Federal State Autonomous Educational Institution of Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA named after Patrice Lumumba
RUDN University

Faculty of Science

educational division (faculty/institute/academy) as higher education programme developer

COURSE SYLLABUS

Catalyst (nanomaterials) design and applications

course title

Recommended by the Didactic Council for the Education Field of:

04.04.01 «Chemistry»

field of studies / speciality code and title

The course instruction is implemented within the professional education programme of higher education:

«Bioenergies and Biorefineries»

higher education programme profile/specialisation title

2024

1. COURSE GOAL

The goal of the course "Catalyst (nanomaterials) design and applications" is to provide an overview of conventional vs novel/alternative methodologies currently in place or under development for the synthesis of catalysts in view of various applications in catalytic reactions.

2. REQUIREMENTS FOR LEARNING OUTCOMES

Mastering the course "Catalyst (nanomaterials) design and applications" is aimed at the development of the following competences:

Table 2.1. List of competences that students acquire through the course study

Competence code	**Competence descriptor**	**Competence formation indicators** (within this course)
GPC-1	Ability to carry out complex experimental and computational-theoretical studies in the chosen field of chemistry or related sciences using modern equipment, software and databases for professional purposes.	GPC-1.1. Ability to use existing and develop new methods for obtaining and characterizing substances and materials for solving problems in the chosen field of chemistry or related sciences;
GPC-2	Ability to analyze, interpret and generalize the results of experimental and computational-theoretical work in the chosen field of chemistry or related sciences.	GPC-2.2. Ability to formulate summary and conclusions based on the results of the analysis of literature data, own experimental and computational-theoretical works in the chosen field of chemistry or related sciences
GPC-3	Ability to use computational methods and adapt existing software products to solve problems of professional activity	GPC-3.1. Ability to use modern IT-technologies in the collection, analysis, and presentation of chemical profile information;
		GPC-3.2. Ability to use standard and original software products, if necessary, adapting them to solve the problems of professional activity;
PC-1	Ability to develop a work plan and to choose adequate methods for solving research problems in the chosen field of chemistry, chemical technology or sciences related to chemistry	PC-1.1. Ability to prepare a general plan of research and detailed plans for individual stages;

Competence code	Competence descriptor	Competence formation indicators (within this course)
PC-2	Ability, based on a critical analysis of the results of research and development, to evaluate the prospects for their practical application and continuation of work in the chosen field of chemistry, chemical technology or sciences related to chemistry.	PC-2.1. Ability to systematize information obtained in the course of research and development, to analyze it and compare it with literature data;

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The course "Catalyst (nanomaterials) design and applications" refers to the **variable** component of B1 block of the higher educational programme curriculum.

Within the higher education programme students also master other (modules) and / or internships that contribute to the achievement of the expected learning outcomes as results of the course study.

Table 3.1. The list of the higher education programme components/disciplines that contribute to the achievement of the expected learning outcomes as the course study results

Competence code	Competence descriptor	Previous courses/modules*	Subsequent courses/modules*
GPC-1	Ability to carry out complex experimental and computational-theoretical studies in the chosen field of chemistry or related sciences using modern equipment, software and databases for professional purposes.	Actual problems of modern chemistry Bioenergy Alternative/new tools for organic synthesis Advanced Organic Synthesis	Actual problems of modern chemistry Experimental lab 2: Biorefineries and Bioproducts Experimental lab 3: Advanced Organic Synthesis Student Scientific-Research work Pre-graduation practical training
GPC-2	Ability to analyze, interpret and generalize the results of experimental and computational-theoretical work in the chosen field of chemistry or related sciences.	Actual problems of modern chemistry Bioenergy Modern organic synthesis and pharmacology Alternative/new tools for organic synthesis Bioproducts, Biomaterials and Biorefineries Advanced Organic Synthesis	Actual problems of modern chemistry History and philosophy of science Experimental lab 2: Biorefineries and Bioproducts Experimental lab 3: Advanced Organic Synthesis Student Scientific-Research work Pre-graduation practical training
GPC-3	Ability to use	Bioenergy	Experimental lab 3: Advanced

Competence code	Competence descriptor	Previous courses/modules*	Subsequent courses/modules*
	computational methods and adapt existing software products to solve problems of professional activity	Bioproducts, Biomaterials and Biorefineries	Organic Synthesis Student Scientific-Research work Pre-graduation practical training
PC-1	Ability to develop a work plan and to choose adequate methods for solving research problems in the chosen field of chemistry, chemical technology or sciences related to chemistry	Modern organic synthesis and pharmacology Alternative/new tools for organic synthesis Advanced Organic Synthesis	Experimental lab 2: Biorefineries and Bioproducts Experimental lab 3: Advanced Organic Synthesis Emerging contaminants: from fate to environmental remediation The method of working with databases Student Scientific-Research work Pre-graduation practical training
PC-2	Ability, based on a critical analysis of the results of research and development, to evaluate the prospects for their practical application and continuation of work in the chosen field of chemistry, chemical technology or sciences related to chemistry.	Bioproducts, Biomaterials and Biorefineries	Experimental lab 3: Advanced Organic Synthesis Student Scientific-Research work Pre-graduation practical training

* To be filled in according to the competence matrix of the higher education programme.

