

MINISTRY OF HEALTH OF UKRAINE  
BOGOMOLETS NATIONAL MEDICAL UNIVERSITY

**GUIDELINES  
to the lectures**

**Educational discipline** "Organic chemistry"  
**Field of knowledge** 22 Health care  
**Specialty** 226 "Pharmacy, industrial pharmacy"  
**Specialization** 226.01 "Pharmacy"  
**Form of study** Full-time  
**Department** of medicinal chemistry and toxicology

Approved at the meeting of the department on "30" August 2024, protocol No. 14

Head of the Department of medicinal chemistry and toxicology  
Doctor of Medicine, Professor

Nizhenkovska I.V.

**Considered and approved:**

on the meeting of cycle methodical commission of specialty 226 "Pharmacy,  
industrial pharmacy" dated August 30, 2024, protocol No. 1

**Topic N1.** Classification and nomenclature of organic compounds. Chemical bonds and mutual influence of the atoms in organic compounds. Isomerism of organic compounds. Spatial structure of molecules.

**Type of lecture:** traditional (informational)

**Competencies:**

*integral:* the ability to solve tasks of a research and/or innovative nature in the field of pharmacy and in the field of industrial production of medicinal products.

*general:*

GC01. Ability to abstract thinking, analysis and synthesis.

GC02. Knowledge and understanding of the subject area; understanding of professional activity.

GC03. Ability to communicate in the national language both orally and in writing.

GC05. Ability to evaluate and ensure the quality of the work performed.

GC06. Ability to work in a team.

GC09. Ability to use information and communication technologies

GC10. Ability to make decisions and act in accordance with the principle of inadmissibility of corruption and any other manifestations of dishonesty.

*professionals:*

PC02. Ability to collect, interpret and apply data necessary for professional activity, research and implementation of innovative projects in the field of pharmacy.

PC03. Ability to solve pharmacy problems in new or unfamiliar environments in the presence of incomplete or limited information, taking into account aspects of social and ethical responsibility.

PC04. Ability to clearly and unambiguously convey one's own knowledge, conclusions and arguments in the field of pharmacy to specialists and non-specialists, in particular to people who are studying.

**Purpose:**

to form the systematized foundations of scientific knowledge regarding the classification and nomenclature of organic compounds, chemical bonds and mutual influence of the atoms in organic compounds, isomerism of organic compounds and spatial structure of molecules; to provide an approximate basis for further assimilation of educational material in practical classes.

**Lecture equipment:** laptop, multimedia projector, blackboard.

**Tasks of the lecture:**

*the student should know*

- classification and nomenclature of organic compounds;
- chemical bonds and mutual influence of the atoms in organic compounds;
- isomerism of organic compounds;
- spatial structure of molecules.

## Plan of the Lecture

The name the stage of the lecture	Content of the stages	Educational goal of the stage	Time
Introduction	Announcement of the topic of the lecture, plan of the lecture, definition of the purpose of the lecture, a brief description of the problems proposed to be considered during the lecture, a brief description of the literature.	Activation of the previously acquired scientific knowledge of students in other disciplines and laying the scientific basis for assimilating the lecture material.	10 min
Main part	<p>1. Discipline "Organic chemistry". Purpose and tasks: to reveal the content, purpose and tasks of the discipline.</p> <p>2. Classification and nomenclature of organic compounds (trivial, IUPAC), chemical bonds and mutual influence of the atoms in organic compounds: reveal the basic knowledge about knowledge about the peculiarities of the chemical structure of organic molecules, the typification of carbon atoms, electronic effects in organic molecules.</p> <p>3. Isomerism of organic compounds and spatial structure of molecules: reveal the knowledge about types of isomerism, information and configuration of organic molecules.</p>	<p>To acquire knowledge about the content, purpose and tasks of discipline.</p> <p>To acquire knowledge about classification of organic compounds, nomenclature, chemical bonds and mutual influence of the atoms in organic compounds.</p> <p>To acquire knowledge about isomerism of organic compounds and spatial structure of organic molecules.</p>	65 min
Final part	Generalization in short formulations of the main ideas of the lecture, logically concluding it as a completed work; direction of further independent work for students; laying the scientific basis for the following lectures.	Learning the actual material of the lecture, the main theoretical provisions with the help of logical nodes - the answers to the questions of the lecture.	15 min

### Recommended literature:

#### Basic

1. Organic chemistry. Multiple choice questions with explanations for pharmacy faculty students / Nizhenkovska I.V., Kustovska A.D., Holovchenko O.I. – K.: Lopatina, 2022. – 205 p., p. 7-42. [http://ek.librarynmu.com/cgi-bin/irbis64r\\_plus/cgiirbis\\_64\\_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU\\_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5](http://ek.librarynmu.com/cgi-bin/irbis64r_plus/cgiirbis_64_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5)

## Auxiliary

1. Minxiang Zhang, Hongyan Xie, Zhaohua Yan, Xueyu Fang, Yongsong Fang. Iodotriphenylphosphonium iodide mediated deprotection of aryl alkyl ethers under metal-free and neutral conditions. *Tetrahedron Lett.* 2023, 121, 154460. DOI: [10.1016/j.tetlet.2023.154460](https://doi.org/10.1016/j.tetlet.2023.154460)).
2. Si-Da Wang, Bo Yang, Hao Zhang, Jian-Ping Qu, Yan-Biao Kang. Reductive Cleavage of C–X or N–S Bonds Catalyzed by Super Organoreductant CBZ6. *Org. Lett.* 2023, 25, 816. DOI: [10.1021/acs.orglett.2c04346](https://doi.org/10.1021/acs.orglett.2c04346)).
3. Abdalrahman Khalifa, Dr. Marco Giles, Dr. Hamed I. Ali. Metal- and Catalyst-Free Synthesis of 2-Substituted-Phthalimides Using 2-(Arenesulfonyl)Phthalimide as Key Reagents. *Eur. J. Org. Chem.* 2023, 26, e202300207. DOI: [10.1002/ejoc.202300207](https://doi.org/10.1002/ejoc.202300207).
4. Desirée Steuernagel, Hans-Achim Wagenknecht. Photocatalytic Synthesis of Acetals and Ketals from Aldehydes and Silylenolethers without the Use of Acids. *Chem. Eur. J.* 2023, 29, e202203767. DOI: [10.1002/chem.202203767](https://doi.org/10.1002/chem.202203767).
5. Denisa Hidasová, Tomáš Slanina. Triarylamminium Radical Cation Facilitates the Deprotection of *tert*-Butyl Groups in Esters, Ethers, Carbonates, and Carbamates. *J. Org. Chem.* 2023, 88, 6932. DOI: [10.1021/acs.joc.3c00238](https://doi.org/10.1021/acs.joc.3c00238).

## Information resources

1. European Pharmacopoeia- [pheur.edqm.eu](http://pheur.edqm.eu)
2. The British Pharmacopoeia 2021 - [www.pharmacopoeia.com](http://www.pharmacopoeia.com)
3. The British Pharmacopoeia 2020. London.2020: I-1298. [www.webofpharma.com](http://www.webofpharma.com)
4. Pharmacopoea USP. [www.usp.org](http://www.usp.org).
5. Website of the Department of Medicinal Chemistry and Toxicology of Bogomolets NMU  
<http://nmu.ua/zagalni-vidomosti/kafedri/kafedra-farmatsevticheskoj-byologicheskoj-y-toksykologicheskoj-hymyy/>
6. Distance learning platform LIKAR\_NMU  
<https://likar.nmu.kiev.ua/mc/index.php/usr/login/login>
7. Official website of the Ministry of Health of Ukraine <https://moz.gov.ua/>
8. Journal of Medicinal Chemistry ([J. Med. Chem.](#))
9. QSAR & Combinatorial Science ([QSAR Comb. Sci.](#))
10. Quantitative Structure-Activity Relationships ([Quant. Struct.-Act. Relat.](#))
11. Journal of Chemometrics ([J. Chemom.](#))
12. Journal of Chemical Information and Modeling ([J. Chem. Inf. Model.](#))
13. [QSAR Research Unit](#) of the [University of Insubria](#)

### **Questions for student self-preparation for the lecture:**

1. Discipline “Organic chemistry”: purpose, task and content of the discipline. Basic concepts of the discipline.
2. Classification of organic compounds.
3. Nomenclature of organic compounds: IUPAC nomenclature rules. Trivial nomenclature. Substitute nomenclature.
4. Types of chemical bonds in molecules of organic compounds:  $\delta$ -bond,  $\pi$ -bond, double- and triple-bonds.
5. Types of Carbon atom hybridization:  $sp^3$ -,  $sp^2$ -,  $sp$ -hybridization.
6. Mutual influence of the atoms in organic compounds, electronic effects: +I, -I, +M, -M.
7. Concept of isomerism. Types of isomerism of organic compounds.
8. Spatial structure of molecules. Concepts of configuration and conformation.

