

## CHEMISTRY IN MACEDONIA

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An overview of the current conditions and trends in the research and education in the fields of chemistry, chemical engineering and chemical industry in Macedonia is presented. An outline of the general and specialized chemical education within the Macedonian educational system is given. The research activities in connection with the fundamental chemical disciplines are mainly performed at the Institute of Chemistry of the Faculty of Natural Sciences and Mathematics, and those concerning the applied chemistry branches are a subject of interest at the Faculty of Technology and Metallurgy. The principal components of the chemical industry in Macedonia are the organic polymer basic and processing industry and the metallurgy. In the sense of the pro-European orientation and in order to keep step with the international standards, considerable attention is devoted lately to the assessment of the pollution and protection of the environment. As a consequence of the rather complex geological structure of the Republic of Macedonia a large number of ore deposits is present in this district. Being a land with rich past and a crossroad of innumerable civilizations, there is also an interest in projects from the archeological chemistry domain.

**Key words:** Macedonia; chemistry; education; research; industry; ecology; minerals; archeology

### CHEMICAL EDUCATION

Being a principal source of scholars for undergraduate and university level educational profiles as well as for industry employees, the chemical education has played a central role in the overall evolution of the education in the field of natural sciences in Macedonia.

In succession of certain elements of knowledge about all natural sciences within the first four years, specialized chemistry courses are introduced in the 7th and 8th grade of the eight-year compulsory elementary school for all children in Macedonia [1, 2]. At present, chemistry is a compulsory subject in the first two years in almost all secondary schools. The presence of chemistry courses in the curricula of the remaining one or two years of the secondary schools depends on the particular type of school. It is worth mentioning here that the complete elementary and secondary school education in the respective mother language is provided for all children of the minorities in Macedonia.

The Republic of Macedonia has a fifty-five years old tradition in chemical education at aca-

demical level. Chemistry teaching in Macedonian mother language started at the Department of Natural Sciences and Mathematics (Chair of Chemistry), a part of the first established institution of higher education in Macedonia – the Faculty of Philosophy, in 1946 [3, 4]. In 1958 the Department of Natural Sciences and Mathematics was set apart from the Faculty of Philosophy and grew into the Faculty of Natural Sciences and Mathematics, consisting of five institutes for: mathematics, physics, chemistry, biology and geography. In 1976 the institutes grew into five corresponding faculties, whereas in 1985 the Faculty of Natural Sciences and Mathematics was again established and enriched with foundation of the Institute of Computer Science and the Seismological Observatory (in 1987).

A list of the leaders of the Chair of Chemistry, the Institute of Chemistry or the Faculty of Chemistry from 1946 to 2001 is given in Table 1 [4].

Table 1

*Leaders of the Chair of Chemistry,  
Institute of Chemistry or the Faculty of Chemistry  
from 1946 to 2001*

Faculty of Philosophy (1946 – 1958) Department of Natural Sciences and Mathematics Chair of Chemistry	
Head	Tenure
Dimče Tošev	1946 – 1951
Gilbert Flumiani	1951 – 1958
Faculty of Natural Sciences and Mathematics (1958 – 1976) Institute of Chemistry	
Head	Tenure
Gilbert Flumiani	1958 – 1964
Dimče Tošev	1964 – 1976
Faculty of Chemistry (1976 – 1985)	
Dean	Tenure
Dimče Tošev	1976 – 1979
Ivan Petrov	1979 – 1983
Dimče Tošev	1983 – 1985
Faculty of Natural Sciences and Mathematics (1985 – 2001) Institute of Chemistry	
Head	Tenure
Ivan Petrov	1985 – 1987
Gligor Jovanovski	1987 – 1989
Blagoja Topuzovski	1989 – 1991
Bogdan Bogdanov	1991 – 1995
Trajče Stafilov	1995 – 1999
Kiro Stojanoski	1999 – 2001
Orhideja Grupče	2001 –

At present the Institute of Chemistry at the Faculty of Natural Sciences and Mathematics offers both Undergraduate and Graduate programs [3, 5]. The Undergraduate programs encompass majoring in chemical education or in chemical engineering. Upon completion of these programs the students are awarded either a BEd degree and are trained to teach in high school (chemical education major), or a BSc diploma (chemical engineering majors) being trained to work in the control laboratories of the chemical industry capacities, medicine, pharmaceutical industry, mining, metallurgy, food industry, textile industry, leather industry, departments for health protection, etc. Both are four-year studies and last for eight semesters, having around thirty credit hours per week. The first two years of the study comprise common courses for all majors [3].

## Faculty of Natural Sciences and Mathematics Institute of Chemistry

### Undergraduate program

Educational and Engineering Chemistry		
Course	Semester	
	I	II
<b>First Year</b>		
1. Fundamentals of Inorganic Chemistry	4+6	–
2. Chemistry of s and p Elements	–	4+6
3. Mathematics I	4+3	–
4. Mathematics II	–	4+3
5. Physics I	3+4	–
6. Physics II	–	3+4
7. Defense	2+1	2+1
8. Foreign Language	0+2	0+2
9. Physical Education	(0+2)	(0+2)
	Total hours/week:	13+16 13+16
<b>Second Year</b>		
		III IV
1. Analytical Chemistry	3+9	3+7
2. Organic Chemistry I	3+9	–
3. Organic Chemistry II	–	3+6*
4. Introduction to Computers	2+2	–
5. Mathematical Methods in Chemistry	–	2+2
6. Physical Chemistry I	–	3+6*
7. Psychology**	2+0	2+0
	Total hours/week:	8+20 11+21
	Educ. Chem.:	10+20 13+19
* 3+5 (for Educational Chemistry)		
** Only for Educational Chemistry		

### Educational Chemistry

Course	Semester	
	V	VI
<b>Third Year</b>		
1. Physical Chemistry II	3+5	–
2. Topics in Physical Chemistry	–	3+3
3. Topics in Analytical Chemistry	2+4	2+4
4. Topics in Inorganic Chemistry	2+4	2+3
5. Pedagogy	2+0	2+0
6. Computers in Chemistry	2+2	–
7. Fundamentals of Chemical Technology	3+0	3+0
8. History of Chemistry	–	2+0
9. Philosophy of Science	2+1	2+1
	Total hours/week:	16+16 16+11
<b>Fourth Year</b>		
		VII VIII
1. Biochemistry	3+2	3+2
2. Structure of Molecules	3+4	–
3. Chemistry and the Environment	2+3	–

4. Topics in Organic Chemistry	2+3	2+3
5. Methodology of Chemistry Teaching	3+2	3+2
6. School Experiments in Chemistry	2+2	2+2
7. Macedonian	0+2	0+2
8. Use of Chemical Literature	–	1+2
– Diploma Thesis	–	0+6
Total hours/week:	15+18	11+19

#### Analytical and Structural Engineering Chemistry

Third Year	V	VI
1. Physical Chemistry II	3+5	–
2. Structure of Atoms and Chemical Bonding	–	3+3
3. Instrumental Analysis	2+4	2+4
4. Theoretical Organic Chemistry	2+3	2+3
5. Chemistry of Transition Elements	2+1	–
6. Computers in Chemistry	2+2	–
7. Industrial Chemistry	3+0	3+0
8. Topics in Electrochemistry	–	2+2
9. Philosophy of Science	2+1	2+1
10. Source and Use of Chemical Information	–	1+2
Total hours/week:	16+16	15+15

Forth Year	VII	VIII
1. Biochemistry	3+3	3+3
2. Structure of Molecules	3+4	–
3. Methods for Elucidation of Molecular Structures	–	2+2
4. Selected Topics in Instrumental Analysis	2+3	–
5. Radiochemistry	2+2	–
6. Crystal Chemistry	–	2+2
7. Chemistry and Environment	2+5	–
8. Chemical Analysis of Complex Materials	–	2+6
– Diploma Thesis	–	0+6
Total hours/week:	12+17	9+19

#### Preparative Engineering Chemistry

Third Year	V	VI
1. Physical Chemistry II	3+5	–
2. Structure of Atoms and Chemical Bonding	–	3+3
3. Instrumental Analysis	2+4	2+4
4. Theoretical Organic Chemistry	2+3	2+3
5. Chemistry of Transition Elements	2+1	–
6. Computers in Chemistry	2+2	–
7. Industrial Chemistry	3+0	3+0
8. Preparative Inorganic Chemistry	–	2+2
9. Philosophy of Science	2+1	2+1
10. Source and Use of Chemical Information	–	1+2
Total hours/week:	16+16	15+15

Forth Year	VII	VIII
1. Biochemistry	3+3	3+3
2. Synthesis and Analysis in Organic Chemistry	–	3+5
3. Structure of Molecules	3+4	–
4. Methods for Elucidation of Molecular Structures	–	2+2
5. Chemistry of Heterocyclic Compounds	2+2	–
6. Chemistry of Natural Products	–	2+2
7. Chemistry of Complexes	2+3	–
8. Radiochemistry	2+2	–
9. Chemistry and the Environment	2+3	–
– Diploma Thesis	–	0+6
Total hours/week:	16+16	15+15

#### Analytical Biochemistry

First Year	I	II
1. General and Inorganic Chemistry I	4+4	–
2. General and Inorganic Chemistry II	–	3+3
3. General Biology	4+2	2+2
4. Mathematics	4+4	4+3
5. Physics	–	4+4
6. Defense	2+1	2+1
7. Foreign Language	0+2	0+2
8. Physical Education	(0+2)	(0+2)
Total hours/week:	14+13	15+15

  

Second Year	III	IV
1. Physical Chemistry I	3+3	–
2. Physical Chemistry II	–	3+3
3. Analytical Chemistry I	4+6	–
4. Analytical Chemistry II	–	2+6
5. Organic Chemistry	4+6	4+4
6. Chemistry of Natural Products	–	4+4
7. Computers in Biochemistry	2+2	–
Total hours/week:	13+17	13+17

Third Year	V	VI
1. Biochemistry I	4+4	–
2. Biochemistry II	–	3+3
3. General Physiology	3+3	3+3
4. Instrumental Analytical Methods	2+4	2+4
5. Chemical Microbiology	3+3	–
6. Fundamentals of Molecular Biology	–	3+2
7. Theoretical Organic Chemistry	–	2+2
8. Philosophy of Science	2+1	2+1
Total hours/week:	14+15	15+15

Fourth Year	VII	VIII
1. Medicinal Biochemistry	4+3	–
2. Biochemistry III	4+4	–
3. Fundamentals of Biotechnology	2+2	–

4. Molecular Genetics	2+3	–
5. Application of Computers in Biochemistry and Molecular Modeling	2+1	–
6. Immunochemistry and Fundamentals of Immunology	2+1	–
8. Drugs Metabolism	–	2+2
9. Experimental Biochemistry	–	2+4
10. Clinical Biochemistry	–	2+2
11. Elective Course I	–	2+1
12. Elective Course II	–	2+1
– Diploma Thesis	–	0+8
Total hours/week:	16+14	10+18

### List of Elective Courses

(One topic from each group should be elected)

#### Group I

1. Clinical and Biochemical Laboratory Methods
2. Toxicological Chemistry
3. Food Biochemistry
4. Macromolecules
5. Enzimology

#### Group II

6. Environmental Biochemistry
7. Inorganic Biochemistry
8. Biochemistry of Industrial Processes
9. Biochemical Engineering

In addition to these, ever since 1995 the Faculty offers a four-year combined undergraduate program in biology-chemistry organized by the Institutes of Chemistry and Biology [3, 6]. Upon completion of the program students are awarded a BEd degree (trained as teachers at elementary level). Starting with the first graduated student in 1999, 23 students have graduated at this type of studies until now. The list of the courses is given below.

