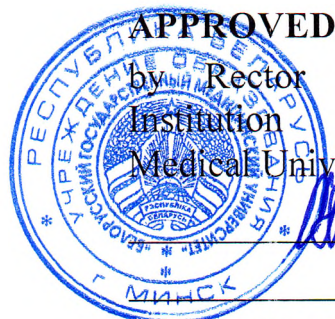
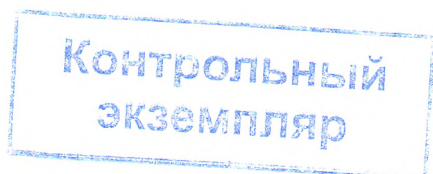


MINISTRY OF HEALTH OF THE REPUBLIC OF BELARUS

Educational Institution

«BELARUSIAN STATE MEDICAL UNIVERSITY»



APPROVED

by Rector of the Educational
Institution «Belarusian State
Medical University»

 S.P. Rubnikov

10.10.2015

Reg. # UD-01-110/2526/elect.

CHROMATOGRAPHIC METHODS OF ANALYSIS

**Curriculum of the elective discipline of the educational institution
for the specialty**

7-07-0912-01 «Pharmacy»

Curriculum is based on the educational plan, approved 15.05.2024, registration # УД 7-07-0912-01/2425/mf.

COMPILERS:

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RECOMMENDED FOR APPROVAL:

by the Department of pharmaceutical chemistry of the Educational Institution «Belarusian State Medical University»
(protocol # 1 of 21.08.2025);

by the Methodological Commission of the educational institution «Belarusian State Medical University»
(protocol # 1 of 10.10.2025)

EXPLANATORY NOTE

«Chromatographic methods of analysis» – the elective discipline, containing systematic scientific knowledge about the physical-chemical basis, apparatus design, practical application in chemistry and pharmacology of chromatographic methods of analysis, as well as knowledge of the possibilities to determine the qualitative and quantitative composition of various objects (e.g. medicinal products, medicinal plant raw materials) by means of chromatography.

The curriculum of the institution of elective discipline «Chromatographic methods of analysis» is aimed at studying the latest scientific data on physical and chemical methods of analysis and methods of investigation of composition of various objects like medicinal products and herbal raw materials.

The purpose of studying the elective discipline «Chromatographic methods of analysis» is to form competencies for obtaining a high level of knowledge, skills for identification and quantification of drugs and other objects using chromatographic methods of analysis.

The tasks of studying the elective discipline are to provide students with scientific knowledge about the physico-chemical phenomena underlying the chromatographic methods of analysis; skills and abilities necessary for the optimal selection of the schedule of chromatographic analysis, conditions of recording the analytical signal, chromatographic system and carrying out identification and quantitative determination of drugs and other objects.

Teaching and successful study of the educational discipline by choice «Chromatographic methods of analysis» is carried out on the basis of acquired knowledge and skills of the student in the sections of the educational disciplines «Chemical module»: «General and inorganic chemistry», «Physical and colloidal chemistry», «Analytical chemistry: Theoretical basis of analysis methods, the design and principle of operation of analytical instruments, metrological processing of analysis results».

As a result of studying the educational discipline by choice «Chromatographic methods of analysis» the student should

know:

- the basic concepts and laws underlying chromatography;
- methods, techniques and ways of performing chromatographic analysis of medicines and other objects;
- chromatographic separation techniques for the mixture of substances;
- the basics of mathematical statistics for the evaluation of results of chromatographic analysis;
- safety rules for work in the chemical laboratory;
- the role and importance of chromatography methods in pharmacy and practical activities of the laboratory-analytic;

be able to:

- perform sample preparation for chromatographic analysis;
- theoretically justify the choice of a specific option of chromatography, chromatographic conditions and chromatographic system;

to choose the most suitable for the analyzed object moving, stationary phase and other chromatographic parameters;

to draw up a chromatographic analysis scheme, to select the optimal conditions for carrying out the chromatographic separation of the mixture of substances, identification of the individual components thereof and their quantitative determination;

to analyze external and internal chromatograms, optimize the chromatographic system based on preliminary experimental data;

process the chromatograms and calculate the chromatographic parameters;

master:

methods of preparation of sorbents for various types of chromatography, preparation of chromatographic systems and columns, preparation of solvents;

skills of performing columnar, paper thin-layer, gas, high-performance liquid chromatography;

methods for the identification and quantification of individual components of complex mixtures.