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

1) The total workload of the course "Catalyst (nanomaterials) design and applications" is 4 credits (144 academic hours).

*Table 4.1. Types of academic activities during the periods of higher education programme mastering **(full-time training)****

Вид учебной работы	ВСЕГО, ак.ч.	Модули			
		1	2	3	4
Контактная работа, ак.ч.	27			*27*	
включая:					
Лекции (**ЛК**)	18			18	
Лабораторные работы (**ЛР**)	9			9	
Практические/семинарские занятия (**СЗ**)					

Вид учебной работы		ВСЕГО, ак.ч.	Модули			
			1	2	3	4
Самостоятельная работа обучающихся		*63*			*63*	
Контроль (экзамен/зачет с оценкой)		*18*			*18*	
Общая трудоемкость дисциплины	ак.ч.	**108**			**108**	
	зач.ед.	**3**			**3**	

5. COURSE MODULES AND CONTENTS

Table 5.1. Course contents and academic activities types

Course module title	Course module contents (topics)	Academic activities types
Module 1. Introduction to synthesis and design of nanomaterials	Topic 1.1 Introduction to synthesis and design of nanomaterials. Types of nanomaterials. Nanoparticles. Nanosclusters. Supported systems. Types of support. Examples. Methodologies to synthesize nanomaterials.	LC
Module 2. Design of catalysts/nanomaterials. Conventional vs alternative	Topic 2.1 Microwave synthesized catalysts. Basic Principles. Methodology. Examples and applications	LC, LW
	Topic 2.2 Mechanochemically synthesized catalysts. Basic Principles. Methodology. Examples and applications	LC, LW
	Topic 2.3 Photochemically synthesized catalysts. Basic Principles. Methodology. Examples and applications	LC, LW
	Topic 2.4 Sonochemical synthesized catalysts. Basic Principles. Methodology. Examples and applications	LC, LW
	Topic 2.5 Electrochemically synthesized catalysts. Basic Principles. Methodology. Examples and applications	LC, LW
	Topic 2.6 Continuous flow synthesized catalysts. Basic Principles. Methodology. Examples and applications	LC, LW
	Topic 2.7 Other catalytic systems (including combinations). Basic Principles and various combinations. Methodology. Examples and applications	LC, LW
Module 3. Catalyst deactivation phenomena. Types and measures to control them.	Topic 3.1 Catalyst deactivation phenomena. Types and measures to control them. Catalyst Characterization (SEM, XRD, TEM, XPS, UV-Vis, etc.). Deactivation phenomena. Poisoning. Fouling/coking. Sintering. Phases transformations/chemical reactions. Leaching. Attrition/Crushing. Explanations and examples. How to detect deactivation (key characterization)	LC, LW
Module 4. Conclusions and prospects	Topic 4.1 Conclusions and prospects. Catalyst design perspectives and examples.	LC

* - to be filled in only for **full**-time training: *LC - lectures; LW - lab work; S - seminars.*

6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Classroom equipment and technology support requirements

Type of academic activities	**Classroom equipment**	**Specialised educational / laboratory equipment, software, and materials for course study** (if necessary)
Lecture	A lecture hall for lecture-type classes, equipped with a set of specialised furniture; board (screen) and a set of devices for multimedia presentations.	Projector, motorized screen for projectors, wi-fi
Lab work	A classroom for laboratory work, individual consultations, current and mid-term assessment; equipped with a set of specialised furniture and machinery.	A set of specialized furniture; specialized equipment of the chemical laboratory: fume hood SHVP-4, fume hood SHVP-2, rotary evaporator Hei-value digital G3B, rotary evaporator IKA, digital devices for determining the melting point SMP10; electronic laboratory scales AND EK-610, MK-M flask heaters of different volumes, drying cabinet, magnetic stirrer MRHei-Mix S, magnetic stirrer with heating MRHei-Standart, refractometer, combined laboratory water bath, vacuum chemical station RS3001 VARIO-pro, circulation cooler Rotacool Mini, rotary plate pump vacuum RZ2.5, membrane vacuum chemical pump MZ2CNT, Steinel thermal air blower, Spectroline UV lamp, electronic vacuum controller with CVC3000 detect Vacuumbrand valve, stainless steel emergency cabin SHVV, chemical dishes, refrigerator; wi-fi
Self-studies	A classroom for self-studies (can be used for seminars and consultations), equipped with a	**Faculty of Science Reading Room**

