# Eleventh National Conference on Chemistry

## Chemistry Education for Public Understanding of Science

## 49th National Chemistry Teachers Conference

# *Book of Abstracts*

23–24 June 2022, Sofia, Bulgaria

Union of Chemists in Bulgaria

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**Chemistry Education for Public Understanding of Science**

**49th National Chemistry Teachers Conference**

**100th Anniversary of the journal Khimiya i Industriya (Химия и индустрия)**

# Book of Abstracts

**University of Chemical Technology and Metallurgy**
**23–24 June 2022, Sofia, Bulgaria**

**Union of Chemists in Bulgaria**

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Ministry of Education and Science of Bulgaria for financial support.

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Eleventh National Conference on Chemistry
Chemistry Education for Public Understanding of Science
Forty-ninth National Chemistry Teachers Conference
100th Anniversary of the journal Khimiya i Industriya (Химия и индустрия)

Book of Abstracts

Sofia 2022


Compiled by V. Beschkov, Ch. Bonev, I. Havezov
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# Organization

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Ministry of Education and Science
Union of Chemists in Bulgaria
Federation of Scientific Technical Unions in Bulgaria
Union of Scientists in Bulgaria
Bulgarian Academy of Sciences
St. Kliment Ohridski University of Sofia
University of Chemical Technology and Metallurgy, Sofia
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# Symposia

| Title | Chair(s) |
|---|---|
| 1. Physical chemistry and electrochemistry | M. Bojinov |
| 2. Organic chemistry and pharmacy | V. Dimitrov |
| 3. Inorganic chemistry and technology | R. Stoyanova, E. Zhecheva |
| 4. Analytical chemistry | D. Tsalev |
| 5. Catalysis | G. Kadinov |
| 6. Chemical engineering and environmental protection | V. Beschkov |
| 7. Biobased and synthetic polymers and bioproducts | N. Dishovski, S. Nenkova |
| 8. Chemistry education | A. Tafrova-Grigorova, M. Kirova |

# Programme

## (As of 16th June 2022)

## Thursday, 23rd June 2022

| | | |
|---|---|---|
| **Asen Zlatarov Hall Foyer** | | |
| 08:30–18:00 | **Registration and information** | Company for International Meetings |
| **Asen Zlatarov Hall** | | |
| 10:00–10:15 | **Opening ceremony** | V. Beschkov, Organizing committee |
| 10:15–11:00 | **L1. Invited lecture**: Metallic glasses: suitable precursors for porous structures by dealloying | T. Spassov, L. Mihaylov, Ev. Vassileva |
| 11:00–11.30 | **Coffee break** | |
| 11:30–12:15 | **L2. Invited lecture**: Smart materials for speciation analysis | I. Dakova, P. Vassileva, I. Karadjova, T. Yordanova, E. Mladenova |
| 12:15–12:30 | **Company presentation**: Innovative teaching and learning tools and programs for teachers and educators from T.E.A.M. and Agilent | K. Doktorov |
| 12:30–12:45 | **Awarding ceremony**: National competition for the best diploma thesis'2022 sponsored by AQUACHIM Company | B. Velikov |
| 12:45–13:00 | **Awarding ceremony**: National competition for the best chemistry teacher'2022 sponsored by St. St. Cyril and Methodius International Foundation | S. Stefanov |
| 13:00–14:00 | **Lunch break** | |
| **Hall 431** | | |
| 14:00–15.45 | **Oral session** | |
| 14:00–14:15 | **1-O1**: Electrochemical process for production of pure iron strip for mechanical tests | K. Kolev, B. Yanachkov, L. Lutov, L. Drenchev |
| 14:15–14:30 | **2-O1**: Use of ([$^{18}$F] FDG) as a prosthetic group for indirect radiofluorination | G. Simeonova, B. Todorov, V. Lyubomirova |
| 14:30–14:45 | **2-O2**: Bis(dichlorotriazine)-substituted reactive dyes containing stabilizer fragment as a decision to solve ecological problems | P. M. Miladinova |
| 14:45–15:00 | **7-O1**: Enabling bioprinting of 3D tissue models: the polymer chemistry of 3D extrusion bioprinting | H. Saradzhova, Y. Sbirkov, D. Molander, S. Todinova, V. Sarafian, M. Redzheb |
| 15:00–15:15 | **7-O2**: Properties of eco-friendly fibreboard panels fabricated with different adhesive systems based on hydrolysis lignin | V. Savov, I. Yordanov, I. Valchev |
| 15:15–15:30 | **7-O3**: Novel hybrid materials based on polycarboxybetaine methacrylate and calcium phosphates | K. Ruseva, M. Simeonov, E. Djulgerova, P. Shestakova, E. Vassileva |
| 15:30–15:45 | **7-O4**: Two-layer polyzwitterionic hydrogels capable of changing own shape in a controlled manner | N. Petrov, K. Ruseva, E. Vassileva |
| 16:00–16:30 | **Coffee break** | |
| **Hall 439** | | |
| 14:00–16.00 | **Junior and high school student session** | |
| 14:00–14.30 | **Orally presented posters** | |
| 14:00–14.15 | Significant achievements in chemistry | S. Hammashi, 10th grade, Uvekind Private High School, Sofia |