Total number of hours for the study of the elective discipline is 90 academic hours, of which 39 classroom hours and 51 hours of student independent work. Classroom hours according to the types of studies: lectures - 15 hours (including 3 hours of supervised student independent work (SSIW)), laboratory classes - 24 hours.

Intermediate assessment is carried out according to the syllabus of the specialty in the form of a credit (3 semester).

Form of higher education – full-time.

ALLOCATION OF ACADEMIC TIME ACCORDING TO SEMESTERS OF STUDY

Code, name of the specialty	Semester	Total number of academic hours	Number of classroom hours				Out-of-class self-studies	Form of intermediate assessment
			Number of classroom hours	including				
				class lectures	SSIW	laboratory classes		
7-07-0912-01 «Pharmacy»	3	90	39	12	3	24	51	credit

THEMATIC PLAN

Section (topic) name	Number of class hours	
	lectures (incl. SSIW)	practical (laboratory or seminars)
1. General characteristics and classification chromatographic methods of analysis. Theoretical basis of chromatography	4,5	3
1.1. Chromatography as a method of analysis. History of the development of chromatography. Principle of separation in chromatography	1,5	3
1.2. Terminology used in chromatography. Classification of chromatographic methods		
1.3. Chromatographic parameters	1,5	
1.4. Principle of chromatographic separation. Theory of theoretical plates and kinetic theory. The efficiency and selectivity of chromatographic separation	1,5	
2. Gas chromatography	3	3
2.1. Theoretical basis of the method. Arrangement of gas chromatograph	1,5	3
2.2. Influence of the conditions of the procedure on the parameters of the separation process. Methods of preparation of chromatographic columns. Application of gas chromatography in pharmaceutical analysis	1,5	
3. Liquid chromatography	3	9
3.1. Classification. Theoretical description of the process of separation. Planer chromatography	1,5	3
3.2. Columnar chromatography. High-Performance liquid chromatography	1,5	6
4. Other chromatography	1,5	3
5. Chromamass spectrometry	1,5	3
6. Quantitative determination in chromatography	1,5	3
6.1. Methods of quantitative analysis in chromatography	1,5	3
6.2. Reliability of results and sources of errors in chromatography.		
Total hours	15	24

CONTENT OF THE EDUCATIONAL MATERIAL

1. General characteristics and classification chromatographic methods of analysis. Theoretical basis of chromatography

1.1. Chromatography as a method of analysis. History of the development of chromatography. Principle of separation in chromatography

Content of the material for study.

The concept of chromatography. Main terms: chromatogram, moving phase, stationary phase, eluent, solvent system, carrier gas, sorbent.

Attempts to separate pure organic substances in the XVIII century. Separation of vegetable dyes by M.S.Color - the first classical experiments on chromatography. The first chromatographic columns based on calcium carbonate. Development and practical introduction of chromatography in XX and XXI centuries.

Features of chromatographic methods. Theoretical and practical problems solved by means of chromatographic methods. The place of chromatography among other processes of separation. Examples of chromatographic processes. Objects for chromatographic research. Chromatography as a dynamic process. Multiple acts of distribution and sorption-desorption.

1.2. Terminology used in chromatography. Classification of chromatographic methods

Main terms: chromatogram, carrier gas, sorbent, chromatographic column, retention time, retention volume, corrected retention time, corrected retention volume, K_d sorption, distribution coefficient, dead time, dead volume, retention factor, separation factor, column capacity ratio, separation efficiency expressed as number of theoretical plates, height equivalent to theoretical plate, resolution of chromatographic peaks.

Classification of chromatographic methods by separation mechanism; by purpose of the operation; by aggregate state of phases; by the nature of interactions of separated compounds with the stationary phase; by method of execution; by method of obtaining a chromatogram. Rare types of chromatography.

1.3. Chromatographic parameters

Retention and separation parameters in chromatography. Internal and external chromatograms. Time and volume of component retention. Dead time and volume. Corrected holding time and volume of the component Hold factor. Width of chromatographic peak at base. Width of peak at half height. Peak height. Peak area. Standard deviation and width of the peak. Peak widening. Column efficiency and width of the peak. Calculation of chromatographic peak resolution.

