evaluation

Short description of the method(s) used to evaluate the learning outcomes assigned to the course, e.g., exam, test, report, presentation, etc.

Oral presentation on a selected topic

7. Teaching methods

Short description of the teaching methods used during the course, e.g., multimedia presentation, discussion, literature studies, developing written documents, own work, etc.

• Blackboard lectures • Multimedia presentations • Group discussions • Quantitative problem-solving sessions • Individual student work and critical literature analysis

8. Literature

List of primary and secondary literature used to prepare the course and including additional knowledge for participants, e.g., books, textbooks, research papers, standards, web pages, etc.

Primary and Secondary Literature

1. Jonathan W. Steed and Jerry L. Atwood. Title: Supramolecular Chemistry
2. Joseph R. Lakowicz. Title: Principles of Fluorescence Spectroscopy.
3. Vincenzo Balzani, Paola Ceroni and Alberto Juris. Title: Photochemistry and Photophysics: Concepts, Research, Applications

Current scientific articles related to the subjects (examples):

1. Chem. Rev., 2015, 115, 15, 7794–7839
2. Chem. Rev., 2015, 115, 21, 11718–11940
3. Chem. Rev., 2018, 118, 15, 7069–7163
4. ACS Nano, 2023, 17, 15, 14347–14405
5. Nanoscale Horiz., 2024, 9, 1390–1416
6. Cell Chem. Biol., 2019, 26, 600–614
7. J. Med. Chem. 2020, 63, 5, 1996–2012
8. Chem. Rev. 2022, 122, 1, 209–268

9. Other remarks

Additional remarks, comments, (e.g., language of the course)

This interdisciplinary course, rooted in supramolecular chemistry and photophysics, provides an in-depth exploration of how molecular assemblies and non-covalent interactions govern emission behavior, sensing, and therapeutic function. Emphasis is placed on aggregation-induced emission (AIE), aggregation-caused quenching (ACQ), disaggregation-induced emission (DIE), host–guest systems, exciton theory, and quantitative binding analysis.
The course also covers phototherapeutic principles, including light-activated drug release, ROS generation, and supramolecular strategies for drug delivery, highlighting their emerging relevance in cancer and precision medicine.
It is designed for PhD students with interests in chemical biology, nanotechnology, photochemistry, materials science, and biomedical applications.