### **Questions for preparing for the exam, which reveals the lecture material:**

1. Classes of organic compounds and their representatives.
2. The main rules of IUPAC nomenclature of organic compounds.
3.  $\delta$ -bond,  $\pi$ -bond, double- and triple-bonds in the organic molecules
4. Name the types of isomerism of organic molecules. describe them.
5. Optical isomerism of organic molecules. Properties of optical isomers.
6. Types of carbon atom hybridization in molecules of saturated and unsaturated compounds.
7. The influence of electronic effects (mesomeric and inductive) on the properties of organic molecules.

**The methodical development was made by:** as. prof., PhD Golovchenko O.I., prof., doctor of pharm. sc. Welchinska O.V., as. prof., PhD Afanasenko O.V.

**Topic N2.** Alkanes. Cycloalkanes. Alkenes (ethylene hydrocarbons, olefins). Alkadienes (dienes hydrocarbons, diolefins). Alkynes (acetylene hydrocarbons). Reactions of electrophilic addition ( $A_E$ ).

**Type of lecture:** traditional (informational)

**Competencies:**

*integral:* the ability to solve tasks of a research and/or innovative nature in the field of pharmacy and in the field of industrial production of medicinal products.

*general:*

GC01. Ability to abstract thinking, analysis and synthesis.

GC02. Knowledge and understanding of the subject area; understanding of professional activity.

GC03. Ability to communicate in the national language both orally and in writing.

GC05. Ability to evaluate and ensure the quality of the work performed.

GC06. Ability to work in a team.

GC09. Ability to use information and communication technologies

GC10. Ability to make decisions and act in accordance with the principle of inadmissibility of corruption and any other manifestations of dishonesty.

*professionals:*

PC02. Ability to collect, interpret and apply data necessary for professional activity, research and implementation of innovative projects in the field of pharmacy.

PC03. Ability to solve pharmacy problems in new or unfamiliar environments in the presence of incomplete or limited information, taking into account aspects of social and ethical responsibility.

PC04. Ability to clearly and unambiguously convey one's own knowledge, conclusions and arguments in the field of pharmacy to specialists and non-specialists, in particular to people who are studying.

**Purpose:** to form the systematized foundations of scientific knowledge regarding the classes of organic compounds: alkanes, cycloalkanes, alkenes (ethylene hydrocarbons, olefins), alkadienes (dienes hydrocarbons, diolefins), alkynes (acetylene hydrocarbons), reactions of electrophilic addition ( $A_E$ ); to provide an approximate basis for further assimilation of educational material in practical classes.

**Lecture equipment:** laptop, multimedia projector, blackboard.

**Tasks of the lecture:**

*the student should know*

- class of alkanes: structure, nomenclature, methods of synthesis, chemical and biological properties;
- class of cycloalkanes: structure, nomenclature, methods of synthesis, chemical and biological properties;
- class of alkenes (ethylene hydrocarbons, olefins): structure, nomenclature, methods of

- synthesis, chemical and biological properties;
- class of alkadienes (dienes hydrocarbons, diolefins): structure, nomenclature, methods of synthesis, chemical and biological properties;
- class of alkynes (acetylene hydrocarbons): structure, nomenclature, methods of synthesis, chemical and biological properties;
- reactions of electrophilic addition ( $A_E$ ).

### Plan of the Lecture

The name the stage of the lecture	Content of the stages	Educational goal of the stage	Time
Introduction	Announcement of the topic of the lecture, plan of the lecture, definition of the purpose of the lecture, a description of the problems proposed to be considered during the lecture, a brief description of the literature.	Activation of the previously acquired scientific knowledge of students in other disciplines and laying the scientific basis for assimilating the lecture material.	10 min
Main part	<p>1. Alkanes and cycloalkanes: to reveal the structure, nomenclature, methods of synthesis, chemical and biological properties.</p> <p>2. Alkenes and alkadienes: to reveal the structure, nomenclature, methods of synthesis, chemical and biological properties.</p> <p>3. Alkynes: to reveal the structure, nomenclature, methods of synthesis, chemical and biological properties. Reactions of electrophilic addition (<math>A_E</math>).</p>	<p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical and biological properties of alkanes and cycloalkanes.</p> <p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical and biological properties of alkenes and alkadienes.</p> <p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical and biological properties of alkynes and reactions of electrophilic addition (<math>A_E</math>).</p>	65 min
Final part	Generalization in short formulations of the main content of the lecture, logically concluding it as a completed work; direction of further independent work for students; laying the scientific basis for the following lectures.	Learning the actual material of the lecture, the main theoretical provisions with the help of logical nodes - the answers to the questions of the lecture.	15 min

### Recommended literature: Basic

1. Organic chemistry. Multiple choice questions with explanations for pharmacy faculty students / Nizhenkovska I.V., Kustovska A.D., Holovchenko O.I. – K.: Lopatina, 2022. – 205 p., p. 43-79. [http://ek.librarynmu.com/cgi-bin/irbis64r\\_plus/cgiirbis\\_64\\_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU\\_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5](http://ek.librarynmu.com/cgi-bin/irbis64r_plus/cgiirbis_64_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5)

### Auxiliary

1. Minxiang Zhang, Hongyan Xie, Zhaohua Yan, Xueyu Fang, Yongsong Fang. Iodotriphenylphosphonium iodide mediated deprotection of aryl alkyl ethers under metal-free and neutral conditions. *Tetrahedron Lett.* 2023, 121, 154460. DOI: [10.1016/j.tetlet.2023.154460](https://doi.org/10.1016/j.tetlet.2023.154460).
2. Si-Da Wang, Bo Yang, Hao Zhang, Jian-Ping Qu, Yan-Biao Kang. Reductive Cleavage of C–X or N–S Bonds Catalyzed by Super Organoreductant CBZ6. *Org. Lett.* 2023, 25, 816. DOI: [10.1021/acs.orglett.2c04346](https://doi.org/10.1021/acs.orglett.2c04346).
3. Abdalrahman Khalifa, Dr. Marco Giles, Dr. Hamed I. AliDr. Metal- and Catalyst-Free Synthesis of 2-Substituted-Phthalimides Using 2-(Arenesulfonyl)Phthalimide as Key Reagents. *Eur. J. Org. Chem.* 2023, 26, e202300207. DOI: [10.1002/ejoc.202300207](https://doi.org/10.1002/ejoc.202300207).
4. Desirée Steuernagel, Hans-Achim Wagenknecht. Photocatalytic Synthesis of Acetals and Ketals from Aldehydes and Silylenoethers without the Use of Acids. *Chem. Eur. J.* 2023, 29, e202203767. DOI: [10.1002/chem.202203767](https://doi.org/10.1002/chem.202203767).
5. Denisa Hidasová, Tomáš Slanina. Triarylamminium Radical Cation Facilitates the Deprotection of *tert*-Butyl Groups in Esters, Ethers, Carbonates, and Carbamates. *J. Org. Chem.* 2023, 88, 6932. DOI: [10.1021/acs.joc.3c00238](https://doi.org/10.1021/acs.joc.3c00238).