| | | |
|---|---|---|
| 14:15–14.30 | Occasional discoveries in chemistry | M. Stankov, V. Tsvetkov, 10th grade, Prof. E. Ivanov High School of Natural Sciences and Mathematics, Kyustendil |
| 14:30–14.45 | **Essay**: Significant achievements in chemistry | D. Hristev, 11th grade, Acad. Kiril Popov High School of Mathematics, Plovdiv |
| 14:45–16:00 | **Oral presentations** | |
| 14:45–15:00 | Occasional discoveries in chemistry | I. Milev, 5th grade, Dimcho Debelyanov 134 School, Sofia |
| 15:00–15:15 | Occasional discoveries in chemistry | M. Georgieva, 11th grade, Holy Septuagint First Secondary School, Targovishte |
| 15:15–15:30 | Occasional discoveries in chemistry | I. Ivanov, M. Hristova, 11th grade, Mathematics High School, Lovech |
| 15:30–15:45 | Outlook and challenges for chemistry of the future | P. Yordanova, N. Velichkova, 9th grade, Ivan Vazov Secondary School for Foreign Languages and Management, Sofia |
| 15:45–16:00 | Occasional discoveries in chemistry | V. Toev, 10th grade, Prof. E. Ivanov High School of Natural Sciences and Mathematics, Kyustendil |
| 16:00–16:30 | **Coffee break** | |
| 16:30–17:45 | **Oral session** | |
| 16:30–16:45 | **8-O1**: Desired future profession: a factor influencing students' chemistry learning motivation at school | V. Todorova, M. Kirova |
| 16:45–17:00 | **8-O2**: Attitudes of chemistry teachers to application of computer technologies in classes | M. Kirova, M. Tsenova |
| 17:00–17:15 | **8-O3**: Increasing cognitive interests and professional competencies through chemical experiment | N. Stambolieva |
| 17:15–17:30 | **8-O4**: Hydrocarbons educational products by students from Elisaveta Vazova Vocational Design School in Sofia | G. Aralova |
| 17:30–17:45 | **8-O5**: Top emerging technologies in chemistry and education of chemistry and natural science in Bulgaria | H. Hristov |
| 16:30–18:00 | **Poster session** 1-P1-P6, 2-P1-P2, 3-P1-P5, 4-P1-P9, 5-P1-P5, 6-P1-P5, 7-P1-P4, 8-P1-P3 | |
| 18:00–20:00 | **Welcome reception at University of Chemical Technology and Metallurgy** | |

## Friday, 24th June 2022

**Asen Zlatarov Hall Foyer**

| | | |
|---|---|---|
| 10:00–18:00 | **Registration and information** | Company for International Meetings |

**Asen Zlatarov Hall**

| | | |
|---|---|---|
| 11:00–11:45 | **L3. Invited lecture**: Are the expected learning outcomes in chemistry and environmental protection attainable? Results of a national survey for lower secondary stage | A. Tafrova-Grigorova, G. Shumanova |
| 11:45–12:30 | **L4. Invited lecture**: Bioelectrochemical processes in industrial biotechnology | V. Beschkov, E. Razkazova-Velkova |
| 12:30–14:00 | **Lunch break** | |