## Faculty of Natural Sciences and Mathematics Institute of Chemistry + Institute of Biology

### Undergraduate program

#### Double Major in Biology and Chemistry

Course	Semester	
	I	II
First Year		
1. Inorganic Chemistry with Fundamentals of Inorganic Technology	3+3	3+3
2. General Botany	2+2	2+2
3. General Zoology	2+2	2+2
4. Mathematics with Computer Science	2+2	4+4

5. Physics	3+2	–
6. Civil Defense	2+0	2+0
7. Physical Education	0+2	0+2
8. Foreign Language	0+2	0+2
Total hours/week:	14+15	13+15

#### Second Year

	III	IV
1. Organic Chemistry with Fundamentals of Organic Technology	3+3	3+3
2. Analytical Chemistry	3+3	3+3
3. Human Anatomy and Physiology	3+3	2+2
4. Systematics of Animals	3+3	3+3
5. Psychology	2+0	2+0
6. Applied Informatics	1+2	–
7. Microbiology	–	2+2
Total hours/week:	15+14	15+13

#### Third Year

	V	VI
1. Fundamentals of Physical Chemistry	3+3	3+3
2. Biochemistry	2+2	2+2
3. History of Chemistry	2+0	–
4. General Genetics (or Molecular Biology)	2+0	–
5. Physiology of Plants	2+2	2+2
6. Systematics of Plants	3+3	3+3
7. Pedagogy	3+0	3+0
8. Didactics	–	3+0
Total hours/week:	17+10	16+10

#### Fourth Year

	VII	VIII
1. Methodology in Teaching Chemistry with Practice in Elementary Education	3+2+2	3+2+3
2. Methodology in Teaching Biology with Practice in Elementary Education	3+2+2	3+2+3
3. Chemistry and Environment	2+2	2+2
4. Ecology and Protection of the Living Environment	3+3	3+3
5. Fundamentals of Organic Evolution	2+0	–
6. Philosophy of Natural Sciences	2+0	2+0
7. Macedonian Language	0+2	0+2
– Seminar	0+2	–
– Diploma Thesis	–	0+2
Total hours/week:	15+13+4	13+13+6

The Graduate program at the Institute of Chemistry consists of two-level studies leading to M.Sc. or Ph.D. degrees in chemistry. The Master's degree program takes two years (four semesters) and is being consisted of both compulsory and elective courses. A list of the compulsory and elective courses is given below [5].

**Faculty of Natural Sciences and Mathematics****Institute of Chemistry**

## Graduate program

**Compulsory Courses**

- Computers in Chemistry
- Methodology of Research

**Elective Courses**

- Trace Analysis
- Topics in Biochemistry
- Chemical Applications of Group Theory
- Chemical Aspects of Environment Protection
- Chemistry and Physics of Polymers
- Chemistry of Heterocyclic Compounds and Natural Products
- Chromatography
- Coordination Chemistry
- Methods for Investigation of Crystal Substances
- Methods in Molecular Spectroscopy
- Contemporary Electroanalytical Methods
- New Syntheses in Organic Chemistry
- Organic Stereochemistry
- Quantum Mechanics for Chemists
- Topics in Inorganic Chemistry
- Topics in Theoretical Organic Chemistry
- Solid State Physics
- Spectroscopic and Radiochemical Methods of Analysis

It is interesting to mention that the Institutes within the Faculty as well as the Faculties within the University are exchanging their services. In this sense, the Institute of Chemistry participates in the educational programs of the students from the Institute of Physics and the Institute of Biology and in addition organizes courses for several other faculties at the "Sv. Kiril i Metodij" University in Skopje which include chemical disciplines in their curricula (Faculty of Medicine, Faculty of Pharmacy, Dental Faculty, Interdisciplinary Studies on Environmental Engineering, Faculty of Mining and Geology, Faculty of Agriculture, Veterinary Faculty, Faculty of Forestry) [4]. At present, the Institute of Chemistry has a faculty staff of 40 professors and associates. 1861 chemistry students from the undergraduate program have graduated at the Faculty of Natural Sciences and Mathematics from 1946 till the present days. Additional 75 and 44 students from the graduate program have reached their M.Sc. and Ph.D. degree in chemistry, respectively [4].

**Faculty of Natural Sciences and Mathematics****Institute of Chemistry**

## Faculty and Staff

**Division of Inorganic Chemistry**

Grozdanov Dr. Ivan, Professor

*Research:* Preparation of Thin Semiconductor Films of Inorganic Materials and Study of Their Physical and Chemical Properties

*Teaching:* Fundamentals of General and Inorganic Chemistry

Jordanovska Dr. Vera, Professor

*Research:* Synthesis and Identification of Complex Compounds of Two- and Three-Valent Elements

*Teaching:* General Chemistry

Jordanovski Dr. Blagoja, Professor

*Research:* Electroanalytical Studies of Organic Compounds

*Teaching:* General Chemistry

Zdravkovski Dr. Zoran, Professor

*Research:* Reagents on Polymer Carriers, Theoretical Organic Chemistry

*Teaching:* Medicinal Chemistry, Computers in Chemistry

Genčova Dr. Olga, Associate Professor

*Research:* Electroanalytical Methods, Thermal Analysis

*Teaching:* General Chemistry

Ristova Dr. Mirjana, Associate Professor

*Research:* Structural Chemistry

*Teaching:* Chemistry of Transition Elements, Chemistry of Complexes, Preparative Inorganic Chemistry

Anastasova Dr. Frosa, Assistant Professor

*Research:* Synthesis of Heterocyclic Organic Compounds with Pronounced Cytostatic Activity

*Teaching:* General Chemistry

Čundeва Dr. Katarina, Assistant Professor

*Research:* Trace Elements Analysis in Waters

*Teaching:* General Chemistry

Mirčeski Dr. Valentin, Assistant

Najdoski Dr. Metodija, Assistant

Stojković Goran, M.Sc., Assistant

Naumov Panče, Assistant

Pejova Biljana, Assistant

**Division of Organic Chemistry**

Bogdanov Dr. Bogdan, Professor

*Research:* QSAR Studies, Drug Analysis

*Teaching:* Theoretical Organic Chemistry

Stojanoski Dr. Kiro, Professor

*Research:* Molecular Spectroscopy of Organic, Inorganic and Bioinorganic Compounds

*Teaching:* Fundamentals of Organic Chemistry, Biochemistry

Janev Dr. Ivan, Associate Professor

*Research:* Synthesis of Polyketones

*Teaching:* Organic Synthesis and Analysis

Jovevska Dr. Liljana, Associate Professor

*Research:* Amides and Thioamides-Synthesis and Properties

*Teaching:* Chemistry of Heterocyclic Compounds and Natural Products

Gočeva Nataša, M.Sc., Assistant

Popovski Emil, M.Sc., Assistant

Stojanov Risto, M.Sc., Assistant

**Division of Analytical Chemistry**

Petrovska-Jovanović Dr. Simka, Professor

*Research:* Application of the Analytical Methods for the Determination of Metal Ions in Water

*Teaching:* Fundamentals of Analytical Chemistry

Spirevska Dr. Ilinka, Professor

*Research:* Application of the Analytical Chemistry in Environmental Protection, Analytical Chemistry of Complex Compounds

*Teaching:* Chemistry and the Environment

Šoptrajanova Dr. Lidija, Professor

*Research:* Examination of Complex Compounds with Spectroscopic Methods (UV and IR)

*Teaching:* Instrumental Methods in Analytical Chemistry

Donova Dr. Ilinka, Associate Professor

*Research:* Inorganic Synthesis, Thermal Analysis

*Teaching:* History of Chemistry, General and Inorganic Chemistry

Georgieva Dr. Marija, Associate Professor

*Research:* Electroanalytical Methods – Stripping Voltametry

*Teaching:* Fundamentals of the Technology

Grupče Dr. Orhideja, Associate Professor

*Research:* Structural Chemistry

*Teaching:* Analytical Chemistry

Trpkovska Dr. Mira, Associate Professor

*Research:* Synthesis and Investigation of the IR Spectra of Aquacomplexes and Systems Containing Tetrahedral Anions

*Teaching:* Selected Topics in Analytical Chemistry and Instrumental Analysis

Andonovski Dr. Blagoja, Assistant

Stefova Dr. Marina, Assistant

Trajkovska Vera, M.Sc., Assistant

Kuzmanovski Igor, Assistant

**Division of Physical Chemistry**

Jovanovski Dr. Gligor, Professor

*Research:* X-ray Crystal Structure Determination, Vibrational Spectroscopy

*Teaching:* Structure of Atoms and Chemical Bonding, Structure of Molecules, Crystal Chemistry

Minčeva-Šukarova Dr. Biljana, Professor

*Research:* Vibrational Spectra of Ice Phases and Clathrates

*Teaching:* Physical Chemistry

Petruševski Dr. Vladimir, Professor

*Research:* Vibrational Spectra of Doped Crystals, Distortions of Small Molecules

*Teaching:* Radiochemistry, Spectroscopic Methods as a tool in Structure Elucidation

Stafilov Dr. Trajče, Professor

*Research:* Atomic Absorption Analysis of Metal Traces

*Teaching:* Industrial Chemistry

Šoptrajanov Dr. Bojan, Professor

*Research:* Molecular Spectroscopy and Structural Chemistry of Crystallohydrates and Other Hydrogen Bonded Systems

*Teaching:* Physical Chemistry

Andreeva Dr. Liljana, Associate Professor

*Research:* Vibrational Spectroscopy

*Teaching:* Physical Chemistry, Electrochemistry, History of Chemistry

Stefov Dr. Viktor, Assistant Professor

*Research:* Structural Chemistry, Vibrational Spectroscopy

*Teaching:* Methods for Molecular Structure Determination, Topics of Physical Chemistry, Sources and Use of Chemical Information

Pejov Ljupčo, M.Sc., Assistant

Ivanovski Vladimir, Assistant

### Faculty of Technology and Metallurgy

Specialized education of professionals for the industry in the field of chemical engineering is organized by the Faculty of Technology and Metallurgy in Skopje (92 professors and associates), where about 4160 students have graduated up to now, most of them being employed in various branches of chemical and related industries [7]. The graduated students are trained to work in the various capacities of the chemical industry, metallurgy, food industry, textile industry, pharmaceutical industry, mining, biotechnology, leather industry, etc.

The teaching in the field of chemical engineering in Macedonian mother language started at the Department of Technology, a part of the Technical Faculty – Skopje, in 1959 [7]. In 1965 the Department was set apart from the Technical Faculty and grew into the Faculty of Technology and Metallurgy, consisting in the beginning of two streams: inorganic technology and organic technology. In the meantime (1969) three additional streams for chemical engineering, electrochemistry and metallurgy have been established. In 1976 the Faculty of Technology and Metallurgy was separated into the Faculty of Technology (with four institutes for: inorganic technology, organic technology, chemical engineering and textile) and the Faculty of Metallurgy and Mining (from 1980 – Faculty of Metallurgy) (with two institutes for: extractive metallurgy and metal processing). In 1984 the Faculty of Technology and Metallurgy was reestablished. At the time being the Faculty of Technology and Metallurgy consists of five institutes for: inorganic technology, organic technology, chemical and control engineering, extractive metallurgy and metal processing [7].

A list of the leaders of the Department of Technology, the Faculty of the Technology and Metallurgy or the Faculty of Technology from 1959 to 2001 is given in Table 2 [7].