### Information resources

1. European Pharmacopoeia- [pheur.edqm.eu](http://pheur.edqm.eu)
2. The British Pharmacopoeia 2021 - [www.pharmacopoeia.com](http://www.pharmacopoeia.com)
3. The British Pharmacopoeia 2020. London.2020: I-1298. [www.webofpharma.com](http://www.webofpharma.com)
4. Pharmacopoea USP. [www.usp.org](http://www.usp.org).
5. Website of the Department of Medicinal Chemistry and Toxicology of Bogomolets NMU  
<http://nmu.ua/zagalni-vidomosti/kafedri/kafedra-farmatsevtycheskoj-byologicheskoj-y-toksykologicheskoj-hymyy/>
6. Distance learning platform LIKAR\_NMU  
<https://likar.nmu.kiev.ua/mc/index.php/usr/login/login>
7. Official website of the Ministry of Health of Ukraine <https://moz.gov.ua/>
8. Journal of Medicinal Chemistry ([J. Med. Chem.](#))
9. QSAR & Combinatorial Science ([QSAR Comb. Sci.](#))
10. Quantitative Structure-Activity Relationships ([Quant. Struct.-Act. Relat.](#))
11. Journal of Chemometrics ([J. Chemom.](#))



12. Journal of Chemical Information and Modeling ([J. Chem. Inf. Model.](#))

13. [QSAR Research Unit](#) of the [University of Insubria](#)

**Questions for student self-preparation for the lecture:**

1. Class of alkanes: structure, nomenclature, methods of synthesis, chemical and biological properties.
2. Class of cycloalkanes: structure, nomenclature, methods of synthesis, chemical and biological properties.
3. Class of alkenes (ethylene hydrocarbons, olefins): structure, nomenclature, methods of synthesis, chemical and biological properties.
4. Class of alkadienes (dienes hydrocarbons, diolefins): structure, nomenclature, methods of synthesis, chemical and biological properties.
5. Class of alkynes (acetylene hydrocarbons): structure, nomenclature, methods of synthesis, chemical and biological properties.
6. Reactions of electrophilic addition ( $A_E$ ). Electrophiles.

**Questions for preparing for the exam, which reveals the lecture material:**

1. Peculiarities of the chemical structure and chemical properties of alkanes.
2. Peculiarities of the chemical structure and chemical properties of cycloalkanes.
3. Peculiarities of the chemical structure and chemical properties of alkenes.
4. Peculiarities of the chemical structure and chemical properties of alkadienes.
5. Peculiarities of the chemical structure and chemical properties of alkynes.
6. The use of representatives of the classes of alkanes, cycloalkanes, alkenes, alkadienes, alkynes in medical and pharmaceutical practices.

**The methodical development was made by:** as. prof., PhD Golovchenko O.I., prof., doctor of pharm. sc. Welchinska O.V., as. prof., PhD Afanasenko O.V.

**Topic N3.** Aromatic hydrocarbons. Mononuclear arenes. Reactions of electrophilic substitution ( $S_E$ ). Poly nuclear condensed and non-condensed arenes.

**Type of lecture:** traditional (informational)

**Competencies:**

*integral:* the ability to solve tasks of a research and/or innovative nature in the field of pharmacy and in the field of industrial production of medicinal products.

*general:*

GC01. Ability to abstract thinking, analysis and synthesis.

GC02. Knowledge and understanding of the subject area; understanding of professional activity.

GC03. Ability to communicate in the national language both orally and in writing.

GC05. Ability to evaluate and ensure the quality of the work performed.

GC06. Ability to work in a team.

GC09. Ability to use information and communication technologies

GC10. Ability to make decisions and act in accordance with the principle of inadmissibility of corruption and any other manifestations of dishonesty.

*professionals:*

PC02. Ability to collect, interpret and apply data necessary for professional activity, research and implementation of innovative projects in the field of pharmacy.

PC03. Ability to solve pharmacy problems in new or unfamiliar environments in the presence of incomplete or limited information, taking into account aspects of social and ethical responsibility.

PC04. Ability to clearly and unambiguously convey one's own knowledge, conclusions and arguments in the field of pharmacy to specialists and non-specialists, in particular to people who are studying.

**Purpose:** to form the systematized foundations of scientific knowledge regarding the class of organic compounds: aromatic hydrocarbons, mononuclear arenes, poly nuclear condensed and non-condensed arenes and its reactions of electrophilic substitution ( $S_E$ ); to provide an approximate basis for further assimilation of educational material in practical classes.

**Lecture equipment:** laptop, multimedia projector, blackboard.

**Tasks of the lecture:**

*the student should know*

- class of aromatic hydrocarbons: structure, nomenclature, methods of synthesis, chemical and biological properties, Huckel  $4n+2$  rule;
- mononuclear arenes: structure, nomenclature, methods of synthesis, chemical and biological properties;
- poly nuclear condensed and non-condensed arenes: structure, nomenclature, methods of synthesis, chemical and biological properties;
- reactions of electrophilic substitution ( $S_E$ ), electrophiles.

## Plan of the Lecture

The name the stage of the lecture	Content of the stages	Educational goal of the stage	Time
Introduction	Announcement of the topic of the lecture, plan of the lecture, definition of the purpose of the lecture, a description of the problems proposed to be considered during the lecture, a brief description of the literature.	Activation of the previously acquired scientific knowledge of students in other disciplines and laying the scientific basis for assimilating the lecture material.	10 min
Main part	<p>1. Aromatic hydrocarbons, mononuclear arenes: to reveal the structure, nomenclature, methods of synthesis, chemical and biological properties.</p> <p>2. Poly nuclear condensed and non-condensed arenes: to reveal the structure, nomenclature, methods of synthesis, chemical and biological properties.</p> <p>3. Reactions of electrophilic substitution (<math>S_E</math>).</p>	<p>To acquire knowledge about structure, nomenclature, methods of synthesis, chemical and biological properties of mononuclear arenes.</p> <p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical and biological properties of poly nuclear condensed and non-condensed arenes.</p> <p>To acquire knowledge about reactions of electrophilic substitution (<math>S_E</math>).</p>	65 min
Final part	Generalization in short formulations of the main ideas of the lecture, logically concluding it as a completed work; direction of further independent work for students; laying the scientific basis for the following lectures.	Learning the actual material of the lecture, the main theoretical provisions with the help of logical nodes - the key questions of the lecture.	15 min

### Recommended literature:

#### Basic

1. Organic chemistry. Multiple choice questions with explanations for pharmacy faculty students / Nizhenkovska I.V., Kustovska A.D., Holovchenko O.I. – K.: Lopatina, 2022. – 205 p., p. 80-101. [http://ek.librarynmu.com/cgi-bin/irbis64r\\_plus/cgiirbis\\_64\\_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU\\_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5](http://ek.librarynmu.com/cgi-bin/irbis64r_plus/cgiirbis_64_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5)

## Auxiliary

1. Minxiang Zhang, Hongyan Xie, Zhaohua Yan, Xueyu Fang, Yongsong Fang. Iodotriphenylphosphonium iodide mediated deprotection of aryl alkyl ethers under metal-free and neutral conditions. *Tetrahedron Lett.* 2023, 121, 154460. DOI: [10.1016/j.tetlet.2023.154460](https://doi.org/10.1016/j.tetlet.2023.154460)).
2. Si-Da Wang, Bo Yang, Hao Zhang, Jian-Ping Qu, Yan-Biao Kang. Reductive Cleavage of C–X or N–S Bonds Catalyzed by Super Organoreductant CBZ6. *Org. Lett.* 2023, 25, 816. DOI: [10.1021/acs.orglett.2c04346](https://doi.org/10.1021/acs.orglett.2c04346)).
3. Abdalrahman Khalifa, Dr. Marco Giles, Dr. Hamed I. Ali. Metal- and Catalyst-Free Synthesis of 2-Substituted-Phthalimides Using 2-(Arenesulfonyl)Phthalimide as Key Reagents. *Eur. J. Org. Chem.* 2023, 26, e202300207. DOI: [10.1002/ejoc.202300207](https://doi.org/10.1002/ejoc.202300207).
4. Desirée Steuernagel, Hans-Achim Wagenknecht. Photocatalytic Synthesis of Acetals and Ketals from Aldehydes and Silylenolethers without the Use of Acids. *Chem. Eur. J.* 2023, 29, e202203767. DOI: [10.1002/chem.202203767](https://doi.org/10.1002/chem.202203767).
5. Denisa Hidasová, Tomáš Slanina. Triarylamminium Radical Cation Facilitates the Deprotection of *tert*-Butyl Groups in Esters, Ethers, Carbonates, and Carbamates. *J. Org. Chem.* 2023, 88, 6932. DOI: [10.1021/acs.joc.3c00238](https://doi.org/10.1021/acs.joc.3c00238).