1.4. Principle of chromatographic separation. Theory of theoretical plates and kinetic theory. The efficiency and selectivity of chromatographic separation

Separation mechanisms (adsorption, distribution, ion exchange, selective bonding, spatial effects, etc.). Physical and chemical adsorption. Theory of adsorption, its quantitative characteristic. Distribution of substances between two liquid phases, between liquid and gaseous phase, between liquid and solid phases. Nernst coefficient. Phase ratio. Equilibrium of steam-liquid.

Plate theory: multiple acts of distribution between two phases. The factor of separation (selectivity). Number of theoretical plates (efficiency). Resolution of chromatographic peaks. Influence of the parameters of the chromatographic column on the appearance of the obtained chromatogram.

Cause of the widening of chromatographic peaks (kinetic theory). Van-Deemeter equation. Finding the optimal velocity of a moving phase.

Influence of various factors on the efficiency of the chromatographic column (temperature, shape and size of sorbent, longitudinal diffusion, concentration of substances in the sample, thickness of the stationary phase, length of the chromatographic column, size of the molecule of the substance under analysis, etc.).

2. Gas chromatography

2.1. Theoretical basis of the method. Arrangement of gas chromatograph

Concept of gas chromatography. Advantages and disadvantages of the method. Gas-adsorption chromatography. Gas-liquid chromatography.

The physical phenomena underlying the gas chromatography method. Van der Waals forces and intermolecular interactions in gas chromatography. Requirements and classification of sorbents for gas chromatography. Requirements and classification of sorbent carriers. Classification and main properties of gas chromatographic columns. Requirements and types of moving phases in gas chromatography.

Basic diagram of the gas chromatograph. System of preparation of gas. Injector and features of sample insertion. Types of chromatographic columns. Detectors used in gas chromatography (heat conductivity detector, flame ionisation detector, electron capture detector, ionisation resonance detector, thermion detector, etc.).

2.2. Influence of the conditions of the procedure on the parameters of the separation process. Methods of preparation of chromatographic columns. Application of gas chromatography in pharmaceutical analysis

Henry's law. Raoul's law. Herrington's ratio. Necessary conditions for the gas chromatographic separation.

Influence of the chromatographic column parameters on the separation in gas chromatography (type, temperature, internal diameter, length, thickness of film of column, etc.). Preparation of the distillation columns. Production of capillary columns. Columns with chemically bound fixed liquid phases. Influence of polarity of the stationary phase on the elution sequence.

Rationale for the carrier gas selection. Speed of the carrier gas.

Requirements for substances determined by gas chromatography.

Theoretical and experimental selection of chromatographic parameters for the separation of substances. Evaluation of the influence of chromatographic conditions on retention and separation. Identification of drugs by gas chromatography. Kovac retention index. Quantification of drugs. Identification of impurities by gas chromatography.

3. Liquid chromatography

3.1. Classification. Theoretical description of the process of separation.

Planer chromatography

Concept of liquid chromatography. Classification of liquid chromatography methods.

Flat (planar) chromatography: paper, thin-layer. Advantages and disadvantages of flat chromatography. Physical-chemical basis of the method.

The concept of thin layer chromatography (TSH). Principle of the method. Substrates, fixed and mobile phases (solvent systems) in TSH. Plates for pCH. The Stalya Triangle. Steps of obtaining a chromatogram. Ways to obtain a chromatogram.

Two-dimensional TSH. Highly effective TSH. Methods of detection of chromatographic zones, the developers. Application in pharmaceutical analysis. Densitometric and video-sensitometric determination of substances under DCS conditions.

The concept of paper chromatography. Classification by method of obtaining a chromatogram. Mobile and stationary phases in paper chromatography. Application in pharmaceutical analysis.

3.2. Columnar chromatography. High-Performance liquid chromatography

The concept of columnar chromatography. Classification of columnar chromatography methods. Normal-phase and inverted-phase chromatography. Preparative column chromatography.

Separation parameters. Efficiency, selectivity and resolution of the chromatographic column. Sorbents in liquid adsorption chromatography. Requirements for mobile phases. Eluatotropic series. The chromatographic properties of the separated compounds (polarity and hydrophobicity, solubility in eluent, ability to intermolecular interactions, etc.). The concept of a chromatophical system.