**Hall 431**

| | | |
|---|---|---|
| 14:00–15.45 | **Oral session** | |
| 14:00–14.15 | **3-O1**: Synthesis and characterization of organic-inorganic hybrid membranes modified with gold nanoparticles | H. Hristov, P. Vasileva |
| 14:15–14.30 | **4-O1**: Diversity in the coordination chemistry of polyether ionophore antibiotics | I. Pantcheva |
| 14:30–14.45 | **4-O2**: Atomic absorption analysis of copper and zinc and spectrophotometric analysis of antioxidant activity in serum of women with impair bone density | R. Tomova, S. Asenova, L. Atanasova, B. Atanasova, R. Nestorova, M. Nikolova, M. Slavova |
| 14:45–15:00 | **6-O1**: The potential of CCS and CCU technologies in mitigating climate change | D. Panayotov, M. Mihailov, K. Hadjiivanov |
| 15:00–15.15 | **6-O2**: Influence of applied external voltage on anaerobic digestion with outside integrated microbial electrolysis cell | P. G. Velichkova, S. G. Bratkova, A. T. Angelov |
| 15:15–15.30 | **6-O3**: Modelling of 1,2-dibromoethane biodegradation under constant electric field | P. Popova-Krumova, V. Beschkov, E. Vasileva, T. Parvanova-Mancheva |
| 15:30–15.45 | **6-O4**: Impact of *Spirulina platensis* biomass on the viability of *Lactobacillus delbrueckii* subsp. *bulgaricus* strain during freeze-drying process | I. Ganchev, L. Dobreva |
| 16:00–16:30 | **Coffee break** | |

**Hall 439**

| | | |
|---|---|---|
| 14:00–16.00 | **Oral session** | |
| 14:00–14.15 | **8-O6**: Teacher's role in the formation of metacognitive skills in students: a study's results | N. Markova, E. Boiadjieva, V. Tzvetkov |
| 14:15–14.30 | **8-O7**: The role of chemistry in the refinement of worsted and thick fabrics | Y. I. Kalosheva-Andonova, P. N. Petrov |
| 14:30–14.45 | **8-O8**: Physicochemical experiment for the formation of natural scientific literacy of students in primary school | R. Georgieva Draganova-Hristova |
| 14:45–15.00 | **8-O9**: The place of microplastics issue in the Bulgarian chemistry curriculum | Z. Peteva, S. Georgieva |
| 15.00–15.15 | **8-O10**: Opportunities for development of science literacy with a 10$^{th}$ grade chemistry textbook in French | N. Y. Raycheva |
| 15:15–15.30 | **8-O11**: A STEM lesson in chemistry education | Z. Garova |
| 15:30–15.45 | **8-O12**: Laboratory exercises in module 4. Challenges and answers | N. Stamenov |
| 16:00–16:30 | **Coffee break** | |
| 16:30–18.00 | **Discussion**: Chemistry education for public understanding of science | A. Tafrova-Grigorova, E. Boiadjieva |
| 18:00–18.10 | **Closing ceremony** | V. Beschkov, Organizing committee |

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Invited lecture

# L1. Metallic glasses: suitable precursors for porous structures by dealloying

T. Spassov, L. Mihaylov, Ev. Vassileva

*Faculty of Chemistry and Pharmacy St. Kliment Ohridski University of Sofia, 1 James Bourchier Blvd., 1164 Sofia, Bulgaria*
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The use of amorphous alloy precursors for producing porous structures by dealloying is a relatively new research topic. However, it is already certain these materials are attractive for obtaining interesting porous materials with important applications. The choice of suitable amorphous alloy precursor is crucial for finding mechanically stable porous material by dealloying. Some of the first attempts to synthesize porous metals by selective dissolution of amorphous precursors were made in 2009 and our works in this field are among the first to be found in the literature. The main advantages of the amorphous precursors compared with crystalline alloy systems are mentioned in the following lines. Being monolithic in phase they possess homogeneous composition; over thousands of metallic glasses have been produced, which ensure multiple dealloying precursors, and the majority of amorphous alloys are composed of more than three different metals giving the opportunity to form nanoporous metals with multiple elements. When selectively dissolving amorphous alloys there are no grain boundaries and crystalline structure to provide active centres for dealloying process to occur. Parameters, which play a crucial role during dealloying both crystalline and amorphous precursors, involve difference in electrochemical potential between alloy components, critical potential for corrosion, amount of noble element, composition, pH, and electrolyte temperature. The purpose of this contribution is to discuss results available so far of the formation of porous structures by dealloying metallic glasses. Findings over the last 10–12 years are included in which amorphous alloys were used as the starting material. Alloy chemical composition and the conditions of selective dissolution (chemical and electrochemical) and their relationship with pore size and ligaments of the material are considered. Furthermore, both pore size and pore size distribution in alloy volume as well as ligament composition and microstructure are decisive for the application of porous metal structures. Therefore, all the factors that influence these characteristics are important for achieving a controlled synthesis of desired porous alloys.