Type of academic activities	Classroom equipment	Specialised educational / laboratory equipment, software, and materials for course study (if necessary)
	set of specialised furniture and computers with access to the electronic information and educational environment.	Ordzhonikidze D.3. Coworking area Monday - Friday 10.00 – 22.00 **Reading room of the main building of the RUDN** Coworking area Monday - Saturday 9.00 - 23.00 Hall No. 2 Monday - Thursday 10.00 - 17.45 Friday 10.00 - 16.45 Hall No. 6 Monday - Thursday 10.00 - 17.45 Friday 10.00 - 16.45

* The premises for students' self-studies are subject to **MANDATORY** mention

7. RECOMMENDED RESOURCES FOR COURSE STUDY

Main sources:

1. Microwaves in Chemistry Applications, Fundamentals, Methods and Future Trends 1st Edition 2021, Authors: Aparna Das, Bimal Banik, ISBN: 9780128228951
2. Handbook of Electrochemistry, Ed. C.G. Zoski, Elsevier, 2007.
3. Advances in Photochemistry, volumes 1 to 27, Series Online ISSN: 1934-4570 Series DOI: 10.1002/SERIES2020
4. Sonochemistry: From Basic Principles to Innovative Applications, Eds. J.C. Colmenares, G. Chatel, Topics in Current Chemistry, Springer, 2017.
5. Mechanochemistry: Fundamentals, Applications and Future: Faraday Discussion 241, February 2023.
6. Flow Chemistry – Fundamentals, Eds. Ferenc Darvas, Volker Hessel, György Dorman Walter de Gruyter GmbH & Co KG, 2014.
7. Flow Chemistry: Integrated Approaches for Practical Applications, Ed. Santiago Luis, E. Garcia-Verdugo, https://doi.org/10.1039/9781788016094, RSC 2019.

Additional sources:

1. Website of the American Chemical Society ACS Publications: Chemistry journals, books, and references https://pubs.acs.org/

2. http://www.thieme.com/journals-main
3. http://onlinelibrary.wiley.com/
4. http://www.springer.com/gp/products/journals
5. Server with the ability to search for methods for synthesizing compounds http://www.orgsyn.org/

Internet sources

1. Electronic libraries with access for RUDN students:
- RUDN Electronic Library System (RUDN ELS) http://lib.rudn.ru/MegaPro/Web
- EL "University Library Online" http://www.biblioclub.ru
- EL "Yurayt" http://www.biblio-online.ru
- EL "Student Consultant" www.studentlibrary.ru
- EL "Lan" http://e.lanbook.com/
- EL "Trinity Bridge"

2. Databases and search engines:
- electronic foundation of legal and normative-technical documentation http://docs.cntd.ru/
- Yandex search engine https:// www .yandex.ru/
- Google search engine https://www.google.ru/
- Scopus abstract database http://www.elsevierscience.ru/products/scopus/
- www.scholar.google.ru

*Training toolkit for self- studies to master the course *:*

1. A set of lectures on "Catalyst (nanomaterials) design and applications"
2. The laboratory workshop on "Catalyst (nanomaterials) design and applications"

* The training toolkit for self- studies to master the course is placed on the course page in the university telecommunication training and information system under the set procedure.

8. ASSESSMENT TOOLKIT AND GRADING SYSTEM* FOR EVALUATION OF STUDENTS' COMPETENCES LEVEL UPON COURSE COMPLETION

The assessment toolkit and the grading system* to evaluate the competences formation level (competences in part) upon the course study completion are specified in the Appendix to the course syllabus.

* The assessment toolkit and the grading system are formed on the basis of the requirements of the relevant local normative act of RUDN University (regulations / order).

DEVELOPERS:

Organic Chemistry Department		**Rafael Luque**

position, department	signature	name and surname

HEAD OF EDUCATIONAL DEPARTMENT:
Organic Chemistry Department **Voskressensky L.G**

name of department	signature	name and surname

HEAD OF HIGHER EDUCATION PROGRAMME:
Dean of Faculty of Science,
Head of Organic Chemistry Department **Voskressensky L.G**

position, department	signature	name and surname