Theoretical basis and features of the method of high-performance liquid chromatography (HPLC). Principle scheme of liquid chromatograph. Mobile phase supply unit. Features of sample preparation and sample input. Autosampler. Features of chromatographic columns. Principles of sorbent selection in HEVC. Preparation of mobile phases. Optimization of the chromatographic separation process (regulation of the flow speed of the mobile phase, temperature of the sample and column, quantity of the sample, etc.). Retention models in WEEE. Detectors (spectroscopic, electrochemical detectors, heat sorption detector, transport type detectors and others). Theoretical and experimental selection of chromatographic parameters for the separation of substances. Evaluation of the influence of chromatographic conditions on retention and separation rates. Application in pharmaceutical analysis.

4. Other chromatography

Ion-exchange, ion and ion-pair chromatography. Concept, properties and classification of ion-exchangers (ionites). Similarity of ions to ionite. Ion exchange equilibrium. Mobile phases. Selectivity coefficient. Fundamental scheme of ion chromatograph. Application in pharmaceutical analysis. Electrophoresis, capillary electrophoresis.

Supercritical fluoridated chromatography. Distributive (liquid-liquid chromatography). Affine chromatography.

Exclusive chromatography. Separation mechanism. Carriers, moveable and moveable phases.

5. Chromamass spectrometry

General characteristics of hybrid analysis methods. Basic laws and application areas of mass spectrometry. Principle diagram of the mass spectrometer. Modern laboratory chromato-mass spectrometers. Main components: ion source, lens system, mass filters, detector. Sample input. Methods of ionization. Dependence of the type of spectrum on the energy of ionization. Pumps for creating a vacuum. Types of mass analyzers and their working principles. Quadrupole mass analyzer. Magnetic sector

mass analyzer. Time-running mass analyzer. Enrichment devices (separators). Options of chromato-mass spectrometry. Combination of gas and liquid chromatography with mass spectrometry. Options of interface. The steps of the Chromato-mass analysis. Applications in pharmaceutical analysis.

6. Quantitative determination in chromatography

6.1. Methods of quantitative analysis in chromatography

Methods of quantitative processing of chromatograms. Parameters of the chromatographic peak as a characteristic of the quantitative content of the substance. Baseline. Noise and drift of baseline. Signal to noise ratio as key analytical signal. Detection limit and determination limit. Methods of quantitative determination of substances. Method of calibration graph, statistical information on the nature of the regression line. Additive method, normalization method (internal normalization), internal and external standard.

6.2. Reliability of results and sources of errors in chromatography

Reliability of results in chromatography. Sources of error. Reproducibility of results of the method. Features of quantitative analysis in liquid and gas chromatography.

Variation and adjustment of chromatographic conditions with the aim of optimizing retention and separation parameters, increasing identification reliability and quantitative determination.

ELECTIVE DISCIPLINE CURRICULAR CHART

Section, topic #	Section (topic) name	Number of hours		Supervised student work	Literature	Student independent work	Form of control
		lectures	laboratory				
	3 semester						
	Lectures						
1.	Chromatography as a method of analysis. History of the development of chromatography. Principle of separation in chromatography Terminology used in chromatography. Classification of chromatographic methods	1,5	-	-		6	
2.	Chromatographic parameters	1,5	-	-		3	
3.	Principle of chromatographic separation. Theory of theoretical plates and kinetic theory. The efficiency and selectivity of chromatographic separation	-	-	1,5		3	tests
4.	Gas chromatography. Method variants. Theoretical basis of the method. Arrangement of a gas chromatograph	1,5	-			5	
5.	The influence of the conditions of the process on the parameters of the separation. Methods of preparation of chromatographic columns. Application of gas chromatography in	-	-	1,5		5	tests