Table 2

*Leaders of the Department of Technology, the Faculty of the Technology and Metallurgy or the Faculty of Technology from 1959 to 2001*

#### Technical Faculty (1959 – 1965)

##### Department of Technology

Head	Tenure
Hristo Stamboliev	1959 – 1965

### Faculty of Technology and Metallurgy (1965 – 1976)

Dean	Tenure
Hristo Stamboliev	1965 – 1967
Panče Kirkov	1967 – 1969
Dragoljub Popović	1969 – 1971
Aleksandar Grizo	1971 – 1973
Petar Anastasovski	1973 – 1975
Gjuro Petrov	1975 – 1976

### Faculty of Technology (1976 – 1984)

Dean	Tenure
Zdravko Kovačevski	1976 – 1978
Vladimir Stamenkov	1978 – 1980
Milka Matkalieva	1980 – 1982
Radmila Kiprijanova	1982 – 1984

### Faculty of Technology and Metallurgy (1984 – 2001)

Dean	Tenure
Radmila Kiprijanova	1984 – 1986
Branko Popov	1986 – 1988
Frederika Popovska–Pavlovska	1988 – 1990
Svetomir Hadži Jordanov	1990 – 1992
Ljubomir Cvetkov	1992 – 1997
Marija Lazarević	1997 – 1999
Ljubomir Cvetkov	1999 –

### Undergraduate program

Stream:

#### Food Technology

Courses	Semester	
	I	II
I Year		
1. Mathematics I	3+3	–
2. Mathematics II	–	3+3
3. General and Inorganic Chemistry	3+3	3+3
4. Physics	2+2	3+3
5. Introduction to Programming	–	3+2
6. Elements of Chemical Engineering Techniques	2+2	2+2
7. General Ecology	2+0	–
8. Engineering Information Resources	1+3	–
9. Foreign Language	2+1	2+0
10. Defense and Protection	2+1	2+1
	Total hours/week:	17+15 17+14
11. Sport (optional)	0+2	0+2

II Year	III	IV
1. Analytical Chemistry	3+3	-
2. Organic Chemistry	3+2	2+5
3. Physical Chemistry I	3+3	-
4. Physical Chemistry II	-	3+3
5. Technical Thermodynamics	2+2	-
6. Applied Mathematical Methods	2+2	2+2
7. Biological Fundamentals of Raw Materials	3+2	-
8. Methods for Organic Compounds Characterization	-	3+4
9. Healthy Food and Nutrition	-	2+2
10. Foreign Language	2+0	2+0
Total hours/week: 18+14 14+16		
11. Sport (optional)	0+2	0+2
III Year	V	VI
1. Unit Operations	3+3	3+3
2. Chemical Reactor Engineering	2+2	-
3. Biochemistry	4+5	-
4. Microbiology	3+3	-
5. Food Chemistry	2+2	-
6. Food Analysis and Quality Control	-	3+4
7. Introduction to Biochemical Engineering	-	3+4
8. Introduction to Food Process Engineering	-	4+5
9. Modelling and Process Optimization	2+1	-
Total hours/week: 16+16 13+16		
IV Year	VII	VIII
1. Process Analysis and Synthesis	-	3+3
2. Measuring and Process Control	-	2+2
3. Computer Application in Process Engineering	-	2+2
4. Food Microbiology and Sanitation	2+3	2+2
5. Environmental Biotechnology	3+3	-
6. Packaging Technology	2+2	-
7. Technology of Wine and Alcoholic Beverages	-	2+0
8. Technology of Malt and Beer	2+3	-
9. Technology of Milk and Dairy Products	-	3+3
10. Industrial Microbiology in Food Industry	2+2	-
11. Preservation Technology of Fruits and Vegetables	-	3+3
12. Technology of Fats and Oils	2+2	-
13. Milling and Cereal Technology	2+2	-
14. Technology of Meat and Meat Products	-	2+2
Total hours/week: 15+17 19+17		

**Stream:  
Biotechnology**

Courses	Semester	
	I	II
I Year		
1. Mathematics I	3+3	-
2. Mathematics II	-	3+3
3. General and Inorganic Chemistry	3+3	3+3
4. Physics	2+2	3+3
5. Introduction to Programming	-	3+2
6. Elements of Chemical Engineering Techniques	2+2	2+2
7. General Ecology	2+0	-
8. Engineering Information Resources	1+3	-
9. Foreign Language	2+1	2+0
10. Defense and Protection	2+1	2+1
Total hours/week: 17+15 17+14		
11. Sport (optional)	0+2	0+2
II year	III	IV
1. Analytical Chemistry	3+3	2+2
2. Organic Chemistry	3+2	2+5
3. Physical Chemistry I	3+3	-
4. Physical Chemistry II	-	3+3
5. Technical Thermodynamics	2+2	-
6. Applied Mathematical Methods	2+2	2+2
7. Biological Fundamentals of Biotechnology	3+2	-
8. Methods for Organic Compounds Characterization	-	3+4
9. Foreign Language	2+0	2+0
Total hours/week: 18+14 14+16		
10. Sport (optional)	0+2	0+2
III Year	V	VI
1. Unit Operations	3+3	3+3
2. Chemical Reactor Engineering	3+3	-
3. Biochemistry	4+5	-
4. Microbiology	3+3	-
5. Genetics of Industrial Microorganisms	-	2+1
6. Basic Processes in Biotechnology	-	4+5
7. Quality Control in Biotechnology Products	-	3+4
8. Packaging Technology	2+2	-
9. Downstream Processes	-	2+2
Total hours/week: 15+16 14+15		
IV year	VII	VIII
1. Process Analysis and Synthesis	-	3+3
2. Measuring and Process Control	-	2+2



3. Computer Application in Process Engineering	-	2+2
4. Corrosion and Protection of Materials	2+2	-
5. Environmental Biotechnology	3+3	-
6. Industrial Microbiology	4+4	-
7. Pharmaceutical Technology	3+3	-
8. Technology of Biopolymers	-	4+4
9. Technology of Cosmetic Products		3+3
10. Elective Course		2+2
Total hours/week:		12+12 14+14

*Elective courses for the IV year*  
(VII and VIII semester):

1. Leather Technology	2+2
2. Tobacco Technology	2+2
3. Technologies from the Streaming Food Technology	

The total hours/week have to be 32/week, including elective courses.

Stream:

**Basic Organic and Polymer Engineering**

Courses	Semester		
	I Year	II	
1. Mathematics I	3+3	-	
2. Mathematics II	-	3+3	
3. General and Inorganic Chemistry	3+3	3+3	
4. Physics	2+2	3+3	
5. Introduction to Programming	-	3+2	
6. Elements of Chemical Engineering Techniques	2+2	2+2	
7. General Ecology	2+0	-	
8. Engineering Information Resources	1+3	-	
9. Foreign Language	2+1	2+0	
10. Defense and Protection	2+1	2+1	
Total hours/week:		17+15 17+14	
11. Sport (optional)	0+2	0+2	
II Year		III	IV
1. Analytical Chemistry	3+3	2+2	
2. Organic Chemistry	3+2	2+5	
3. Physical Chemistry I	3+3	-	
4. Physical Chemistry II	-	3+3	
5. Technical Thermodynamics	2+2	-	
6. Applied Mathematical Methods	2+2	2+2	
7. Natural Polymeric Materials	2+3	-	
8. Methods for Organic Compounds Characterization	-	3+4	
9. Foreign Language	2+0	2+0	
Total hours/week:		17+15	16+16
10. Sport (optional)	0+2	0+2	

III Year	V	VI
1. Unit Operations	3+3	3+3
2. Measuring and Process Control	-	2+2
3. Corrosion and Protection of Materials	2+2	-
4. Computer Application in Process Engineering	-	2+2
5. Chemistry and Physical Chemistry of Polymers	5+5	-
6. Raw Materials for Synthetic Products	4+5	-
7. Basic Processes for Synthetic Products	-	4+5
8. Chemical Structure and Properties of Polymers	-	2+2
9. Chemical Reactions of Polymers	-	2+2
Total hours/week:		14+15 15+16

IV Year	VII	VIII
1. Process Analysis and Synthesis	-	3+3
2. Chemical Reactor Engineering	3+3	-
3. Technology of Synthetic Polymers	4+5	-
4. Processing of Plastic Materials and Elastomers	-	4+5
5. Fibre Forming Processes	-	4+3
6. Technology of Basic Organic Products	4+5	-
7. Film-forming Materials	-	2+3
8. Protection in Industrial Processes	2+2	-
9. Polymer Characterization	2+0	-
10. Polymer Modification	-	2+0
11. Elective Course 1	2+0	-
12. Elective Course 2	-	2+0
Total hours/week:		17+15 17+14

*Elective courses:*

1. Chemistry of Heterocyclic Compounds
2. Polymers for Industrial Application
3. Engineering Materials
4. Fibres for Special Applications
5. Courses 1 & 2 are in VII semester
6. Courses 3 & 4 are in VIII semester

Stream:

**Basic Inorganic Engineering**

Courses	Semester	
	I Year	II
1. Mathematics I	3+3	-
2. Mathematics II	-	3+3
3. General and Inorganic Chemistry	3+3	3+3
4. Physics	2+2	3+3
5. Introduction to Programming	-	3+2
6. Elements of Chemical Engineering	2+2	2+2

Techniques			
7. General Ecology	2+0	-	
8. Engineering Information Resources	1+3	-	
9. Foreign Language	2+1	2+0	
10. Defense and Protection	2+1	2+1	
Total hours/week:	17+15	17+14	
11. Sport (optional)	0+2	0+2	
<b>II Year</b>	<b>III</b>	<b>IV</b>	
1. Analytical Chemistry	3+3	2+2	
2. Topics in Organic Chemistry	2+2	2+2	
3. Physical Chemistry I	3+3	-	
4. Physical Chemistry II	-	3+3	
5. Technical Thermodynamics	2+2	-	
6. Applied Mathematical Methods	2+2	2+2	
7. General Inorganic Technology	3+3	3+3	
8. Industrial Mineralogy and Petrography	-	3+3	
9. Foreign Language	2+0	2+0	
Total hours/week:	17+15	17+15	
10. Sport (facultative)	0+2	0+2	
<b>III Year</b>	<b>V</b>	<b>VI</b>	
1. Unit operations	3+3	3+3	
2. Measuring and Process Control	-	2+2	
3. Corrosion and protection of Materials	2+2	-	
4. Colloidal and Surface Chemistry	3+3	2+2	
5. Dressing of Raw Materials in inorganic Chemical Technology	5+5	-	
6. Raw Materials in Inorganic Chemical Technology	-	3+1	
7. Theoretical Bases of Technology for Inorganic Basic Materials	-	4+5	
8. Science of Inorganic Materials	3+3	2+3	
Total hours/week:	16+16	16+16	
<b>IV Year</b>	<b>VII</b>	<b>VIII</b>	
1. Processes Analysis and Synthesis	-	3+3	
2. Computer Application in Process Engineering	-	2+2	
3. Industrial Management	-	3+1	
4. Fuels, Combustion and Furnaces	4+5	-	
5. Technology of Acids and Bases	4+5	-	
6. Technology of Mineral Salts and Fertilizers	-	4+5	
7. Technology of Water	4+5	-	
8. Technology of Waste Waters and Protection	-	3+3	
9. Pollution Protection in Inorganic Basic Technology Chemical Industry	3+2	2+1	
Total hours/week:	15+17	17+15	