## Information resources

1. European Pharmacopoeia - [pheur.edqm.eu](http://pheur.edqm.eu)
2. The British Pharmacopoeia 2021 - [www.pharmacopoeia.com](http://www.pharmacopoeia.com)
3. The British Pharmacopoeia 2020. London. 2020: I-1298. [www.webofpharma.com](http://www.webofpharma.com)
4. Pharmacopoeia USP. [www.usp.org](http://www.usp.org).
5. Website of the Department of Medicinal Chemistry and Toxicology of Bogomolets NMU  
<http://nmu.ua/zagalni-vidomosti/kafedri/kafedra-farmatsevticheskoj-byologicheskoj-y-toksykologicheskoj-hymyy/>
6. Distance learning platform LIKAR\_NMU  
<https://likar.nmu.kiev.ua/mc/index.php/usr/login/login>
7. Official website of the Ministry of Health of Ukraine <https://moz.gov.ua/>
8. Journal of Medicinal Chemistry ([J. Med. Chem.](#))
9. QSAR & Combinatorial Science ([QSAR Comb. Sci.](#))
10. Quantitative Structure-Activity Relationships ([Quant. Struct.-Act. Relat.](#))
11. Journal of Chemometrics ([J. Chemom.](#))
12. Journal of Chemical Information and Modeling ([J. Chem. Inf. Model.](#))
13. [QSAR Research Unit](#) of the [University of Insubria](#)

**Questions for student self-preparation for the lecture:**

1. Class of aromatic hydrocarbons: structure, nomenclature, methods of synthesis, chemical and biological properties.
2. Aromaticity. Huckel  $4n+2$  rule;
3. Mononuclear arenes: structure, nomenclature, methods of synthesis, chemical and biological properties.
4. Poly nuclear condensed arenes: structure, nomenclature, methods of synthesis, chemical and biological properties.
5. Poly nuclear non-condensed arenes: structure, nomenclature, methods of synthesis, chemical and biological properties.
6. Reactions of electrophilic substitution ( $S_E$ ). Rules of orientation of substitution. Functional groups of I and II kinds. Electrophiles.

**Questions for preparing for the exam, which reveals the lecture material:**

1. Peculiarities of the chemical structure and chemical properties of mononuclear arenes.
2. Peculiarities of the chemical structure and chemical properties of polynuclear arenes.
3. Peculiarities of the chemical structure and chemical properties of polynuclear arenes condensed.
4. Polynuclear arenes condensed and not condensed. The main representatives.
5. Peculiarities of the chemical reactions of arenes in reactions of electrophilic and nucleophilic substitution.
6. The use of representatives of the classes of arenes in medical and pharmaceutical practices.

**The methodical development was made by:** as. prof., PhD Golovchenko O.I., prof., doctor of pharm. sc. Welchinska O.V., as. prof., PhD Afanasenko O.V.

**Topic N4.** Alkyl Halides. Reactions of nucleophilic substitution ( $S_N$ ).

**Type of lecture:** traditional (informational)

**Competencies:**

*integral:* the ability to solve tasks of a research and/or innovative nature in the field of pharmacy and in the field of industrial production of medicinal products.

*general:*

GC01. Ability to abstract thinking, analysis and synthesis.

GC02. Knowledge and understanding of the subject area; understanding of professional activity.

GC03. Ability to communicate in the national language both orally and in writing.

GC05. Ability to evaluate and ensure the quality of the work performed.

GC06. Ability to work in a team.

GC09. Ability to use information and communication technologies

GC10. Ability to make decisions and act in accordance with the principle of inadmissibility of corruption and any other manifestations of dishonesty.

*professionals:*

PC02. Ability to collect, interpret and apply data necessary for professional activity, research and implementation of innovative projects in the field of pharmacy.

PC03. Ability to solve pharmacy problems in new or unfamiliar environments in the presence of incomplete or limited information, taking into account aspects of social and ethical responsibility.

PC04. Ability to clearly and unambiguously convey one's own knowledge, conclusions and arguments in the field of pharmacy to specialists and non-specialists, in particular to people who are studying.

**Purpose:** to form the systematized foundations of scientific knowledge regarding the class of alkyl halides, reactions of nucleophilic substitution ( $S_N$ ); to provide an approximate basis for further assimilation of educational material in practical classes.

**Lecture equipment:** laptop, multimedia projector, blackboard.

**Tasks of the lecture:**

*the student should know*

- class of alkyl halides;
- aliphatic alkyl halides: structure, nomenclature, methods of synthesis, chemical and biological properties;
- aromatic alkyl halides: structure, nomenclature, methods of synthesis, chemical and biological properties;
- reactions of nucleophilic substitution ( $S_N$ ).

## Plan of the Lecture

The name the stage of the lecture	Content of the stages	Educational goal of the stage	Time
Introduction	Announcement of the topic of the lecture, plan of lecture, definition of the purpose of the lecture, a description of the problems proposed to be considered during lecture, a brief description of the literature.	Activation of the previously acquired scientific knowledge of students in other disciplines and laying the scientific basis for assimilating the lecture material.	10 min
Main part	<p>1. Characteristic of class of alkyl halides. Aliphatic alkyl halides: structure, nomenclature, methods of synthesis, chemical and biological properties: to reveal the structure, nomenclature, methods of synthesis, chemical and biological properties.</p> <p>2. Aromatic alkyl halides: to reveal the structure, nomenclature, methods of synthesis, chemical and biological properties.</p> <p>3. Reactions of nucleophilic substitution (<math>S_N</math>).</p>	<p>To acquire knowledge about structure, nomenclature, methods of synthesis, chemical and biological properties of aliphatic alkyl halides.</p> <p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical and biological properties of aromatic alkyl halides.</p> <p>To acquire knowledge about the reactions of nucleophilic substitution (<math>S_N</math>).</p>	65 min
Final part	Generalization in short formulations of the main ideas of the lecture, logically concluding it as a completed work; direction of further independent work for students; laying the scientific basis for the following lectures.	Learning the actual material of the lecture, the main theoretical provisions with the help of logical nodes - the key questions of the lecture.	15 min

### Recommended literature:

#### Basic

1. Organic chemistry. Multiple choice questions with explanations for pharmacy faculty students / Nizhenkovska I.V., Kustovska A.D., Holovchenko O.I. – K.: Lopatina, 2022. – 205 p., p. 102-106. [http://ek.librarynmu.com/cgi-bin/irbis64r\\_plus/cgiirbis\\_64\\_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU\\_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5](http://ek.librarynmu.com/cgi-bin/irbis64r_plus/cgiirbis_64_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5)

## Auxiliary

1. Minxiang Zhang, Hongyan Xie, Zhaohua Yan, Xueyu Fang, Yongsong Fang. Iodotriphenylphosphonium iodide mediated deprotection of aryl alkyl ethers under metal-free and neutral conditions. *Tetrahedron Lett.* 2023, 121, 154460. DOI: [10.1016/j.tetlet.2023.154460](https://doi.org/10.1016/j.tetlet.2023.154460).
2. Si-Da Wang, Bo Yang, Hao Zhang, Jian-Ping Qu, Yan-Biao Kang. Reductive Cleavage of C–X or N–S Bonds Catalyzed by Super Organoreductant CBZ6. *Org. Lett.* 2023, 25, 816. DOI: [10.1021/acs.orglett.2c04346](https://doi.org/10.1021/acs.orglett.2c04346).
3. Abdalrahman Khalifa, Dr. Marco Giles, Dr. Hamed I. Ali. Metal- and Catalyst-Free Synthesis of 2-Substituted-Phthalimides Using 2-(Arenesulfonyl)Phthalimide as Key Reagents. *Eur. J. Org. Chem.* 2023, 26, e202300207. DOI: [10.1002/ejoc.202300207](https://doi.org/10.1002/ejoc.202300207).
4. Desirée Steuernagel, Hans-Achim Wagenknecht. Photocatalytic Synthesis of Acetals and Ketals from Aldehydes and Silylenolethers without the Use of Acids. *Chem. Eur. J.* 2023, 29, e202203767. DOI: [10.1002/chem.202203767](https://doi.org/10.1002/chem.202203767).
5. Denisa Hidasová, Tomáš Slanina. Triarylamminium Radical Cation Facilitates the Deprotection of *tert*-Butyl Groups in Esters, Ethers, Carbonates, and Carbamates. *J. Org. Chem.* 2023, 88, 6932. DOI: [10.1021/acs.joc.3c00238](https://doi.org/10.1021/acs.joc.3c00238).