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Invited lecture

# L2. Smart materials for speciation analysis

I. Dakova, P. Vassileva, I. Karadjova, T. Yordanova, E. Mladenova

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*St. Kliment Ohridski University of Sofia, 1 James Bourchier Blvd., 1164 Sofia, Bulgaria*
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Hyphenated methods combining chromatographic separation with highly sensitive ICP-MS detection are well-known and preferable tool for speciation analysis. However, in most cases determination of only one chemical species of element is required for toxicity profile assessment of samples. Smart materials incorporated in selective sensing procedure or in selective separation procedure are accepted as an efficient non-chromatographic fit-to-purpose approach in such cases. Usually, sensing is accepted as a fast screening approach with possibilities to be performed during sampling, visible even with naked eyes, however, with more or less qualitative character. Incorporation of noble metal nanoparticles in a sensing system ensures better sensitivity as well as high reliability and accuracy of acquired results. In several systems based on Ag nanoparticle quantitative determination of Hg(II), Fe(III), and Cr(VI), representatives of usually determined toxic forms of these elements, was achieved by careful optimization. This included AgNPs synthesis and applied capping agent and employing critical experimental parameters such pH, type of acid and concentration used, and operated reducing agents in the absence of any additional colour forming ligand. In all cases, the method is based on variation of LSPR absorption band intensity because of electrostatic interaction between the metal ions and AgNPs. The latter were coated with starch (Cr(VI) and Fe(III) or raffinose for Hg(II) in the presence of 0.005 mol $L^{-1}$ $HNO_3$, for Hg(II), 0.001 mol $L^{-1}$ HCl for Fe(III), and *in situ* reduction at pH 4 by ascorbic acid for Cr(VI). Quantitative determination is ensured by established linear response between the intensity of localized surface plasmon resonance (LSPR) band and concentration of toxic species. Experiments performed showed high selectivity of developed sensing systems and lack of matrix interferences from other metal ions. Relatively low determination limits achieved ensured application of sensing systems in national monitoring of surface waters and quality of wastewaters.

Selective solid phase extraction is widely used method for separation and determination of toxic analytes; however, any simplification of analytical procedure is highly preferable. Application of membranes is a useful method to retain analytes thus avoiding in most cases long centrifugation of very small particles. Several types of membranes were synthesized and applied for multielement enrichment (chitosan, poly(vinyl alcohol) membrane loaded with noble metal nanoparticles), speciation of Cr (membrane based on Cr(III) imprinted poly(vinyl alcohol)/sodium alginate/AuNPs) and for simultaneous speciation of Cr and Mn (hybrid nano-sorbent of membrane type based on poly(vinyl alcohol)-polyethylene oxide-tetraethoxysilane-Au@Starch NPs). Careful optimization of synthesis procedures ensured membranes with high mechanical stability, easy for manipulation. All attempts to find suitable elution agent failed and instead membrane dissolution is proposed for analyte recovery. In this way, the membranes were not reusable but for each sorption/desorption cycle a new membrane with high efficiency was used. Experiments performed with membranes from different batches showed good reproducibility of synthesis procedure: relative standard deviation for degree of sorption was between 4 and 8%. Extraction efficiency of membranes was tested with model solutions and real samples. Recoveries achieved varied within 95–98% for all studied analytes and toxic species. Electrothermal atomic absorption spectrometry or mass spectrometry with inductively coupled plasma were used as measurement methods. Simple and fast analytical procedures were developed and applied for analysis of surface waters, haemodialysis solutions, and textile. Determination limits achieved depend on the instrumental method used but, in all cases, they fulfilled the requirements of national and EU legislation. Relative standard deviation is good due to simplicity of analytical steps and possibility to perform whole procedure in one vessel avoiding analyte losses or contamination.

Acknowledgment: Bulgarian National Science Fund under Ministry of Education and Science of Bulgaria supported this study through Grant DN19/10 ‘Smart speciation’.