		Stream:	
		Non-metal Engineering	
Courses		Semester	
I Year		I	II
1. Mathematics I		3+3	-
2. Mathematics II		-	3+3
3. General and Inorganic Chemistry		3+3	3+3
4. Physics		2+2	3+3
5. Introduction to Programming		-	3+2
6. Elements of Chemical Engineering Techniques		2+2	2+2
7. General Ecology		2+0	-
8. Engineering Information Resources		1+3	-
9. Foreign Language		2+1	2+0
10. Defense and Protection		2+1	2+1
Total hours/week:		17+15	17+14
11. Sport (optional)		0+2	0+2
<b>II Year</b>		<b>III</b>	<b>IV</b>
1. Analytical Chemistry		3+3	2+2
2. Topics in Organic Chemistry		2+2	2+2
3. Physical Chemistry I		3+3	-
4. Physical Chemistry II		-	3+3
5. Technical Thermodynamics		2+2	-
6. Applied Mathematical Methods		2+2	2+2
7. General Inorganic Technology		3+3	3+3
8. Industrial Mineralogy and Petrography		-	3+3
9. Foreign Language		2+0	2+0
Total hours/week:		17+15	17+15
10. Sport (optional)		0+2	0+2
<b>III Year</b>		<b>V</b>	<b>VI</b>
1. Unit Operations		3+3	3+3
2. Measuring and Process Control		-	2+2
3. Corrosion and Protection of Materials		2+2	-
4. Colloidal and Surface Chemistry		3+3	2+2
5. Technological Preparation in Inorganic Chemical Technology		5+5	-
6. Raw Materials in Inorganic Chemical Technology		-	3+1
7. Theoretical Bases of Technology for Inorganic Non-metal Materials		-	4+5
8. Inorganic Materials Science		3+3	2+3
Total hours/week:		16+16	16+16
<b>IV Year</b>		<b>VII</b>	<b>VIII</b>
1. Processes Analysis and Synthesis		-	3+3
2. Computer Application in Process Engineering		-	2+2
3. Industrial Management		-	3+1
4. Fuels, Combustion and Furnaces		4+5	-
5. Technology of Acids and Bases		4+5	-
6. Technology of Mineral Salts and Fertilizers		-	4+5
7. Technology of Water		4+5	-
8. Technology of Waste Waters and Protection		-	3+3
9. Pollution Protection in Inorganic Basic Technology Chemical Industry		3+2	2+1
Total hours/week:		15+17	17+15

Engineering			
3. Industrial Management	-	3+1	
4. Fuels, Combustion and Furnaces	4+5	-	
5. Technology of Coarse and Fine Ceramics	3+3	2+2	
6. Technology of Binders and Binding-Products	5+5	-	
7. Technology of Refractories and Special Ceramics	3+4	2+2	
8. Technology of Glass and Enamel	-	4+3	
9. Process Pollutants and Protection in Inorganic Non-metal Industry	-	2+1	
Total hours/week:		15+17	18+14

## Stream:

**Ready Made Cloth Engineering**

Courses	Semester		
	I	II	
1. Mathematics I	3+3	-	
2. Mathematics II	-	3+3	
3. General and Inorganic Chemistry	3+3	3+3	
4. Physics	2+2	3+3	
5. Introduction to Programming	-	3+2	
6. Elements of Chemical Engineering Techniques	2+2	2+2	
7. General Ecology	2+0	-	
8. Engineering Information Resources	1+3	-	
9. Foreign Language	2+1	2+0	
10. Defense and Protection	2+1	2+1	
Total hours/week:		17+15	17+14
11. Sport (optional)	0+2	0+2	
II Year		III	IV
1. Polymer Physics and Chemistry	3+3	-	
2. Thermodynamics	2+2	-	
3. Textile Fibers	3+2	3+2	
4. Organic Chemistry Topics	2+2	2+2	
5. Fashion Design	-	3+3	
6. Clothing History	2+2	-	
7. Textile Design Basics	-	2+2	
8. Foreign Language	2+0	2+0	
Total hours/week:		14+11	12+9
9. Sport (optional)	0+2	0+2	
III Year		V	VI
1. Spinning Technology	4+2	-	
2. Weaving Technology	4+2	-	
3. Fashion Design I	2+4	2+2	
4. Chemical Textile Technology	4+2	4+2	

5. Work Study in Garment Production	2+2	-
6. Knitting Technology	-	2+2
7. Nonwoven Technology	-	3+2
8. Pattern Design in Clothing I	-	3+3
9. Apparel Technology I	-	2+3
Total hours/week:		16+12 16+14

IV Year	VII	VIII
1. Pattern Design in Ready-made Clothing II	2+4	2+4
2. Apparel Technology II	3+3	-
3. Textile Care	-	2+2
4. Textile Materials Testing	3+3	-
5. Quality Management	-	2+2
6. Fabrics Design	3+3	-
7. Machines in Clothing Production	2+1	2+1
8. Measurement and Automation Techniques	-	2+2
9. Fashion Design II	-	2+3
10. Clothing Plant Management	2+0	-
11. Clothing Processes Design	-	3+3
Total hours/week:		15+14 15+17

## Stream:

**Design and Management in Chemical Industry**

Courses	Semester		
	I	II	
1. Mathematics I	3+3	-	
2. Mathematics II	-	3+3	
3. General and Inorganic Chemistry	3+3	3+3	
4. Physics	2+2	3+3	
5. Introduction to Programming	-	3+2	
6. Elements of Chemical Engineering Techniques	2+2	2+2	
7. General Ecology	2+0	-	
8. Engineering Information Resources	1+3	-	
9. Foreign Language	2+1	2+0	
10. Defense and Protection	2+1	2+1	
Total hours/week:		17+15	17+14
11. Sport (optional)	0+2	0+2	
II Year		III	IV
1. Analytical Chemistry	3+3	-	
2. Organic Chemistry	3+2	2+5	
3. Physical Chemistry I	3+3	-	
4. Physical Chemistry II	-	3+3	
5. Chemical Engineering Thermodynamics	2+2	-	
6. Applied Mathematical Methods	2+2	2+2	
7. Mathematics III	2+3	-	

8. Topics in Applied Chemistry	-	3+1
9. Introduction to Chemical Engineering	-	4+5
10. Foreign Language	2+0	2+0
Total hours/week:	17+15	16+16
11. Sport (optional)	0+2	0+2

III Year	V	VI
1. Unit Operations	3+3	3+3
2. Measuring and Process Control	-	2+2
3. Computer Application in Process Engineering	-	2+2
4. Chemical Reactor Engineering	3+3	-
5. Separation Processes	3+3	-
6. Industrial Management I	-	3+1
7. Corrosion and Protection of Materials	2+2	-
8. Modelling and Process Optimisation	2+1	4+3
9. Elective Course 1	3+3	-
10. Elective Course 2	-	3+3
Total hours/week:	16+15	17+14

IV Year	VII	VIII
1. Industrial Reactors	3+3	-
2. Measuring and Process Control	2+2	-
3. Process Analysis and Synthesis	-	3+3
4. Process Equipment Design	3+3	-
5. Computer Application in Process Engineering	2+2	-
6. Process Dynamics With Complex Control	-	4+4
7. Materials in Chemical Engineering	2+2	-
8. Industrial Management II	-	4+4
9. Elective Course 3	3+3	-
10. Elective Course 4	-	3+3
Total hours/week:	15+15	14+14
11. Seminar I	0+2	-
12. Seminar II	-	0+2
13. Practical	-	0+2
Total hours/week:	15+17	14+18

#### Elective courses:

- Petroleum Refining
- Processes and Operation of Primary Petrochemical Products
- Conventional Energy Resources, Economy and Environment
- Alternative Energy Resources, Economy and Environment
- Transport Phenomena
- Quality Management
- Catalysts and Catalysis
- Environmental Management
- Risk Analysis
- Processes and Operation of Secondary Petrochemical Products
- Small Plants Equipment Design
- Equipment Design for Electrochemical Processes

- Elective courses 1-6 are in the III year
- Elective courses 7-12 are in the IV year

#### Stream: Extractive Metallurgy

Courses	Semester	
	I	II
I Year		
1. Mathematics I	3+3	-
2. Mathematics II	-	3+3
3. General and Inorganic Chemistry	3+3	3+3
4. Physics	2+2	3+3
5. Introduction to Programming	-	3+2
6. Elements of Chemical Engineering Techniques	2+2	2+2
7. General Ecology	2+0	-
8. Engineering Information Resources	1+3	-
9. Foreign Language	2+1	2+0
10. Defense and Protection	2+1	2+1
Total hours/week:	17+15	17+14
11. Sport (optional)	0+2	0+2
II Year	III	IV
1. Analytical Chemistry	-	2+3
2. Physical Chemistry	2+3	2+3
3. Ore Preparation and Mineral Processing	2+4	-
4. Metallurgy – Elementary Principals	3+2	2+2
5. Mineralogy	2+2	-
6. Theory of Metallurgical Processes – Elementary Principals	-	4+4
7. Physical Metallurgy – Elementary Principals	2+2	2+2
8. Powder Metallurgy – Elementary Principals	3+3	2+2
9. Foreign Language	2+0	2+0
Total hours/week:	16+16	16+16
10. Sport (optional)	0+2	0+2
III Year	V	VI
1. Theory of Metallurgical Processes – Selected Topics	2+2	3+2
2. Metallurgical Furnaces and Heat Transfer	4+4	3+3
3. Measuring and Process Control	2+2	2+2
4. Rolling	2+2	2+2
5. Casting	2+2	2+2
6. Techniques of Metal Characterization I	2+2	-
7. Techniques of Metal Characterization II	-	3+2
8. Powder Metallurgy	2+2	2+2
Total hours/week:	16+16	17+15
IV Year	VII	VIII
1. Ferrous Metallurgy	3+4	4+4

2. Nonferrous Metallurgy	3+4	4+4
3. Designing in Metallurgy	2+2	2+2
4. Ferroalloys	2+2	3+3
5. Electrometallurgy	3+3	-
6. Metallurgy of Rare Metals	-	2+2
7. Technical Electrochemistry	2+2	-
8. Elective Course	-	2+0
Total hours/week:		15+17 17+15

**Elective Courses:**

1. Industrial Management
  2. Experimental Design and Mathematical Methods
  3. Automatisation of Metallurgical Processes
  4. Electron Microscopy – Selected Topics
  5. Theory and Technology of Continuing Casting
  6. Production of High Purity Metals
  7. Nonferrous Metallurgy – Selected Topics
  8. Ferrous Metallurgy – Selected Topics
  9. Theory of Metallurgical Processes – Selected Topics
  10. Powder Metallurgy – Selected Topics
1. Elective courses 1 – 5 are for the two metallurgical streams  
2. Elective courses 6 – 10 are only for this stream.