## Information resources

1. European Pharmacopoeia - [pheur.edqm.eu](http://pheur.edqm.eu)
2. The British Pharmacopoeia 2021 - [www.pharmacopoeia.com](http://www.pharmacopoeia.com)
3. The British Pharmacopoeia 2020. London. 2020: I-1298. [www.webofpharma.com](http://www.webofpharma.com)
4. Pharmacopoeia USP. [www.usp.org](http://www.usp.org).
5. Website of the Department of Medicinal Chemistry and Toxicology of Bogomolets NMU  
<http://nmu.ua/zagalni-vidomosti/kafedri/kafedra-farmatsevtycheskoj-byologicheskoj-y-toksykologicheskoj-hymyy/>
6. Distance learning platform LIKAR\_NMU  
<https://likar.nmu.kiev.ua/mc/index.php/usr/login/login>
7. Official website of the Ministry of Health of Ukraine <https://moz.gov.ua/>
8. Journal of Medicinal Chemistry ([J. Med. Chem.](#))
9. QSAR & Combinatorial Science ([QSAR Comb. Sci.](#))
10. Quantitative Structure-Activity Relationships ([Quant. Struct.-Act. Relat.](#))
11. Journal of Chemometrics ([J. Chemom.](#))
12. Journal of Chemical Information and Modeling ([J. Chem. Inf. Model.](#))
13. [QSAR Research Unit](#) of the [University of Insubria](#)



**Questions for student self-preparation for the lecture:**

1. Alkyl halides. Characteristic of class.
2. Aliphatic alkyl halides: structure, nomenclature, methods of synthesis, chemical and biological properties.
3. Aromatic alkyl halides: structure, nomenclature, methods of synthesis, chemical and biological properties.
4. Reactions of nucleophilic substitution ( $S_N$ ). Nucleophile.

**Questions for preparing for the exam, which reveals the lecture material:**

1. Peculiarities of the chemical structure and chemical properties of alkyl halides.
2. Peculiarities of methods of extraction of the alkyl halides.
3. Peculiarities of the chemical structure and chemical properties of unsaturated alkyl halides.
4. Peculiarities of the chemical structure and chemical properties of aromatic halides.
5. The use of representatives of the classes of alkyl halides in medical and pharmaceutical practices.

**The methodical development was made by:** as. prof., PhD Golovchenko O.I.,  
prof., doctor of pharm. sc. Welchinska O.V., as. prof., PhD Afanasenko O.V.

**Topic N5.** Nitro compounds. Amines. Azo-, diazo compounds.

**Type of lecture:** traditional (informational)

**Competencies:**

*integral:* the ability to solve tasks of a research and/or innovative nature in the field of pharmacy and in the field of industrial production of medicinal products.

*general:*

GC01. Ability to abstract thinking, analysis and synthesis.

GC02. Knowledge and understanding of the subject area; understanding of professional activity.

GC03. Ability to communicate in the national language both orally and in writing.

GC05. Ability to evaluate and ensure the quality of the work performed.

GC06. Ability to work in a team.

GC09. Ability to use information and communication technologies

GC10. Ability to make decisions and act in accordance with the principle of inadmissibility of corruption and any other manifestations of dishonesty.

*professionals:*

PC02. Ability to collect, interpret and apply data necessary for professional activity, research and implementation of innovative projects in the field of pharmacy.

PC03. Ability to solve pharmacy problems in new or unfamiliar environments in the presence of incomplete or limited information, taking into account aspects of social and ethical responsibility.

PC04. Ability to clearly and unambiguously convey one's own knowledge, conclusions and arguments in the field of pharmacy to specialists and non-specialists, in particular to people who are studying.

**Purpose:** to form the systematized foundations of scientific knowledge regarding the classes of nitro compounds, amines, azo- and diazo compounds; to provide an approximate basis for further assimilation of educational material in practical classes.

**Lecture equipment:** laptop, multimedia projector, blackboard.

**Tasks of the lecture:**

*the student should know*

- Nitrogen containing organic compounds;
- aliphatic nitro compounds: structure, nomenclature, methods of synthesis, chemical and biological properties;
- aromatic nitro compounds: structure, nomenclature, methods of synthesis, chemical and biological properties;
- aliphatic amines: structure, nomenclature, methods of synthesis, chemical and biological properties;
- aromatic amines: structure, nomenclature, methods of synthesis, chemical and biological properties;

- aliphatic azo- and diazo compounds: structure, nomenclature, methods of synthesis, chemical and biological properties;
- aromatic azo- and diazo compounds: structure, nomenclature, methods of synthesis, chemical and biological properties.

### Plan of the Lecture

The name the stage of the lecture	Content of the stages	Educational goal of the stage	Time
Introduction	Announcement of the topic of the lecture, plan of the lecture, definition of the purpose of the lecture, a description of the problems proposed to be considered during the lecture, a brief description of the literature.	Activation of the previously acquired scientific knowledge of students in other disciplines and laying the scientific basis for assimilating the lecture material.	10 min
Main part	<p>1. Characteristic of classes of Nitrogen containing organic compounds. Aliphatic and aromatic nitro compounds: structure, nomenclature, methods of synthesis, chemical and biological properties: to reveal structure, nomenclature, methods of synthesis, chemical and biological properties.</p> <p>2. Aliphatic and aromatic amines: to reveal structure, nomenclature, methods of synthesis, chemical and biological properties.</p> <p>3. Aliphatic and aromatic azo- and diazo-compounds: to reveal the structure, nomenclature, methods of synthesis, chemical and biological properties.</p>	<p>To acquire knowledge about structure, nomenclature, methods of synthesis, chemical and biological properties of aliphatic and aromatic compounds.</p> <p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical and biological properties of amines.</p> <p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical and biological properties of azo- and diazo-compounds.</p>	65 min
Final part	Generalization in short formulations of the main ideas of the lecture, logically concluding it as a completed work; direction of further independent work for students; laying the scientific basis for the following lectures.	Learning the actual material of the lecture, the main theoretical provisions with the help of logical nodes - the key questions of the lecture.	15 min

### Recommended literature:

## Basic

1. Organic chemistry. Multiple choice questions with explanations for pharmacy faculty students / Nizhenkovska I.V., Kustovska A.D., Holovchenko O.I. – K.: Lopatina, 2022. – 205 p., p. 107-126. [http://ek.librarynmu.com/cgi-bin/irbis64r\\_plus/cgiirbis\\_64\\_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU\\_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5](http://ek.librarynmu.com/cgi-bin/irbis64r_plus/cgiirbis_64_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5)

## Auxiliary

1. Minxiang Zhang, Hongyan Xie, Zhaohua Yan, Xueyu Fang, Yongsong Fang. Iodotriphenylphosphonium iodide mediated deprotection of aryl alkyl ethers under metal-free and neutral conditions. *Tetrahedron Lett.* 2023, 121, 154460. DOI: [10.1016/j.tetlet.2023.154460](https://doi.org/10.1016/j.tetlet.2023.154460).
2. Si-Da Wang, Bo Yang, Hao Zhang, Jian-Ping Qu, Yan-Biao Kang. Reductive Cleavage of C–X or N–S Bonds Catalyzed by Super Organoreductant CBZ6. *Org. Lett.* 2023, 25, 816. DOI: [10.1021/acs.orglett.2c04346](https://doi.org/10.1021/acs.orglett.2c04346).
3. Abdalrahman Khalifa, Dr. Marco Giles, Dr. Hamed I. AliDr. Metal- and Catalyst-Free Synthesis of 2-Substituted-Phthalimides Using 2-(Arenesulfonyl)Phthalimide as Key Reagents. *Eur. J. Org. Chem.* 2023, 26, e202300207. DOI: [10.1002/ejoc.202300207](https://doi.org/10.1002/ejoc.202300207).
4. Desirée Steuernagel, Hans-Achim Wagenknecht. Photocatalytic Synthesis of Acetals and Ketals from Aldehydes and Silylenolethers without the Use of Acids. *Chem. Eur. J.* 2023, 29, e202203767. DOI: [10.1002/chem.202203767](https://doi.org/10.1002/chem.202203767).
5. Denisa Hidasová, Tomáš Slanina. Triarylamminium Radical Cation Facilitates the Deprotection of *tert*-Butyl Groups in Esters, Ethers, Carbonates, and Carbamates. *J. Org. Chem.* 2023, 88, 6932. DOI: [10.1021/acs.joc.3c00238](https://doi.org/10.1021/acs.joc.3c00238).