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Invited lecture

# L3. Are the expected learning outcomes in chemistry and environmental protection attainable? Results of a national survey for lower secondary stage

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Since 2016, new State Education Standards for general school education have been in force. They define: (i) objectives, content, and characteristics of general education; (ii) general education subjects; and (iii) requirements for learning outcomes in each general education subject. Compared to the previous State Education Requirements of 2000, the new standards are aimed at mastering competences based on the nine groups of key competences. For the subject of Chemistry and Environmental Protection, the general education curriculum is primarily oriented towards formation and development of scientific literacy, which is reflected in the new curricula. The competences are specified in the curricula as expected learning outcomes of students for a grade. The amount of curriculum content has been reduced to no more than 58% for new knowledge at the expense of more time for practical activities, revision, and summarization, with a focus on independent study and analysis of information from different sources, planning experimental work, and inquiry. Prompted by the need to verify the achievement of key learning objectives following introduction of the new standards and curricula, the Centre for Assessment of Pre-School and School Education, as mandated by the Ministry of Education and Science, conducted a study of achievements in Chemistry and Environmental Protection of a cohort of student grades 8, 9, and 10. The sample was nationally representative by covering all 28 districts, systematic, two-step stratified, and cluster-based. It consisted of two groups of students: in one are non-profiled classes and vocational high classes, and in the other are profiled foreign language classes. The former group consisted of 1 267 eighth-graders in 2018 and 1 248 ninth-graders in 2019. At the beginning of the 2020/2021 school year, the final stage of the study on Grade 10 curriculum was conducted with 2 407 students (testing was delayed due to the pandemic situation). With a few exceptions, the students are the same as in previous years. To measure the degree of achievement of the expected outcomes, regulated by the curricula, three tests with 12 multiple-choice and 3 free-response items were prepared: Test 1 (Grade 8 curriculum), Test 2 (Grade 9 curriculum) and Test 3 (Grade 10 curriculum). The tests have good psychometric properties and are based on test specifications prepared by expert evaluation. Students from non-profiled and vocational classes did not exceed 45% of the maximum score for all three tests: Grade 8 (44%), Grade 9 (32%) and Grade 10 (37%). There was not a single skill mastered by 50% or more of the students in the group of ninth graders from non-profiled and vocational classes. Even though students from the foreign language classes did not study chemistry for a whole school year and had to master both grade 8 and grade 9 material in grade 9, their results were better. For Test 1, the correct response rate was 65%, significantly higher than that of the non-profiled classes, and the differences were statistically significant. For Test 2, the performance of ninth graders from profiled foreign language classes was still higher than that of non-profiled classes (40% and 32% respectively), however, there was a significant drop compared to Test 1: from 65% for Test 1 to 40% for Test 2. For Test 3, the proportion of correct answers for profiled classes was 53% against 37% for non-profiled classes. Development of some core competences common to Test 1 and Test 2 was also tracked. Both groups of students, from non-profiled and profiled classes, showed a relatively low level of mastery of some competences but still with a positive development, e.g. 'The student uses data from a chemistry experiment'. Regression in both groups of students was observed for skills such as 'Composes chemical formulae according to rules'. Some conclusions made from the study mark a significant group of all students who found the tasks difficult regardless of their type and the way they were set as well as free-response tasks made it considerably more difficult for students. Students found it hard to extract and evaluate information about substances and processes presented in text, models, tables, graphs, and diagrams. Further difficulties involve how to plan and carry out chemical experiments; to present results of a chemical experiment orally and in writing; and to draw conclusions and inferences. Supporting policies need to be proposed, discussed, and implemented to address identified problems.

In addition to the test tasks, 8th and 9th grade students answered a questionnaire in order to study their interest and attitudes towards natural sciences, in particular the subject of Chemistry and Environmental Protection. Analysis and conclusions from students' answers were made.

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## L4. Bioelectrochemical processes in industrial biotechnology

V. Beschkov, E. Razkazova-Velkova

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Industrial fermentation and biological wastewater treatment are usually based on both redox processes taking place in living cells and enzyme processes. Practical application of these redox processes is usually associated with electricity generation in microbial fuel cells or process enhancement in microbial electrolysis cells. The microbial fuel cell approach leads to straightforward wastewater treatment with less energy demand. Additional advantages of these processes are direct removal of various pollutants and avoidance of addition of chemical agents with the resulting waste products of treatment as it is familiar with traditional chemical methods. Another option for using bioelectrochemical processes in practice is the approach of microbial electrolysis cells. Application of electric field on fermentation or microbial wastewater treatment processes might result in different aspects: either in purely electrochemical processes on the electrodes or in different types of bioelectrochemical stimulation of enzyme activity in the living cells. These applications are associated with the combination of enzyme activity with electrochemical processes to produce or remove certain compounds rapidly at high concentrations with no additions of other chemicals. Both approaches (microbial fuel cells and microbial electrolysis cells) are presented and discussed. Some practical applications and experimental examples of such bioelectrochemical redox processes stimulated by constant electric field are demonstrated.