**Stream:****Metal Processing**

Courses	Semester	
	I	II
I Year		
1. Mathematics I	3+3	-
2. Mathematics II	-	3+3
3. General and Inorganic Chemistry	3+3	3+3
4. Physics	2+2	3+3
5. Introduction to Programming	-	3+2
6. Elements of Chemical Engineering Techniques	2+2	2+2
7. General Ecology	2+0	-
8. Engineering Information Resources	1+3	-
9. Foreign Language	2+1	2+0
10. Defense and Protection	2+1	2+1
Total hours/week:		17+15 17+14
11. Sport (optional)	0+2	0+2
II Year	III	IV
1. Analytical Chemistry	-	2+3
2. Physical Chemistry	2+3	2+3
3. Ore Preparation and Mineral Processing	2+4	-
4. Metallurgy – Elementary Principals	3+2	2+2
5. Mineralogy	2+2	-
6. Theory of Metallurgical Processes – Elementary Principals	-	4+4
7. Physical Metallurgy – Elementary Principals	2+2	2+2

8. Powder Metallurgy – Elementary Principals	3+3	2+2
9. Foreign Language	2+0	2+0
Total hours/week:		16+16 16+16
10. Sport (optional)	0+2	0+2

III Year	V	VI
1. Theory of Metallurgical Processes – Selected Topics	2+2	3+2
2. Metallurgical Furnaces and Heat Transfer	4+4	3+3
3. Measuring and Process Control	2+2	2+2
4. Rolling	2+2	2+2
5. Casting	2+2	2+2
6. Techniques of Metal Research I	2+2	-
7. Techniques of Metal Research II	-	3+2
8. Powder Metallurgy	2+2	2+2
Total hours/week:		16+16 17+15

IV Year	VII	VIII
1. Designing in Metallurgy	2+2	2+2
2. Theory and Technology of Liquid Processing of Metals	4+4	3+4
3. Theory and Technology of Plastic Deformation of Metals	4+4	3+4
4. Heat Treatment	4+4	-
5. Special Steels and Alloys	-	2+2
6. Welding	2+2	2+2
7. Corrosion and Protection of Materials	-	2+2
8. Elective Course	-	2+0
Total hours/week:		16+16 16+16

**Elective Courses:**

1. Industrial Management
  2. Experimental Design and Mathematical Methods
  3. Automatisation of Metallurgical Processes
  4. Electron Microscopy – Selected Topics
  5. Theory and Technology of Continuing Casting
  6. Liquid Processing of Metals – Selected Topics
  7. Non-destructive Testing of Metals – Selected Topics
  8. Technology of Plastic Deformation of Non-ferrous Metals
  9. Subject from Extractive Metallurgy
- Elective courses 1–5 are for the both metallurgical  
Elective courses 6–9 are only for this stream

**Graduate program**

Graduate two-level programs leading to M.Sc. or Ph.D. degrees in technical sciences are also offered at this Faculty [7]. Since 1973, 169 students from the graduate program have reached their M.Sc. Degree and 62 students their Ph.D. Degree in Technical Sciences.

## Faculty and Staff

### Professors

#### Arsov Dr. Ljubomir

*Research:* Electrochemistry of Metal Surfaces, Anode Oxide Films, Electrochemical Synthesis of Electroconductive Polymers, Spectroscopic and Optical Methods in Electrochemistry

*Teaching:* Methods of Organic Compounds Characterization, Physical Chemistry I

#### Bogoeva-Gaceva Dr. Gordana

*Research:* Polymer Composites, Thermoplastic Polymers, Crystallization of Polymers

*Teaching:* Technology of Synthetic Polymers, Fiber Forming Processes

#### Boševska Dr. Vasa

*Research:* Layer Silicates, Crystallochemistry and Modification

*Teaching:* General and Inorganic Chemistry

#### Burevski Dr. Dončo

*Research:* Adsorption at the Interphase Solid/Gas

*Teaching:* Interface Phenomena, Colloidal and Surface Chemistry, Catalysts and Catalysis

#### Cvetkovska Dr. Maja

*Research:* Regradable Polymers, Synthesis of Block Copolymers, Polymer Characterization

*Teaching:* Chemistry and Physical Chemistry of Polymers, Polymer Characterization

#### Cvetkov Dr. Ljubomir

*Research:* Separation Processes (Plants, Herbs, Vegetables and Fruits)

*Teaching:* Technology of Food Products, Packing Technology (Technology of Preserving), Technology of Cellulose

#### Čepujnovska Dr. Violeta

*Research:* Quality Management, Textile Materials Testing

*Teaching:* Textile Material Testing, Quality Management, Quality Management in Redy Made Cloth Technology

#### Čoseva Dr. Slobodanka

*Research:* Free Radical Polymerization, Dilute Solution Properties, Polymer Blends, Compatibility, Thermal Stability, Recycling

*Teaching:* Chemistry and Physical Chemistry of Polymers, Processes and Operation of Secondary Petrochemical Products, Chemical Structure and Properties of Polymers, Chemical Reaction of Polymers

#### Davkova Dr. Katica

*Research:* Fuels, Glass Technology

*Teaching:* Fuels, Combustion and Furnaces, Fundamentals of Cole Processing, Glass and Enamel Technology

#### Dimitrovski Dr. Aco

*Research:* Food Fermentation Products

*Teaching:* Microbiology and Food Microbiology, Industrial Microbiology, Technology of Wine, Technology of Malt and Beer

#### Grčev Dr. Toma

*Research:* Electroconductive Polymers and Composites (Materials for Rechargeable Batteries), Corrosion of Metals

*Teaching:* Corrosion and Protection of Materials, Physical Chemistry, Materials in Chemical Engineering, Alternative Energy Resources, Economy and Environment, Equipment Design for Electrochemical Processes

#### Hadži-Jordanov Dr. Svetomir

*Research:* Electrochemistry, Corrosion and Protection of Metals, Electrocatalyzers, Environment

*Teaching:* Electrometallurgy, Corrosion and Protection of Materials, Physical Chemistry I

#### Ilievska Dr. Slobodanka

*Research:* Textile Materials: Bleaching and Finishing

*Teaching:* Technology of Bleaching and Finishing

#### Jačovski Dr. Vladimir

*Research:* Materials Science

*Teaching:* Measuring and Process Control, Designing in Metallurgy

#### Kiprijanova Dr. Radmila

*Research:* Modelling and Optimization of Technological Processes, Experimental Design and Analysis

*Teaching:* Applied Mathematical Methods, Modeling and Process Optimization

#### Kuzmanovska Dr. Slobodanka

*Research:* Bioconversion of Lignocellulose, Biocatalysts, Bioproduction of Polyoles

*Teaching:* Basic Processes in Biotechnology, Technology of Cellulose, Introduction to Biochemical Engineering, Introduction to Food Process Engineering

#### Ljapčeva Dr. Kostadinka

*Research:* Structure and Modification of Textile Fibers, Knitted Fabrics in Composite Materials

*Teaching:* Textile Fibers, Technology of Knitting

**Mangovska Dr. Biljana**

*Research:* Use of Enzymes in Textile Finishing, Modification of Textile Fibers, New Processes of Dyeing and Finishing of Textile

*Teaching:* Technology of Dyeing and Printing, Chemical Textile Processing & Properties, Dry Cleaning of Ready Made Cloth

**Mickovski Dr. Jovan**

*Research:* Phase Transformation in Metals, Process of Deformation Strengthened of Metals, Structure of Metals

*Teaching:* Physical Metallurgy – Elementary Principles, Physical Metallurgy

**Miloševska Dr. Ratka**

*Research:* Non-Conventional Method of Synthesis, Biomaterials

*Teaching:* Analytical Chemistry

**Miloševski Dr. Milosav**

*Research:* Solid State Reactions, Sintering, Biomaterials Thermophysical Properties

*Teaching:* Theoretical Principles of Technology of Inorganic Basic Materials, Technology of Acids and Bases, Materials Science

**Mitrovski Dr. Ivan**

*Research:* Chemical Thermodynamic of Hetero Metallurgic Processes and their Analysis, Kinetics of Hetero Processes in Metallurgic Engineering, Development of Computer Programs for Polyphase Metallurgic Systems

*Teaching:* Theory of Metallurgical Processes – Elementary Principals, Theory of Metallurgical Processes – Selected Topics

**Načevski Dr. Nikola**

*Research:* Extractive Ferrous Metallurgy, Ecology in Metallurgy

*Teaching:* Ferrous Metallurgy – Extractive, Ferrous Metallurgy – Processing

**Nikolovski Dr. Kostadin**

*Research:* Process Design, Management, Separation Processes, Environmental Engineering

*Teaching:* Introduction to Chemical Engineering, Industrial Management I, Industrial Management II, Risk Analysis

**Pavlovski Dr. Blagoja**

*Research:* Sintering of Nonmetallic Materials, Technology of Refractories, Technology of Oxide Ceramics

*Teaching:* Theoretical Principles of Technology of Inorganic Non-Metal Materials, Technology of Refractories and Special Ceramics

**Petrovska Dr. Nedka**

*Research:* Silicate Chemistry and Technology, Synthesis of Inorganic Salts and Acids, Fundamental and Theoretical Investigation of Diffusion Processes, Spectroelectrochemical Investigations of Surface Films

*Teaching:* General and Inorganic Chemistry

**Pocev Dr. Stefan**

*Research:* Inorganic Salts, Structure Determination, Technology and Application

*Teaching:* Technology of Mineral Salts and Fertilizers, General Inorganic Technology

**Poposka Dr. Filimena**

*Research:* Separation Processes, Process Modeling and Design

*Teaching:* Chemical Reactor Engineering, Petroleum Refining, Industrial Reactors

**Popovska-Pavlovska Dr. Frederika**

*Research:* Reology, Polymer Blends, Separation Processes, Multiple Emulsions (Modeling)

*Teaching:* Unit Operations, Processing of Plastic Materials and Elastomers, Processes and Unit Operations

**Pop-Tonev Dr. Kiril**

*Research:* Casting Alloys resistant Against Corrosion and Al-alloys, Interaction Between Solid Metal/Liquid Al

*Teaching:* Theory and Technology of Liquid Processing of metals, Heat Treatment

**Sekulovski Dr. Radojko**

*Research:* Numeric Mathematics

*Teaching:* Mathematics I, Mathematics II

**Spaseska Dr. Dijana**

*Research:* Polymer Modification, Composites, Biomaterials

*Teaching:* Raw Materials for Synthetic Products, Basic Processes for Production of Synthetic Materials

**Stojmenski Dr. Kiril**

*Research:* Algebra

*Teaching:* Mathematics I, Mathematics II

**Zafirovski Dr. Stojan**

*Research:* Row Silicate Materials, Sintering, Building Ceramics, Tine Ceramics, Ceramics Glazes

*Teaching:* Coarse and Fine Ceramics Technology, General Inorganic Technology

**Zafirova Dr. Koleta**

*Research:* Design and Properties of Woven Fabrics, Textile Materials – in Sound Absorption and Sound Insulation

*Teaching:* Technology of Weaving, Design, Construction of Woven Fabrics

Zlatanović Dr. Vladan

*Research:* Non-Metallic Raw Materials Dressing, Enrichment and Application, Optimization of Ceramic Processes, Synthesis of Na-Si Products Utilizing Non-Standard Raw Materials and Processes

*Teaching:* Basic Raw Materials and Their Processing

### Associate Professors

Anovski Dr. Todor

*Research:* Environmental Physics (Application of Isotopes in Research and Environmental Protection)

*Teaching:* Physics, General Ecology, Radiation protection

Jančev Dr. Simeon

*Research:* Mineralogy, Rare Mineral Associations from the Metamorphic Complex of the Pelagonian Massif

*Teaching:* Mineralogy, Industrial Mineralogy and Petrography

Maletić Dr. Mirjana

*Research:* Destabilization of Colloids in Water and Waste Water Treatment, Oxidative Processes in Water and Waste Water Treatment, Environment Protection

*Teaching:* Technology of Water, Technology of Waste Waters and Protection

Markovska Dr. Liljana

*Research:* Process Mathematical Modelling

*Teaching:* Applied Mathematical Methods, Modeling and Process Optimization, Computer Application in Process Engineering

Meško Dr. Verka

*Research:* Process Design, Adsorption Processes Modeling and Design

*Teaching:* Process Analysis and Synthesis, Process Equipment Design, Process and Operation of Primary Petrochemical Products, Small Plants Equipment Design

