GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	High-energy and pyrotechnic materials , PG_00066093		
Field of study	Chemistry		
Date of commencement of studies	February 2027	Academic year of realisation of subject	2026/2027
Education level	second-cycle studies	Subject group	Specialty subject group
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	Polish
Semester of study	1	ECTS credits	3.0
Learning profile	general academic profile	Assessment form	exam
Conducting unit	Department of Organic Chemistry -> Faculty of Chemistry -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. Sławomir Makowiec	
	Teachers		

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	15.0	0.0	15.0	0.0	15.0	45

E-learning hours included: 0.0

Learning activity and number of study hours

Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
Number of study hours	45	5.0	25.0	75

Subject objectives

To familiarize students with the fundamentals of the chemistry and technology of high-energy and pyrotechnic materials, covering their structure, physicochemical properties, classification, energy transformations, applications, and safety procedures for handling these materials.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_K01] is aware of the problems related to the profession of a chemist, is able to assess the effects of the activity performed	is aware of the hazards associated with working with high-energy materials, particularly nitro compounds, nitroesters, and nitramines.	[SK5] Assessment of ability to solve problems that arise in practice
[K7_K04] is aware of the responsibility for decisions made, observing and developing the principles of professional ethics and working to ensure compliance with these principles	aware of the responsibility for decisions made while working with high-energy and pyrotechnic materials.	[SK2] Assessment of progress of work
[K7_W03] recognizes and describes phenomena in the field of physics, including elements of quantum mechanics, solid state physics and nuclear physics, necessary to predict the course of physical phenomena and to solve technical problems	has knowledge to identifie and describe physical phenomena associated with the energy transformations of nitro compounds, nitroesters, nitramines, azides, and high-nitrogen compounds.	[SW2] Assessment of knowledge contained in presentation
[K7_K03] understands non-technical aspects and effects of the graduate's activities, including the impact of the chemical industry on the environment	Understands the issues associated with the production, use, and disposal of high-energy and pyrotechnic materials, and is able to assess their potential impact on the environment and human safety.	[SK2] Assessment of progress of work

Subject contents	Course content – lecture 1. High-energy materials – classification, structure, and properties 2. Chemistry of explosives – mechanisms of reactions and high-energy transformations 3. Nitro compounds – synthesis, reaction mechanisms, and energetic properties 4. High-energy materials containing azo and azide groups – synthesis, structure, and reactivity 5. Peroxides, peroxyacids, and other oxygen-rich high-energy materials – properties and decomposition mechanisms 6. Pyrotechnic, initiating, high, and propellant explosives – composition, reactions, and transformation mechanisms 7. Stability, safety, and environmental impact of high-energy materials Course content – laboratory Synthesis of nitronaphthalene – nitration of an aromatic compound Synthesis of nitroaromatic derivatives – influence of substituents on reactivity in nitration reactions Preparation and characterization of nitric acid esters – structure and properties of nitroesters Synthesis of model compounds containing a nitramine group – structural characterization and properties Preparation of a high-nitrogen compound – synthesis and characterization of a selected heterocyclic nitrogen compound Synthesis and characterization of a compound containing an azide group – structure and properties of high-nitrogen compounds Course content – seminar Topics to choose from: History of the development of explosives – from black powder to modern high-energy materials Chemical structure and energetic properties of explosives Nitro compounds, nitrate esters, and nitramines – comparison of structure, properties, and applications Azides and high-nitrogen compounds as high-energy materials Organic peroxides as high-energy compounds – structure, reactivity, and hazards Primary explosives – chemical structure, properties, and technical significance High explosives and propellants – differences in transformation mechanisms and applications Chemical mechanisms of detonation and rapid decomposition of high-energy materials Pyrotechnic materials – chemistry of reactions responsible for light, heat, and gas effects Nitrogen-rich high-energy materials – from molecular structure to energetic properties Thermal and chemical stability of high-energy materials – factors affecting safety Sensitivity of explosives to external stimuli – chemical and physicochemical aspects Explosives and the environment – transformation products, toxicity, and environmental issues Modern high-energy materials – balancing energy, stability, and safety Energetic heterocyclic compounds – the role of nitrogen-rich rings in the design of high-energy materials
Prerequisites and co-requisites	Knowledge of the fundamentals of organic and inorganic chemistry, the basics of physical chemistry—specifically thermodynamics and chemical reaction kinetics—and fundamental laboratory safety principles.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
lecture-based test	60.0%	50.0%
Evaluation of laboratory syntheses performed	60.0%	25.0%
Evaluation of the presentation	60.0%	25.0%

Recommended reading	Basic literature	J. Akhavan, *The Chemistry of Explosives*, 4th ed., Royal Society of Chemistry, 2022. **R. Meyer, J. Köhler, A. Homburg, *Explosives*, 7th ed., Wiley-VCH, 2016.** ISBN 978-3-527-33776-7. **P. W. Cooper, S. R. Kurowski, *Introduction to the Technology of Explosives*, John Wiley & Sons, 1996/1997.** ISBN 978-0-471-18635-9.
	Supplementary literature	none
	eResources addresses	
Example issues/ example questions/ tasks being completed	How does the oxygen balance of a compound affect the products and energy yield of its decomposition? How does chemical structure influence the sensitivity of a high-energy material to external stimuli? Initiating, high, and propellant explosives – differences in structure and properties. Pyrotechnic materials – the roles of fuel, oxidizer, and effect-producing components. What structural features of a nitro compound favor the exhibition of detonating properties?	
Practical activites within the subject	Not applicable	

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