## Information resources

1. European Pharmacopoeia- [pheur.edqm.eu](http://pheur.edqm.eu)
2. The British Pharmacopoeia 2021 - [www.pharmacopoeia.com](http://www.pharmacopoeia.com)
3. The British Pharmacopoeia 2020. London.2020: I-1298. [www.webofpharma.com](http://www.webofpharma.com)
4. Pharmacopoea USP. [www.usp.org](http://www.usp.org).
5. Website of the Department of Medicinal Chemistry and Toxicology of Bogomolets NMU  
<http://nmu.ua/zagalni-vidomosti/kafedri/kafedra-farmatsevtycheskoj-byologicheskoj-y-toksykologicheskoj-hymyy/>
6. Distance learning platform LIKAR\_NMU  
<https://likar.nmu.kiev.ua/mc/index.php/usr/login/login>
7. Official website of the Ministry of Health of Ukraine <https://moz.gov.ua/>
8. Journal of Medicinal Chemistry ([J. Med. Chem.](http://www.jmedchem.com))
9. QSAR & Combinatorial Science ([QSAR Comb. Sci.](http://www.qsarcomb.com))

10. Quantitative Structure-Activity Relationships ([Quant. Struct.-Act. Relat.](#))
11. Journal of Chemometrics ([J. Chemom.](#))
12. Journal of Chemical Information and Modeling ([J. Chem. Inf. Model.](#))
13. [QSAR Research Unit](#) of the [University of Insubria](#)

**Questions for student self-preparation for the lecture:**

1. Nitrogen containing organic compounds. Characteristic of classes. Functional groups.
2. Aliphatic nitro compounds: structure, nomenclature, methods of synthesis, chemical and biological properties.
3. Aromatic nitro compounds: structure, nomenclature, methods of synthesis, chemical and biological properties.
4. Aliphatic amines: structure, nomenclature, methods of synthesis, chemical and biological properties.
5. Aromatic amines: structure, nomenclature, methods of synthesis, chemical and biological properties.
6. Aliphatic azo- and diazo compounds: structure, nomenclature, methods of synthesis, chemical and biological properties.
7. Aromatic azo- and diazo compounds: structure, nomenclature, methods of synthesis, chemical and biological properties.

**Questions for preparing for the exam, which reveals the lecture material:**

1. Peculiarities of the chemical structure and chemical properties of nitro compounds of aliphatic and aromatic lines.
2. Peculiarities of the chemical structure and chemical properties of amino compounds of aliphatic and aromatic lines.
3. Peculiarities of the chemical structure and chemical properties of azo compounds of aliphatic and aromatic lines.
4. Peculiarities of the chemical structure and chemical properties of diazo compounds of aliphatic and aromatic lines.
5. The use of representatives of the classes of nitrogen containing compounds in medical and pharmaceutical practices.

**The methodical development was made by:** as. prof., PhD Golovchenko O.I., prof., doctor of pharm. sc. Welchinska O.V., as. prof., PhD Afanasenko O.V.

**Topic 6.** Alcohols. Ethers. Phenols.

**Type of lecture:** traditional (informational)

**Competencies:**

*integral:* the ability to solve tasks of a research and/or innovative nature in the field of pharmacy and in the field of industrial production of medicinal products.

*general:*

GC01. Ability to abstract thinking, analysis and synthesis.

GC02. Knowledge and understanding of the subject area; understanding of professional activity.

GC03. Ability to communicate in the national language both orally and in writing.

GC05. Ability to evaluate and ensure the quality of the work performed.

GC06. Ability to work in a team.

GC09. Ability to use information and communication technologies

GC10. Ability to make decisions and act in accordance with the principle of inadmissibility of corruption and any other manifestations of dishonesty.

*professionals:*

PC02. Ability to collect, interpret and apply data necessary for professional activity, research and implementation of innovative projects in the field of pharmacy.

PC03. Ability to solve pharmacy problems in new or unfamiliar environments in the presence of incomplete or limited information, taking into account aspects of social and ethical responsibility.

PC04. Ability to clearly and unambiguously convey one's own knowledge, conclusions and arguments in the field of pharmacy to specialists and non-specialists, in particular to people who are studying.

**Purpose:** to form the systematized foundations of scientific knowledge regarding the classes of alcohols, ethers, phenols; to provide an approximate basis for further assimilation of educational material in practical classes.

**Lecture equipment:** laptop, multimedia projector, blackboard.

**Tasks of the lecture:**

*the student should know*

- Oxygen containing organic compounds;
- aliphatic alcohols: structure, nomenclature, methods of synthesis, chemical and biological properties;
- aliphatic ethers: structure, nomenclature, methods of synthesis, chemical and biological properties;
- aromatic ethers: structure, nomenclature, methods of synthesis, chemical and biological properties;
- phenols: structure, nomenclature, methods of synthesis, chemical and biological

properties.

### Plan of the Lecture

The name the stage of the lecture	Content of the stages	Educational goal of the stage	Time
Introduction	Announcement of the topic of the lecture, plan of the lecture, definition of the purpose of the lecture, a description of the problems proposed to be considered during the lecture, a brief description of the literature.	Activation of the previously acquired scientific knowledge of students from other disciplines and laying the scientific basis for assimilating the lecture material.	10 min
Main part	<p>1. Characteristic of classes of Oxygen containing organic compounds. Aliphatic alcohols: structure, nomenclature, methods of synthesis, chemical and biological properties: to reveal structure, nomenclature, methods of synthesis, chemical and biological properties.</p> <p>2. Aliphatic and aromatic ethers: to reveal structure, nomenclature, methods of synthesis, chemical and biological properties.</p> <p>3. Phenols: to reveal the structure, nomenclature, methods of synthesis, chemical and biological properties.</p>	<p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical and biological properties of aliphatic alcohols.</p> <p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical and biological properties of ethers.</p> <p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical and biological properties of phenols.</p>	65 min
Final part	Generalization in short formulations of the main ideas of the lecture, logically concluding it as a completed work; direction of further independent work for students; laying the scientific basis for the following lectures.	Learning the actual material of the lecture, the main theoretical provisions with the help of logical nodes - the key questions of the lecture.	15 min

#### Recommended literature:

##### Basic

1. Organic chemistry. Multiple choice questions with explanations for pharmacy faculty students / Nizhenkovska I.V., Kustovska A.D., Holovchenko O.I. – K.: Lopatina, 2022. – 205 p., p. 127-139. [http://ek.librarynmu.com/cgi-bin/irbis64r\\_plus/cgiirbis\\_64\\_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU\\_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5](http://ek.librarynmu.com/cgi-bin/irbis64r_plus/cgiirbis_64_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5)

## Auxiliary

1. "[Phenol](#)". PubChem, US National Library of Medicine. 10 June 2023. Retrieved 12 June 2023.
2. [Sigma-Aldrich Co.](#), [Phenol](#). Retrieved on 2022-02-15.
3. "[Phenol](#)". *Immediately Dangerous to Life or Health Concentrations (IDLH)*. [National Institute for Occupational Safety and Health \(NIOSH\)](#).
4. Minxiang Zhang, Hongyan Xie, Zhaohua Yan, Xueyu Fang, Yongsong Fang. Iodotriphenylphosphonium iodide mediated deprotection of aryl alkyl ethers under metal-free and neutral conditions. *Tetrahedron Lett.* 2023, 121, 154460. DOI: [10.1016/j.tetlet.2023.154460](https://doi.org/10.1016/j.tetlet.2023.154460).
5. Si-Da Wang, Bo Yang, Hao Zhang, Jian-Ping Qu, Yan-Biao Kang. Reductive Cleavage of C–X or N–S Bonds Catalyzed by Super Organoreductant CBZ6. *Org. Lett.* 2023, 25, 816. DOI: [10.1021/acs.orglett.2c04346](https://doi.org/10.1021/acs.orglett.2c04346).
6. Abdalrahman Khalifa, Dr. Marco Giles, Dr. Hamed I. Ali. Metal- and Catalyst-Free Synthesis of 2-Substituted-Phthalimides Using 2-(Arenesulfonyl)Phthalimide as Key Reagents. *Eur. J. Org. Chem.* 2023, 26, e202300207. DOI: [10.1002/ejoc.202300207](https://doi.org/10.1002/ejoc.202300207).
7. Desirée Steuernagel, Hans-Achim Wagenknecht. Photocatalytic Synthesis of Acetals and Ketals from Aldehydes and Silylenolethers without the Use of Acids. *Chem. Eur. J.* 2023, 29, e202203767. DOI: [10.1002/chem.202203767](https://doi.org/10.1002/chem.202203767).
8. Denisa Hidasová, Tomáš Slanina. Triarylamminium Radical Cation Facilitates the Deprotection of *tert*-Butyl Groups in Esters, Ethers, Carbonates, and Carbamates. *J. Org. Chem.* 2023, 88, 6932. DOI: [10.1021/acs.joc.3c00238](https://doi.org/10.1021/acs.joc.3c00238).