Najdenova Dr. Vasilka

*Research:* Separation Processes, Modeling, Simulation, Control and Dynamics

*Teaching:* Separation Processes, Measuring and Process Control, Process Dynamics with Complex Control

Prendžov Dr. Slobodan

*Research:* Film Forming Materials, Syntheses, Characterization and Application of Polymers and Organic Compounds

*Teaching:* Technology of Basic Organic Products, Fiber Forming Processes, Protection in Industrial Processes

Prendžova Dr. Magdalena

*Research:* Spinning Technology, Nonwoven Textile

*Teaching:* Technology of Spinning of Textile, Technology of Nonwoven Textile

Radjenović Dr. Katica

*Research:* Organic Chemistry, Textile Engineering

*Teaching:* Organic Chemistry

Slavkov Dr. Dragan

*Research:* Electrochemical Deposition and Dissolution of Metals, Corrosion and Protection of Metals

*Teaching:* Techniques of Metal Research I, Welding, Techniques of Metal Research I

Stefanovska Dr. Liljana

*Research:* Applied Mathematics

*Teaching:* Mathematics I, Mathematics II, Introduction to Programming

### Assistant Professors

Aleksovski Dr. Slavčo

*Research:* Super Critical Fluid Extraction

*Teaching:* Mathematics III, Chemical Engineering Thermodynamics, Conventional Energy, Resources, Economy and Environment

Bliznakovska Dr. Blagica

*Research:* Formation and Application of Ceramic Materials, Pollutants and Environmental Protection, Informations and their Use in the Educational Process

*Teaching:* Source of Informations and Their Use, Process Pollutants and Protection in Inorganic Basic Chemical Industry

Bocevaska Dr. Mirjana

*Research:* Natural Antioxidants, Stabilization of Fats and Oils, Rough Rice, Thermophysical Properties of Stand Biodegradable Films

*Teaching:* Biochemistry, Food Chemistry, Dat and oil Technology

Ćortoševa Dr. Sonja

*Research:* Basic Motion Mterials, Structural Process Control

*Teaching:* Testing Textile Material Testing, Sttistical Process Control

Demboski Dr. Goran

*Research:* Technology of Knitting, Cloth Production Processes, Textile Structure for Technical Textile



*Teaching:* Ready Made Cloth Technology, Designing of Ready Made Cloth Capacity

Dimitrov Dr. Aleksandar

*Research:* Electrochemistry, Corrosion and Protection of Metals

*Teaching:* Ferroalloys, Metallurgy of Rare Metals, Technical Electrochemistry

Dudukovska Dr. Mirjana

*Research:* Metallurgy – Process of Plastic Deformation of Metals, Structure and Deformation of Metals and Alloys

*Teaching:* Theory and Technology of Plastic Deformation of Metals, Rolling

Hristova Dr. Eftimija

*Research:* Safety Environment

*Teaching:* Ferrous Metallurgy – Extractive, Ferrous Metallurgy – Processing

Magdeski Dr. Jon

*Research:* Powder Metallurgy and Sintering, Phase Transformations

*Teaching:* Heat Treatment, Special Steels and Alloys, Theory and Technology of Sintering

Marina Dr. Biljana

*Research:* Non-metallic Raw Materials (Structure, Modification, Application, Valorization of Waste Products Binder Materials)

*Teaching:* Technology of Binders and Binding Products, Process Pollutants and Protection in Inorganic Basic Non-Metal Industry, Applied Chemistry – Selected Topics

Prusi Dr. Abdurauf

*Research:* Applied Electrochemical Engineering

*Teaching:* Elements of Chemical Engineering Techniques

Tasev Dr. Milan

*Research:* Nonferrous Metallurgy

*Teaching:* Nonferrous Metallurgy – Extractive, Nonferrous Metallurgy – Processing

Timofeeva Dr. Olga

*Research:* Intermacromolecular reactions, Polymers complexes, Polymer as support for immobilization of calls, Ion exchange resins

*Teaching:* Intermacromolecular reactions

Vinkelhuazen Dr. Eleonora

*Research:* Bioconversion of Lignocellulose, Biocatalysts, Bioproduction of Polyoles

*Teaching:* Healthy Food and Nutrition, Food Analysis and Quality Control

## Assistants

Brezovska Dr. Snežana

Bogoevski Dr. Slobodan

Cvetkovski Dr. Sveto

Čamovska Dr. Dragica

Jankovska Dr. Katica

Pandžakovski Dr. Naum

Rafajlovska Dr. Vesna

Stojanovska Dr. Lepa

Šopova Dr. Nadežda

Arsova Irena, M.Sc

Bojadžiska Milena, M.Sc.

Buntevska Verka, M.Sc.

Bužarovska Aleksandra M.Sc.

Dimova Vesna, M. Sc.

Doneva Donka, M.Sc.

Grozdnov Anita, M.Sc.

Fidančevska Emilija, M.Sc.

Konevska Zagorka, M.Sc.

Knežević Radojko, M.Sc.

Manojlović Ružica, M.Sc.

Maslinko Liljana, M.Sc.

Panova Blagojka, M.Sc.

Paunović Perica, M.Sc.

Pop Janev Sotir, M.Sc.

Rizov Blagoj, M.Sc.

Rusevska Gordana, M.Sc.

Sinadinovska Liljana, M.Sc.

Andonović Beti

Jordanov Igor

Marinkovski Mirko

Stojmenovska Irena

## Research Activities

In addition to the educational activities, another principal objective of the Institute of Chemistry is to provide research in various fields of chemistry which appear to be important for the development of the Republic of Macedonia. The main research activities at the Institute nowadays include inorganic and organic synthetic chemistry, IR and Raman vibrational spectroscopy, UV/VIS spectroscopy, X-ray diffraction, atomic absorption spectrometry, polarography, chromatography, thermal analysis, thin solid films research, theoretical

chemistry etc [3, 4]. Additional researches in the fields of chemical engineering, inorganic technology, material science, polymers, biotechnology, food technology, electrochemistry, textile engineering, etc. are performed at the Faculty of Technology and Metallurgy in Skopje [7]. During the last few years, special research activities are organized in the domain of environmental chemistry and pollution control at both the Institute of Chemistry and the Faculty of Technology and Metallurgy.

In 1986 the Research Center for New Technologies as a research unit of the Macedonian Academy of Sciences and Arts (MANU) is founded [8]. Its main goal is to promote key areas of science and technology in Macedonia in the fields of genetic engineering and biotechnology. This Center is involved in basic and applied research on the molecular nature of common monogenic diseases and hematological neoplasm, in the development of non-radioactive procedures for DNA analysis as well as in some basic studies in protein chemistry.

Many professors and associates of chemistry and chemical engineering have spent some time in various research centers in Europe, the United States of America and Australia. The Institute of Chemistry [3, 4] as well as the Faculty of Technology and Metallurgy [7] cooperate closely with research and development laboratories from various fields of the chemical and drug industry in Macedonia as well as with other faculties from the University in Skopje. Close collaboration is also established with a lot of foreign centers in Austria, Bulgaria, Canada, Czech Republic, Croatia, France, Germany, Great Britain, Italy, Latvia, Russia, Slovenia, Sweden, USA, FR Yugoslavia, Turkey, Ukraine. Unfortunately, collaboration has not yet been established with the corresponding centers from the neighboring Albania.

In general, the scientific research projects in Macedonia (including chemistry and chemical engineering) are mainly supported by financial funds from the Ministry of Science of the Republic of Macedonia (domestic projects) and partly by various foreign or international institutions (international projects). The approximate total amount of finances granted by the Ministry of Science for all types of scientific activities for 2001 does not exceed 0.28 % of the Gross National Product, which is far from being sufficient to support well organized, modern and high-level research work. Instead of being enlarged, the above mentioned amount of finances granted for the science and art

is smaller compared to the corresponding budget for the previous years. As a result of the current economic situation in Macedonia, the real situation is that the faculty libraries are not supplied with the recent issues of the necessary scientific journals, while the laboratories are not adequately equipped with modern instruments. As an example, the last volume of the Chemical Abstracts in the library at the Institute of Chemistry, which in the same time is also the unique example in the whole country, is the one from 1996.

In spite of the above conditions, respectable number of Macedonian researches in the field of chemistry and chemical engineering continuously contribute with the results of their original scientific research in a variety of international journals as well as in the national journal *Bulletin of the Chemists and Technologists of Macedonia* and other local journals. As an illustration, let us mention that the approximate number of published scientific papers in the field of chemistry and chemical engineering in the international journals for 2000 amounts about 80. Otherwise, the total number of the papers in the field of chemistry published by the scientists from the Institute of Chemistry amounts 845 [9]. Of them, 423 are published in the journals out of Macedonia and 422 in the journals from Macedonia. Additional 951 papers are published in the field of the chemical engineering by the staff of the Faculty of Technology and Metallurgy up to now [10]. From them, 397 papers are published in the journals out of Macedonia and 554 in the journals from Macedonia. So, the total number of the published scientific papers in the field of chemistry and chemical engineering for the roughly fifty years period amounts 1796 (820 in the journals out of Macedonia). Besides the published papers, about 2500 scientific presentations in the field of chemistry and chemical engineering have been given by the Macedonian chemists and chemical engineers at various scientific manifestations in Macedonia (1230) and out of Macedonia (1270). It should be mentioned that the papers published by the Research Center for New Technologies as a research unit of the Macedonian Academy of Sciences and Arts (MANU) are not taken here into consideration. On the other hand, a considerable number of various chemical and chemical engineering books (text-books, handbooks, manuals, monographs, etc.) for the students as well as for the pupils from the elementary and secondary schools have been published by the teaching and scientific staff of the Institute of Chemistry (45)

and the Faculty of Technology and Metallurgy (108).

Founded in 1974 by the Society of Chemists and Technologists of Macedonia, the *Bulletin of Chemists and Technologists of Macedonia* is the only specialized national journal covering all fields of chemistry and chemical technology. The Editorial board of the journal (published twice annually) consists of distinguished Macedonian scientists, professors and engineers. In addition, an international Advisory board of the Bulletin was established six years ago. In order to sustain international criteria for the originality of the published original scientific papers, at least one of the two referees for each paper is selected from abroad. In 1999 the Bulletin celebrated the 25th Anniversary. Since 1974, 20 volumes of the journal with the total number of 333 papers (14 reviews) were published. The total number of authors amounts 1032, from which 461 are from abroad (Serbia, Croatia, Slovenia, Bosnia and Herzegovina, Turkey, Germany, Bulgaria, Romania, USA, Sweden, UK, Russia, The Netherlands, Montenegro, Czech Republic, Italy, China, France, India and Uzbekistan).

The scientific papers in the field of chemistry and chemical engineering can also be published in the *Contributions* of the Macedonian Academy of Sciences and Arts (Section of Mathematical and Technical Sciences), *Geologica Macedonica*, *Macedonian Pharmaceutical Bulletin*, *Macedonian Medical Review*, the *bulletins* at the Faculty of Agriculture, Faculty of Forestry and Veterinary Faculty, *Physica Macedonica*, *Bulletin of the Institute of Biology*, etc. Another interdisciplinary journal closely related to environmental chemistry is entitled *Ecology and Protection of the Environment* published by the Society of Ecologists of the Republic of Macedonia.

This year (2001) a new journal (magazine) for popularization of the chemistry among the elementary and secondary school pupils named *Hemko* is established.