	pharmaceutical analysis								
6.	Liquid chromatography. Classification. Theoretical description of the separation process. Planer chromatography	1,5	-	-			6		
7.	Column chromatography. High-performance liquid chromatography	1,5	-	-			6		
8.	Other types of chromatography	1,5	-	-			5		
9.	Chromamass spectrometry	1,5	-	-			-		
10.	Quantitative chromatographic analysis	1,5	-	-			3		
	Laboratory lessons								
1.	General characteristics and classification of chromatographic methods of analysis. Theoretical basis of chromatography L.R. Plant pigments separation by column chromatography	-	3	-	1-5		1		Interview; Lab report; Electronic tests
2.	Gas chromatography. L.R. Identification, quantification and evaluation of substance separation in gas chromatogram processing	-	3	-	1-5		1		Interview; situation problem solving; electronic tests
3.	Liquid chromatography. Classification. Theoretical description of the separation process. Flat-bed chromatography L.R. Detection of biologically active substances by thin layer chromatography	-	3	-	1-5		1		Interview; Lab report; Electronic tests
4.	Column chromatography L.R. Preparation of mobile phases and sample preparation for drug analysis by HPLC	-	3	-	1-5		1		Interview; Lab report; Electronic tests
5.	High performance liquid chromatography L.R. Analysis of biologically active substances by HPLC	-	4	-	1-5		1		Interview; Lab report; Electronic tests
6.	Other chromatography	-	4	-	1-5		1		Interview; situation

	L.R. Determination of substances using ion exchange chromatography							problem solving; electronic tests
7.	Chromatographic mass spectrometry. Quantitative chromatographic analysis L.R. Chromatographic determination of the quantitative composition of a composite mixture. Calculation of results of chromatographic determination of substances	-	4	-	1-5	3		Interview; situation problem solving; credit
	Total	12	24	3		51		

INFORMATION AND INSTRUCTIONAL UNIT

LITERATURE

Basic (relevant):

1. Analytical chemistry : textbook [the textbook for students of higher schools] / I. S. Grytsenko ; ed. by I. S. Grytsenko. - Kharkiv : NUPh : Golden Pages, 2019. - 600 p. - P. 591-592.

Additional:

2. Kharitonov, Y. Y. Analytical chemistry. Analytics 1. General theoretical foundations. Qualitative analysis : textbook / Y. Y. Kharitonov ; ed. V. Yu. Grigorieva. – Moscow : Geotar-Media, 2021. – 602 p.

3. Kharitono, Y. Y. Analytical chemistry. Analytics 2. Quantitative analysis. Physical-chemical (instrumental). Analysis methods / Y. Y. Kharitonov ; ed. V. Yu. Grigorieva. – Moscow : Geotar-Media, 2021. – 587 p.

LIST OF AVAILABLE DIAGNOSTIC TOOLS

The following forms are used for competence assessment:

interview

situational tasks;

tests;

control work;

case-based assessment;

account of laboratory work;

electronic tests.

LIST OF AVAILABLE TEACHING METHODS

Traditional method;

active (interactive) methods:

training based on simulation technologies;

Problem-Based Learning (PBL);

Team-Based Learning (TBL);

Case-Based Learning (CBL);

Research-Based Learning (RBL).

LIST OF PRACTICAL SKILLS

Name of practical skills	Form of practical skills control
Separation of mixtures by column chromatography	Laboratory report
Identification, quantification and evaluation of substance separation in gas chromatogram processing using chromatographic retention and separation parameters	Decision situational tasks
Detection of biologically active substances by TCL	Laboratory report
Preparation of mobile phases for drug analysis by HPLC	Laboratory report
Conducting sample preparation for drug analysis by HPLC	Laboratory report
Performing HPLC analysis of biologically active substances	Laboratory report
Chromatographic determination of the quantitative composition of a composite mixture	Decision situational tasks
Determination of substances by ion exchange chromatography	Decision situational tasks
Calculation of chromatographic results for the determination of substances	Decision situational tasks

COMPILERS/AUTHORS:

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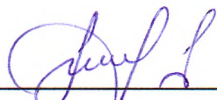
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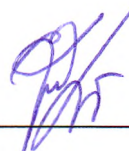
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V.A. Tsiarletskaia

Curriculum content, composition and the accompanying documents comply with the established requirements.

Head of the Office of Educational Activities of the educational institution «Belarusian State Medical University»

10.10.2025



I.L. Kotovich

Methodologist of the Educational and Methodological department of the Office of Educational Activities of the educational institution «Belarusian State Medical University»

10.10.2025



N.A. Kukushinova