## Information resources

1. European Pharmacopoeia- [pheur.edqm.eu](http://pheur.edqm.eu)
2. The British Pharmacopoeia 2021 - [www.pharmacopoeia.com](http://www.pharmacopoeia.com)
3. The British Pharmacopoeia 2020. London.2020: I-1298. [www.webofpharma.com](http://www.webofpharma.com)
4. Pharmacopoea USP. [www.usp.org](http://www.usp.org).
5. Website of the Department of Medicinal Chemistry and Toxicology of Bogomolets NMU  
<http://nmu.ua/zagalni-vidomosti/kafedri/kafedra-farmatsevticheskoj-byologicheskoy-y-toksykologicheskoy-hymyy/>
6. Distance learning platform LIKAR\_NMU  
<https://likar.nmu.kiev.ua/mc/index.php/usr/login/login>
7. Official website of the Ministry of Health of Ukraine <https://moz.gov.ua/>
8. Journal of Medicinal Chemistry ([J. Med. Chem.](#))
9. QSAR & Combinatorial Science ([QSAR Comb. Sci.](#))
10. Quantitative Structure-Activity Relationships ([Quant. Struct.-Act. Relat.](#))



11. Journal of Chemometrics ([J. Chemom.](#))

12. Journal of Chemical Information and Modeling ([J. Chem. Inf. Model.](#))

13. [QSAR Research Unit](#) of the [University of Insubria](#)

**Questions for student self-preparation for the lecture:**

1. Oxygen containing organic compounds. Characteristic of classes. Functional groups.
2. Aliphatic alcohols: structure, nomenclature, methods of synthesis, chemical and biological properties.
3. Aliphatic ethers: structure, nomenclature, methods of synthesis, chemical and biological properties.
4. Aromatic ethers: structure, nomenclature, methods of synthesis, chemical and biological properties.
5. Phenols: structure, nomenclature, methods of synthesis, chemical and biological properties.

**Questions for preparing for the exam, which reveals the lecture material:**

1. Peculiarities of the chemical structure and chemical properties of alcohols of aliphatic and aromatic lines.
2. Peculiarities of the chemical structure and chemical properties of ethers of aliphatic and aromatic lines.
3. Peculiarities of the chemical structure and chemical properties of phenols.
4. The use of representatives of the classes of alcohols, ethers, phenols in medical and pharmaceutical practices.

**The methodical development was made by:** as. prof., PhD Golovchenko O.I.,  
prof., doctor of pharm. sc. Welchinska O.V., as. prof., PhD Afanasenko O.V.

**Topic 7.** Aldehydes and ketones of aliphatic and aromatic lines.

**Type of lecture:** traditional (informational)

**Competencies:**

*integral:* the ability to solve tasks of a research and/or innovative nature in the field of pharmacy and in the field of industrial production of medicinal products.

*general:*

GC01. Ability to abstract thinking, analysis and synthesis.

GC02. Knowledge and understanding of the subject area; understanding of professional activity.

GC03. Ability to communicate in the national language both orally and in writing.

GC05. Ability to evaluate and ensure the quality of the work performed.

GC06. Ability to work in a team.

GC09. Ability to use information and communication technologies

GC10. Ability to make decisions and act in accordance with the principle of inadmissibility of corruption and any other manifestations of dishonesty.

*professionals:*

PC02. Ability to collect, interpret and apply data necessary for professional activity, research and implementation of innovative projects in the field of pharmacy.

PC03. Ability to solve pharmacy problems in new or unfamiliar environments in the presence of incomplete or limited information, taking into account aspects of social and ethical responsibility.

PC04. Ability to clearly and unambiguously convey one's own knowledge, conclusions and arguments in the field of pharmacy to specialists and non-specialists, in particular to people who are studying.

**Purpose:** to form the systematized foundations of scientific knowledge regarding the classes of aldehydes and ketones of aliphatic and aromatic lines; to provide an approximate basis for further assimilation of educational material in practical classes.

**Lecture equipment:** laptop, multimedia projector, blackboard.

**Tasks of the lecture:**

*the student should know*

- Oxygen containing organic compounds;
- aliphatic aldehydes: structure, nomenclature, methods of synthesis, chemical and biological properties;
- aliphatic ketones: structure, nomenclature, methods of synthesis, chemical and biological properties;
- aromatic aldehydes: structure, nomenclature, methods of synthesis, chemical and biological properties;
- aromatic ketones: structure, nomenclature, methods of synthesis, chemical and biological properties.

## Plan of the Lecture

The name the stage of the lecture	Content of the stages	Educational goal of the stage	Time
Introduction	Announcement of the topic of the lecture, plan of the lecture, definition of the purpose of the lecture, a description of the problems proposed to be considered during the lecture, a brief description of the literature.	Activation of the previously acquired scientific knowledge of students from other disciplines and laying the scientific basis for assimilating the lecture material.	10 min
Main part	<p>1. Characteristic of classes of Oxygen containing organic compounds with oxo-functional group. Aliphatic aldehydes and ketones: structure, nomenclature, methods of synthesis, chemical and biological properties: to reveal structure, nomenclature, methods of synthesis, chemical properties.</p> <p>2. Aromatic aldehydes and ketones: to reveal structure, nomenclature, methods of synthesis, chemical properties.</p> <p>3. Biological active aldehydes and ketones, its use in medicine and pharmacy: to reveal the biological properties.</p>	<p>To acquire knowledge about structure, nomenclature, methods of synthesis, chemical properties of aliphatic aldehydes and ketones.</p> <p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical properties of aromatic aldehydes and ketones.</p> <p>To acquire knowledge about biological properties of aldehydes and ketones.</p>	65 min
Final part	Generalization in short formulations of the main content of the lecture, logically concluding it as a completed work; direction of further independent work for students; laying the scientific basis for the following lectures.	Learning the actual material of the lecture, the main theoretical provisions with the help of logical nodes - the key questions of the lecture.	15 min

### Recommended literature:

#### Basic

1. Organic chemistry. Multiple choice questions with explanations for pharmacy faculty students / Nizhenkovska I.V., Kustovska A.D., Holovchenko O.I. – K.: Lopatina, 2022. – 205 p., p. 140-148. [http://ek.library.nmu.com/cgi-bin/irbis64r\\_plus/cgiirbis\\_64\\_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU\\_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5](http://ek.library.nmu.com/cgi-bin/irbis64r_plus/cgiirbis_64_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5)

#### Auxiliary

1. "[Aldehyde and Ketone - NEB Class 12 Chemistry 2080](#)". *Iswori Education*. 2023-07-29. Retrieved 2023-07-29.

2. Desirée Steuernagel, Hans-Achim Wagenknecht. Photocatalytic Synthesis of Acetals and Ketals from Aldehydes and Silylenolethers without the Use of Acids. *Chem. Eur. J.* 2023, 29, e202203767. DOI: [10.1002/chem.202203767](https://doi.org/10.1002/chem.202203767).

### Information resources

1. European Pharmacopoeia- [pheur.edqm.eu](http://pheur.edqm.eu)

2. The British Pharmacopoeia 2021 - [www.pharmacopoeia.com](http://www.pharmacopoeia.com)

3. The British Pharmacopoeia 2020. London.2020: I-1298. [www.webofpharma.com](http://www.webofpharma.com)

4. Pharmacopoea USP. [www.usp.org](http://www.usp.org).

5. Website of the Department of Medicinal Chemistry and Toxicology of Bogomolets NMU

<http://nmu.ua/zagalni-vidomosti/kafedri/kafedra-farmatsevtycheskoj-byologicheskoj-y-toksykologicheskoj-hymyy/>

6. Distance learning platform LIKAR\_NMU  
<https://likar.nmu.kiev.ua/mc/index.php/usr/login/login>

7. Official website of the Ministry of Health of Ukraine <https://moz.gov.ua/>

8. Journal of Medicinal Chemistry ([J. Med. Chem.](#))

9. QSAR & Combinatorial Science ([QSAR Comb. Sci.](#))

10. Quantitative Structure-Activity Relationships ([Quant. Struct.-Act. Relat.](#))

11. Journal of Chemometrics ([J. Chemom.](#))

12. Journal of Chemical Information and Modeling ([J. Chem. Inf. Model.](#))

13. [QSAR Research Unit](#) of the [University of Insubria](#)

### Questions for student self-preparation for the lecture:

1. Oxygen containing organic compounds. Characteristic of classes. Functional oxo-group.
2. Aliphatic aldehydes: structure, nomenclature, methods of synthesis, chemical and biological properties.
3. Aliphatic ketones: structure, nomenclature, methods of synthesis, chemical and biological properties.
4. Aromatic aldehydes: structure, nomenclature, methods of synthesis, chemical and biological properties.
5. Aromatic ketones: structure, nomenclature, methods of synthesis, chemical and biological properties.
6. Biological active aldehydes and ketones, its use in medicine and pharmacy.