The Society of the Chemists and Technologists of Macedonia is an organizer of the biannual (even years) Congress of the Chemists and Technologists of Macedonia with international participation. The last, 16th Congress, took place in 1999 in Skopje, the Macedonian capital. The main topics of the Congress were Structural Chemistry, Textile Engineering, Chemical Engineering, Inorganic Chemistry and Technology, Analytical Chemistry, Environmental Chemistry and Pollution Control, Material Science, Polymers and Polymer Materials,

Biotechnology and Food Technology, Electrochemistry and Chemical Education. Four plenary lectures (lecturers from USA, The Netherlands, FR Yugoslavia and Bulgaria), 6 session lectures, 52 oral presentations and 117 posters were presented at the Congress. About one-third of the participants were from abroad (FR Yugoslavia, Bulgaria, The Netherlands, USA, Turkey, Croatia, Sweden, Spain, Czech Republic, Slovenia and Japan). Since the year 1994, the Society of the Chemists and Technologists of Macedonia by assistance of the Society of Young Chemists of Macedonia biannually (odd years) organizes the Congress of Pure and Applied Chemistry for the students of Macedonia with international participation. Three plenary lectures (lecturers from Bulgaria and Macedonia) and 56 oral presentations were given by 66 authors at the last Third Congress held in Skopje in 2000.

### Current Research Projects

*Faculty of Natural Sciences and Mathematics  
Institute of Chemistry*

1. Experimental and Theoretical Studies of Crystallohydrates and Hydroxides  
Principal Researcher: Dr. Bojan Šoptrajanov
2. Synthesis and Investigation of Some Compounds of Uranium  
Principal Researcher: Dr. Ilinka Donova
3. Experimental and Theoretical Studies of Guest-Host Interactions in Some Clathrates  
Principal Researcher: Dr. Biljana Minčeva-Šukarova
4. Systems of Isostructural and Isotype Compounds: Spectroscopic, Structural and Theoretical Investigations  
Principal Researcher: Dr. Vladimir Petruševski
5. Development of Qualitative and Quantitative Methods for Analysis of Salivary Calculi by FT IR Spectrometry  
Principal Researcher: Dr. Mirjana Ristova
6. Concentration and Determination of Heavy Metals in Aqueous Matrices  
Principal Researcher: Dr. Katerina Čundeva
7. Investigation of Carbonates and their Interaction with Various Inorganic Acids  
Principal Researcher: Dr. Viktor Stefov

8. Use of Thallium Minerals as Solar Neutrino Detectors  
Principal Researcher: Dr. Trajče Stafilov
9. Investigation of Redox Processes in Uracils by Modern Voltametric Methods  
Principal Researcher: Dr. Kornelija Stojanova
10. Development of HPLC Methods for Determination of Pesticides Used in Viticulture  
Principal Researcher: Dr. Simka Petrovska-Jovanović
11. Development of Chemical Techniques for Deposition of Thin Films of Useful Inorganic Materials, their Characterization and Application  
Principal Researcher: Dr. Ivan Grozdanov
12. Minerals from Macedonia: Spectroscopic and Structural Characterization  
Principal Researcher: Dr. Gligor Jovanovski
13. Structural Correlations and Investigation of the Properties of Perovskite Type Compounds  
Principal Researcher: Dr. Slobotka Aleksovska
14. Development of Hemometric Methods for Determination of the Content of the Urinary Calculus  
Principal Researcher: Dr. Mira Trpkovska
15. Synthesis and Pre-clinical Investigation of Thioderivates of Benzoyl Mercaptoacetyl Triglycine  
Principal Researcher: Dr. Bogdan Bogdanov
16. Optimization of the Conditions for Development of Analytical Methods for Determination of Organic Acids and Indole in Various Samples  
Principal Researcher: Dr. Ilinka Spirevska
17. Theoretical Aspects of the Stability of Persistent Organic Pollutants Present in our Environment  
Principal Researcher: Dr. Zoran Zdravkovski
18. Synthesis, Structural Investigations and Quantum-Mechanical Calculations of Some Saccharinate Salts and Complexes with Various N-donor Bases  
Principal Researcher: Dr. Orhideja Grupče
19. Development of New Electroanalytical Methods for Determination of Noble Metals  
Principal Researcher: Dr. Marija Georgieva
20. Quantum-Mechanical and Experimental Investigations of Various Biomolecules  
Principal Researcher: Dr. Kiro Stojanoski

#### *Faculty of Technology and Metallurgy*

1. New Composite Materials Based on Semi Conducting Oxides  
Principal Researcher: Dr. Abdurauf Prusi
2. Metaloxide-polymeric Materials, Preparation and Characterization  
Principal Researcher: Dr. Ljubomir Arsov
3. Design of Degradation and Stabilization Processes of Polymers and Composite Materials  
Principal Researcher: Dr. Diana Spaseska
4. Cellulosic Fibers Properties and Textile Products Quality from the Ecological Point of View  
Principal Researcher: Dr. Kostadinka Ljapceva
5. Hydrothermal Production of Light-weight Ceramic Products  
Principal Researcher: Dr. Blagoja Pavlovski
6. Structure Investigation of the Materials  
Principal Researcher: Dr. Vladimir Jačovski
7. Investigation of Si-Mn Slags Obtained by Electro Melting Alloys Process  
Principal Researcher: Dr. Eftimija Hristova
8. Synthesis, Characterization and Application of Some Organic Compound Belong to the Group of Surfactants  
Principal Researcher: Dr. Katica Čolančevska-Ilievska
9. Block Copolymers Synthesis, Polymer Gels and Networks on their Basis and their Use as Emulsifiers or Controlled Release Formulations”  
Principal Researcher: Dr. Maja Cvetkovska
10. Degradable Multicomponent Polymer Systems  
Principal Researcher: Dr. Maja Cvetkovska
11. Development of Methods for Solving Mathematical Problems in Physics and Technical Sciences  
Principal Researcher: Dr. Liljana Stefanovska
12. Synthesis, Characterization and Structure of Block Copolymers PEO-Polyitaconate and their Blends  
Principal Researcher: Dr. Slobodanka Koseva

13. The Influence of Free and Glucosidically Bond Monoterenes on Wine Aroma  
Principal Researcher: Dr. Aco Dimitrovski
14. Advanced Materials Based on Polymer Blends. Processing-Structure Relationship  
Principal Researcher: Dr. Frederika Popovska-Pavlovska
15. Quality Projection of Textile Materials Through the Mathematical-Statistical Modeling  
Principal Researcher: Dr. Violeta Čepujnovska
16. Microbic Hydrolysis on C–C bonds: Isolation, Characterization and Production  
Principal Researcher: Dr. Slobodanka Kuzmanovska
17. Characterization and Application of Active Components in the Flora of Macedonia  
Principal Researcher: Dr. Vasilka Najdenova
18. Investigation of Ohrid-Prespa Hydro System with Application of Natural and Artificial Tracers  
Principal Researcher: Dr. Todor Anovski
19. Application of New Extraction Technology in Production of Wine Acid  
Principal Researcher: Dr. Filimena Poposka
20. Enzyme Production of Bioemulsifiers  
Principal Researcher: Dr. Slobodanka Kuzmanovska
21. Characterization and Possibilities for Total Use of Rough Rice: Production of Biodegradable Films and Silica Gel and Purification of Waste Water  
Principal Researcher: Dr. Mirjana Bocevska
22. Electrochemical Synthesis and Characterization of New Composite Materials for Electrochemical Capacitors (Supercapacitors)  
Principal Researcher: Dr. Toma Grčev
23. Modeling and Simulation of Simulated Moving Bed Reactors – Application in the Process of Xylenes Isomerization and Separation  
Principal Researcher: Dr. Verka Meško
24. Modeling and Simulation of Heavy Metal Adsorption Processes on Natural Adsorbents  
Principal Researcher: Dr. Liljana Markovska
25. Textile Product Design – Defining the Weavability Limits During Cloth Formation  
Principal Researcher: Dr. Koleta Zafirovska
26. Bioscouring and Biofinishing of Textile  
Principal Researcher: Dr. Biljana Mangova
27. Distribution of Heavy Metals – Microelements in the Recent Surface Layer – Topsoil in Veles Valley  
Principal Researcher: Dr. Mirjana Maletić
28. Recycling and Valorization of Some Waste Materials from the Macedonian Industry  
Principal Researcher: Dr. Milosav Mološevski
29. Desulphurization of the Emission of Pollutants of the Combustion of Macedonian Lignite  
Principal Researcher: Dr. Katica Davkova

### *Chemical Industry*

The contribution of the chemical industry to the overall social product from industry and mining is 9.20 %. It accounts for 6.3 % of the employers in this area and 5.5 % of its exports. It should be pointed out here that about 70 % of the required raw and semi-processed materials for the chemical industry in Macedonia are imported [11].

The basic and processing chemical industry provides large variety of products. The largest and most important capacity is the Organic Chemical Industry (OHIS), Skopje, with production of about 30 000 tons of polyacrylonitrile fiber, 55 000 tons of polyvinyl chloride and its products (10 000 tons PVC granulate and PVC tubing), 30 000 tons detergents and 7 000 tons of plant protection chemicals annually. Other important capacities are: Hemteks, Skopje (28 000 tons polyester fiber); HEK Jugohrom, Jegunovce (7 000 tons sodium dichromate); Zletovo Chemical-Metallurgic Combinat, Veles (120 000 tons fertilizers); RIK Sileks, Kratovo (5 600 tons polyurethane foam) and Prespateks, Resen (6 000 tons polyurethane fiber). There are also several plastics processing capacities producing about 15 000 tons of various types of packing materials each year.

The numerous analyses show that the chemical industry production in Macedonia falls down continuously during the last few years. Besides other factors, this partly comes as a result of the old-fashioned (obsolete) technology. Therefore, revitalization of this field should be one of the priorities of the Macedonian economy, particularly having in mind the technological tendency in the chemical industry in the developed countries. The new technology for production of polyacrylonitrile

and polyester fiber as well as for production of new types of suspension PVC and composite materials based on glass fibers should be introduced. In addition, it is necessary to replace the phosphates with zeolites and also to encourage the production of detergents with biodegradable formulas in detergent production.

Close related to the chemical industry are the oil industry (OKTA Refinery, Skopje), pharmaceuticals and cosmetics industry (Alkaloid, Skopje; Jaka, Radoviš; Medical Plastics, Tetovo, etc.), paper and cellulose industry (Hartija, Kočani; Komuna, Skopje), non-metal industry and building materials industry (Ogražden, Strumica; Bentomak, Kriva Palanka; Bitolastil, Bitola; Porcelanka, Veles; TIPO, Skopje; Silika, Gostivar; Knauf, Debar; USJE, Skopje; BIM, Sveti Nikole), leather and leather industry (GODEL, Skopje) etc.

### Mineral Resources

The geological structure of the Republic of Macedonia is rather complex, consisting of a large number of ore deposits. In a number of locations there are exploited reserves of lead-zinc (Zletovo, Sasa, Toranica) and copper-gold (Bučim). Lignite (Suvodol – Bitola, Oslomej – Kičevo), bentonite (Kriva Palanka), gypsum (Debar), quartz, quartzite, while quartz sand, opalite, feldspar, marble (Prilep, Gostivar), travertine and other kinds of decorative construction stone are also exploited [11].

It is interesting to point out here that although being a rather small country, Macedonia contributes 2 % of the overall world production of lead and zinc. The geological reserves of lead-zinc ore amount to about 42 million tons, the potential reserves being assessed at over 85 million tons. The annual mining and flotation processing capacities amount to about 2 million tons. According to the estimated total reserves of lead-zinc one a production of these ores for over 60 years ore would be enabled.

The producer of copper ore in Macedonia with about 4 million tons annually is Bučim (Radoviš). The major part of the reserves of about 56 million tons in the central body of the mine is already exploited, but other ore deposits are discovered in the meantime (about 100 million tons). Copper ore reserves in other parts of Macedonia are also discovered (estimated to at least about 200 million tons).

Ržanovo (near the Macedonian-Greek border) is the main nickel-ferrous ore deposit with reserves

of about 38 million tons. The ore excavate processed here is the basis for production of nickel in the FENI Industry near Kavadarci with an annual capacity of 14 500 tons of ferro-nickel (at present only one technological line with a capacity of 7 250 tons is active). The remaining three leading ferrous metallurgy companies are: Skopje Steelworks with a capacity of 1.2 million tons of hot- and cold-rolled sheet metal per year; HEK Jugohrom, Jegunovce, with an annual capacity of 80 000 tons of ferrous alloys; FZC 11 Oktomvri, Kumanovo, with an annual capacity of 200 000 tons of seamed tubing.

Silver and gold are also extracted from the polymetallic lead, zinc and copper ores, while gallium, indium, germanium and cadmium are found to be closely linked with deposits of lead and zinc. There are also capacities for aluminium processing (Alumina, Skopje) and copper-based products producing (Kuprum, Skopje). It is also estimated that in Macedonia there are approximately 1.5 million tons of uranium ore reserves (i.e., 760 tons of uranium oxide).

It is interesting to mention that from the total number of 60 non-metallic mineral raw materials used today in the world, no less than 46 are present in Macedonia. From them of a special interest are: gypsum, graphite, kaolin clay, corundum, mica, opalite, natural sulfur, talc, fire-resistant and ceramic clays, feldspar, cement etc. Macedonia has also about 2 billion tons of geologically proved coal reserves [11].

There is a unique ore deposit at Allchar in Macedonia where even 41 mineral varieties have been identified up to now (wallrock and clay minerals being not included) [12]. It is the locality for no less than eleven thallium species, many of them found nowhere else. The famous among them is lorandite,  $TlAs_2$ . Namely, Freedman *et al.* [13] and Freedman [14] proposed that lorandite from the Allchar locality in Macedonia could be used as a solar neutrino detector. The idea was based on the eventual proof of existence of higher concentrations of  $^{205}Pb$  in lorandite than it would be expected as a result of natural radioactivity and cosmic radiation alone. In such a case the excess of  $^{205}Pb$  can be related to its formation by solar neutrino capture in  $^{205}Tl$ . This idea was supported by Morinaga [15] leading lately to the formation of the International Project on Solar Neutrino Detection by Thallium Minerals where numerous scientific institutions from various countries (including Macedonia) have participated.

### *Ecology and Environmental Protection*

The level of pollution of the human and natural environment (air, water and soil pollution) in the Republic of Macedonia is, in general, within the limits of tolerable parameters. There are regions (Mavrovo National Park, Ohrid Lake, Galičica National Park, Prespa Lake, Pelister National Park, Mariovo region, Osogovo massif, Maleševo region etc.) that have mainly remained environmentally unpolluted. On the other hand, some of the industrial regions and cities with high population (e.g., Veles, Bitola, Prilep, Tetovo, Štip, and particularly Skopje) are rather polluted. As an illustration, the air pollution monitoring system in Skopje for one year period (April 1998 – March 1999) has shown that the concentration of major pollutants ( $\text{SO}_2$ ,  $\text{NO}_x$ , CO and SPM) increases remarkably during the heating winter season, very often continuously exceeding the limit for the environmental standards [16].

In 1995 huge steps have been made in Macedonia in catching up with contemporary ecological trends in various parts of the world. Namely, a new law on the promotion and protection of the environment and nature was introduced. The World Bank was included in the financing of specific studies and projects. As a part of these activities, the Ecological Movement of Macedonia (DEM) in 1996 was the organizer of the European Conference of the national environmental associations, promoting ecological cooperation in the Balkans. Significant effects in implementation of higher standards for environmental protection have been achieved by the implementation of the national project for gasification, in the attempt to promote the use of natural gas over some liquid and solid fuels and other energy sources which pollute the environment.

Since its establishment in 1990, the Ecological Movement of Macedonia has developed various activities in the protection of air, water, soil, forests, health food etc. The movement is supported by the electronic and written media. Alongside goes the establishment of the Ministry of Environment and Physical Planning within the Government of the Republic of Macedonia in 1998, the budget of which for 2000 is five times greater compared to the previous 1999. Such tendency is an indication, and, at the same time, a great hope for the ecologists and, of course, for all people in Macedonia, that higher and European-oriented standards in environmental protection would be established in future.

### *Effects of the War in the Region*

It is well known that the Federal Republic of Yugoslavia has been exposed to severe disturbance by the 78 days war activities caused by bombing by the NATO forces since March 24th, 1999. During the war, besides military installations, various civilian industrial facilities, residential areas and protected natural features and centers of biodiversity were bombed. The military action polluting substances endangered the population directly through air, water and food but also accumulated in geological formations or in the biosphere causing a long-term health risk. The additional risk as well as human suffering was caused by the use of weapons banned by the Geneva Convention (cluster bombs and radioactive ammunition).

Of course, the consequences (including the environmental outcomes) of the conflict were not confined to the territory of FR Yugoslavia itself. The neighboring countries were also negatively affected by the military actions. It was especially the case with Macedonia and Albania both being swamped with hundreds of thousands of refugees. About 270000 ethnic Albanians from Kosovo entered Macedonia as refugees which amounts about 14 % of the total population of the country. Eight refugee camps were provided for about 118 000 refugees, while the remaining 152 000 were located in households [17].

The war in Yugoslavia has also directly influenced the chemical science in Macedonia. The lowering of the financial budget owing to the large income of refugees, resulted in restrictions of the grants with which the Ministry of Science has been supporting the scientific research projects. As an illustration to this, it can be pointed out that owing to the lowering of the national budget, the grants for all on-going scientific projects in 1999 were restricted for 30 % of their initial value. In addition, the sponsorships for modernization of the laboratories were brought to minimum.

According to the Ministry of Environment and Physical Planning of Macedonia, an increase in water pollution with chemicals, toxins or radiation during the period of March–June 1999 was not identified. As an illustration it could be mentioned that the total alpha-radioactivity in water samples from the river Lepenec (Northern Macedonia) of 0.083 Bq/L (during May 24th – 28th, 1999) which is 1.5 times lower than the maximum allowed concentration according to the Macedonian standards [17]. Since two camps “Raduša” and “Bojane”

were located in the first protected zone of the karst region of the largest drinking water spring in Macedonia "Rašče", there was a high potential danger for its contamination. Although the results of the analysis showed no presence of any group of bacteria or any kind of micro-biological contamination, the possibilities of contamination of the underground water in future is not excluded. Therefore, the monitoring of underground waters in the area of Rašče should be made obligatory.

The analyses of the alpha-radioactivity in the air in Macedonia during the month of April 1999 discovered up to 8 times higher concentration than the usual [17]. Although this level was under the maximum allowed concentration, it was taken as an indicator that a continuous monitoring of this parameter is needed. The measurements of other types of radioactivity (gamma radiation, beta-radioactivity) during April–June 1999 gave lower values than those used according to Macedonian and EU standards. Macedonia, however, does not possess a permanent monitoring of the radioactivity and it is impossible to compare the above-mentioned results with the previous years.

Since Macedonia does not dispose with a sophisticated equipment for measuring the concentrations (levels) of chemical pollutants in the air, the potential air pollution with highly toxic and dangerous pollutants (dioxins, furans, polychlorinated biphenyls) released from the chemical and petroleum industrial complexes in the FR Yugoslavia in fact has not been monitored [17]. On the other hand, there are no signs of any kind of pollution of the soil. Namely, State monitoring institutions have not announced any measurement nor findings of pollution as a result of the military conflict in the FR Yugoslavia.

Later the war against the terrorism imported mainly from the territory of Kosovo started in Macedonia in March 2001. As a consequence a large amount of the money from the budget was wasted for that purpose instead of being used to increase the percent of GNP spent on education and research in order to provide the necessary stimulus for further development and progress of the country.

### *Chemistry in Art and Archeology*

In spite of being the territory where the Slavic alphabet was invented and the Christianity was spread starting from the 9th century, Macedonia is

a magical country often called "a cradle of culture", a country that in a unique way embraces both the art and archeology. A number of archeological sites exist, including Stobi (Gradsko), Heraclea Lyncestis (Bitola), Lychnidos (Ohrid), Scupi (Skopje) etc., [11] where historical monuments and objects made by various chemical materials were found. Macedonian villages and cities have an imposing number of churches and monasteries characterized by a unique architecture and priceless frescoes and icons made by famous fresco-painters that make use of beautiful varieties of colors from inorganic and organic origin. Only in the town of Ohrid, being under the protection of UNESCO, their number exceeds 30, most of them being built between the 11th and 12th century. This represents inevitable evidence that the knowledge about the use of natural chemicals for fresco-painting has a long tradition in Macedonia. In the site of Viničko Kale (near Vinica) the oldest terracotta icons in Europe from the 6th century were discovered. The physico-chemical investigation of the icon fragments and of the representative clays from the Vinica region has shown that clay material of the local origin was used by the ancient artists [18, 19].

### *Perspectives*

Further development of the research activities in the field of *structural* chemistry, *analytical* chemistry, *synthetic* (inorganic and organic) chemistry, *biochemistry* and *theoretical* chemistry as well as new aspects of *chemical education* is expected in the future period at the Institute of Chemistry, Faculty of Natural Sciences and Mathematics [3, 4]. The research activities at the Faculty of Technology and Metallurgy would be oriented towards the further development of the *electrochemistry*, *material science*, *inorganic* and *organic* chemistry and technology, *polymer* chemistry, *thermal analysis*, *metallurgy*, etc. [7]. The continuation of the interdisciplinary environmental studies as well as the investigation and the characterization of the minerals originating from Macedonia is also expected.

It is well known that one of the best investments and at the same time the driving force for growth and development of each modern society is well organized education and science. Therefore higher standards in education and science should be established in the Republic of Macedonia in future in order to provide the necessary development of the process of education and science. Ac-



ordingly, one of the basic preoccupations in future should be to support the progress of the natural sciences (chemistry, biology and physics) as well as the development of new technologies including the chemical technology (chemical engi-

neering). To achieve such aims, the study programs oriented toward the problem solving and stimulating creativity of teachers and professors as well as the laboratories with contemporary equipment and well stocked libraries are needed.

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## Резиме

### ХЕМИЈАТА ВО МАКЕДОНИЈА

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**Клучни зборови:** Македонија; хемија; образование; наука; индустрија; екологија; минерали; археологија

Направен е преглед на состојбите и тенденциите во образованието и науката од областа на хемијата, хемиското инженерство и хемиската индустрија во

Македонија. Истражувањата од областа на фундаменталните хемиски дисциплини главно се одвиваат на Институтот за хемија при Природно-математичкиот

факултет, додека оние од областа на применетата хемија се предмет на интерес на Технолошко-металуршкиот факултет. Главни гранки на хемиската индустрија во Македонија се органската полимерна база и процесна индустрија и металургијата. Во рамките на проевропската ориентација, а со цел да се држи чекор со интернационалните стандарди, во последно време

значително внимание ѝ е посветено на заштитата на животната средина. Со оглед на богатото минато на Македонија како крстопат на многу цивилизации, од една страна, и познатото минералошко богатство на земјата, од друга, обрнато е внимание и на интересот за истражувањата од областа на хемиските аспекти на археологијата и минералогитата.