**Questions for preparing for the exam, which reveals the lecture material:**

1. Peculiarities of the chemical structure carbonyl group. Electronic effects in the group.
2. Peculiarities of the chemical structure and chemical properties of aldehydes of aliphatic line.
3. Peculiarities of the chemical structure and chemical properties of aldehydes of aromatic line.
4. Peculiarities of the chemical structure and chemical properties of ketones of aliphatic line.
5. Peculiarities of the chemical structure and chemical properties of ketones of aromatic line.
6. The use of representatives of the classes of carbonyl compounds in medical and pharmaceutical practices.

**The methodical development was made by:** as. prof., PhD Golovchenko O.I., prof., doctor of pharm. sc. Welchinska O.V., as. prof., PhD Afanasenko O.V.

**Topic 8.** Carboxylic acid, its functional derivatives.

**Type of lecture:** traditional (informational)

**Competencies:**

*integral:* the ability to solve tasks of a research and/or innovative nature in the field of pharmacy and in the field of industrial production of medicinal products.

*general:*

GC01. Ability to abstract thinking, analysis and synthesis.

GC02. Knowledge and understanding of the subject area; understanding of professional activity.

GC03. Ability to communicate in the national language both orally and in writing.

GC05. Ability to evaluate and ensure the quality of the work performed.

GC06. Ability to work in a team.

GC09. Ability to use information and communication technologies

GC10. Ability to make decisions and act in accordance with the principle of inadmissibility of corruption and any other manifestations of dishonesty.

*professionals:*

PC02. Ability to collect, interpret and apply data necessary for professional activity, research and implementation of innovative projects in the field of pharmacy.

PC03. Ability to solve pharmacy problems in new or unfamiliar environments in the presence of incomplete or limited information, taking into account aspects of social and ethical responsibility.

PC04. Ability to clearly and unambiguously convey one's own knowledge, conclusions and arguments in the field of pharmacy to specialists and non-specialists, in particular to people who are studying.

**Purpose:** to form the systematized foundations of scientific knowledge regarding the classes of carboxylic acids, its functional derivatives (halogen anhydrides, anhydrides, esters, amides, nitriles); to provide an approximate basis for further assimilation of educational material in practical classes.

**Lecture equipment:** laptop, multimedia projector, blackboard.

**Tasks of the lecture:**

*the student should know*

- Oxygen containing organic compounds with –COOH functional group;
- aliphatic carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties;
- aromatic carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties;
- halogen anhydrides of carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties;
- anhydrides of carboxylic acids: structure, nomenclature, methods of synthesis,

- chemical and biological properties;
- esters of carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties;
  - amides of carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties;
  - nitriles of carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties.

### Plan of the Lecture

The name the stage of the lecture	Content of the stages	Educational goal of the stage	Time
Introduction	Announcement of the topic of the lecture, plan of the lecture, definition of the purpose of the lecture, a description of the problems proposed to be considered during the lecture, a brief description of the literature.	Activation of the previously acquired scientific knowledge of students from other disciplines and laying the scientific basis for assimilating the lecture material.	10 min
Main part	<p>1. Characteristic of classes of Oxygen containing organic compounds with carboxy-functional groups: Aliphatic carboxylic acids and its functional derivatives (halogen anhydrides, anhydrides, esters, amides, nitriles): structure, nomenclature, methods of synthesis, chemical and biological properties to reveal the structure, nomenclature, methods of synthesis, chemical properties.</p> <p>2. Aromatic carboxylic acids and its functional derivatives (halogen anhydrides, anhydrides, esters, amides, nitriles): structure, nomenclature, methods of synthesis, chemical and biological properties to reveal the structure, nomenclature, methods of synthesis, chemical properties.</p> <p>3. Biological active carboxylic acids, its use in medicine and pharmacy: to reveal the biological properties.</p>	<p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical properties of aliphatic carboxylic acids and their functional derivatives.</p> <p>To acquire knowledge about the structure, nomenclature, methods of synthesis, chemical properties of aromatic carboxylic acids and their functional derivatives.</p> <p>To acquire knowledge about biological properties of carboxylic acids.</p>	65 min
Final part	Generalization in short formulations of the main ideas of the lecture, logically concluding it as a completed work; direction of further independent work for students; laying the scientific basis for the following lectures.	Learning the actual material of the lecture, the main theoretical provisions with the help of logical nodes - the key questions of the lecture.	15 min

## Recommended literature:

### Basic

1. Organic chemistry. Multiple choice questions with explanations for pharmacy faculty students / Nizhenkovska I.V., Kustovska A.D., Holovchenko O.I. – K.: Lopatina, 2022. – 205 p., p. 149-163. [http://ek.librarynmu.com/cgi-bin/irbis64r\\_plus/cgiirbis\\_64\\_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU\\_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5](http://ek.librarynmu.com/cgi-bin/irbis64r_plus/cgiirbis_64_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU_FULTEXT&P21DBN=NMU&Z21ID=&S21CNR=5)

### Auxiliary

1. CHAPTER 5: Carboxylic Acids, Carbonic Acid and Derivatives. DOI: <https://doi.org/10.1039/9781837670888-00274>. Published: 15 Jun 2022. Special Collection: [RSC eTextbook Collection](#). Product Type: [Textbooks](#). Page range: 274 – 313.
2. Smith, Brian. "[The C=O Bond, Part VIII: Review](#)". *Spectroscopy*. Retrieved 12 February 2024.

### Information resources

1. European Pharmacopoeia- [pheur.edqm.eu](http://pheur.edqm.eu)
2. The British Pharmacopoeia 2021 - [www.pharmacopoeia.com](http://www.pharmacopoeia.com)
3. The British Pharmacopoeia 2020. London.2020: I-1298. [www.webofpharma.com](http://www.webofpharma.com)
4. Pharmacopoeia USP. [www.usp.org](http://www.usp.org).
5. Website of the Department of Medicinal Chemistry and Toxicology of Bogomolets NMU  
<http://nmu.ua/zagalni-vidomosti/kafedri/kafedra-farmatsevticheskoy-byologicheskoy-y-toksykologicheskoy-hymyy/>
6. Distance learning platform LIKAR\_NMU  
<https://likar.nmu.kiev.ua/mc/index.php/usr/login/login>
7. Official website of the Ministry of Health of Ukraine <https://moz.gov.ua/>
8. Journal of Medicinal Chemistry ([J. Med. Chem.](#))
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12. Journal of Chemical Information and Modeling ([J. Chem. Inf. Model.](#))
13. [QSAR Research Unit](#) of the [University of Insubria](#)

### Questions for student self-preparation for the lecture:

1. Oxygen containing organic compounds with –COOH functional group. Structure of functional group.



2. Aliphatic carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties.
3. Aromatic carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties.
4. Halogen anhydrides of carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties.
5. Anhydrides of carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties.
6. Esters of carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties.
7. Amides of carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties.
8. Nitriles of carboxylic acids: structure, nomenclature, methods of synthesis, chemical and biological properties.

**Questions for preparing for the exam, which reveals the lecture material:**

1. Peculiarities of the chemical structure carboxyl group. Electronic effects in the group. Types of carbonic acids.
2. Peculiarities of the chemical structure and chemical properties of carbonic of aliphatic line.
3. Peculiarities of the chemical structure and chemical properties of carbonic of aromatic line.
4. Peculiarities of the chemical structure and chemical properties of halogen anhydrides of carbonic acids of aliphatic and aromatic lines.
5. Peculiarities of the chemical structure and chemical properties of anhydrides of carbonic acids of aliphatic and aromatic lines.
6. Peculiarities of the chemical structure and chemical properties of salts of carbonic acids of aliphatic and aromatic lines.
7. Peculiarities of the chemical structure and chemical properties of esters of carbonic acids of aliphatic and aromatic lines.
8. The use of representatives of the classes of carboxyl containing compounds in medical and pharmaceutical practices.

**The methodical development was made by:** as. prof., PhD Golovchenko O.I., prof., doctor of pharm. sc. Welchinska O.V., as. prof., PhD Afanasenko O.V.