## 1-O1. Electrochemical process for production of pure iron strip for mechanical tests

K. Kolev[1,2], B. Yanachkov[1,2], L. Lutov[1,2], L. Drenchev[2]

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High-purity iron finds use in research for determining the effect of various factors on the structure and mechanical properties of this important metal. However, relatively high cost of commercial material and machining specimens restricts the ability to conduct wide series of experiments. The herein described is a complete process for laboratory-scale production of pure iron strip specimens with similar properties at a moderately low cost. In the process, high purity iron is produced by electrochemical deposition from a chloride bath. The electrolyte of choice has the advantages of being prepared from low-cost reagents as well as the fact that it is relatively non-toxic and can be easily disposed of after neutralization. Control of multiple process variables such as temperature, pH of the electrolyte, cathodic current density, hydrodynamic conditions in the cell and others, is of great importance to obtain iron deposits that are uniform and free of cracks or pits. A special cell employing a rotating cylinder cathode is developed to fit process requirements. Hydrogen evolution at the cathode occurs inevitably during electrodeposition, which causes hydrogen embrittlement in the iron deposits. The hard and brittle iron strip specimens thus obtained are subjected to recrystallization anneal. Annealing is conducted in a specially designed setup and serves the purpose to facilitate complete desorption of hydrogen as well as to remove permanent defects in the crystal grains. The final product of the process is a pure iron strip with good mechanical properties intended for a wide range of research purposes.

## 1-P1. Hydrogen transfer processes in cytosine and isocytosine: a theoretical study

T. D. Cherneva[1], I. G. Shterev[2], E. Horkel[3], V. B. Delchev[1]

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Cytosine and isocytosine are isomers both being derivatives of pyrimidine. Cytosine is a building block of nucleic acids and one of the major chromophores in their macromolecules. Isocytosine is a ‘rare’ pyrimidine nucleobase with opposite positions of the carbonyl and amino group as compared to cytosine. This minor structural change reflects significantly to the photophysics of the isomer compounds. Investigated H-detachment processes in the tautomers of cytosine and isocytosine showed that the driven state of the reactions is the repulsive $^1\pi\sigma^*$ excited state in accord with the PIDA mechanism described well in the scientific literature. For the amino-oxo form of isocytosine the H-detachment process can also occur along the bright $^1n\sigma^*$ excited-state reaction path. Furthermore, we optimized the conical intersections $S_0/S_1$ of the dissociated tautomers of cytosine and isocytosine. The structures were found at the CASSCF level using active space of six electrons on six orbitals. Our experience shows that this active space is the optimal one for such kind of calculations. Conical intersections $S_0/S_1$ are mutually accessible through $^1\pi\sigma^*$ excited-state reaction paths. We found also that inclusion of water molecule as a catalyst for the hydrogen transfer processes drastically change thermal reaction and photoreaction mechanisms. Energy barriers are reduced more than 50% as compared to non-catalyzed reactions.

Acknowledgement: The authors are grateful to Bulgarian National Science Fund for financial support through project No KP-06-N59/7.

## 1-P2. Antenna-effect mechanism in luminescent Ln(PDTC)$_3$phen (Ln ≡ Eu$^{III}$, Sm$^{III}$) complexes: the role of dithiocarbamate ions

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Spectroscopic properties and visible light emission of two sulphur-containing lanthanide complexes with general formula Ln(PDTC)$_3$phen (where PDTC = pyrrolidine dithiocarbamate, phen = 1,10-phenanthroline and Ln ≡ Sm$^{III}$, Eu$^{III}$) were studied by means of experimental techniques and quantum chemical modelling. UV-Vis absorption, excitation and luminescence spectra of the complexes were recorded at room temperature in both solid state and dichloromethane solution. A complete energy diagram of ligand-centred excited states relaxation was constructed with the help of DFT/TDDFT/ωB97xD calculations. Spin-orbit coupling splitting and the $S \rightarrow T$ intersystem crossing rates were assessed on the basis of CASSCF/NEVPT2 wave functions using the quasi-degenerate perturbation formalism. Judd-Ofelt parameters for Eu$^{III}$ were extracted from the recorded luminescence spectrum by using the QDC model of Freire and co-workers. Theoretical apparatus developed by Malta was used to estimate ligand-to-metal energy transfer rates. Accumulated data was implemented to reproduce in detail sensitization mechanism stimulating Ln$^{III}$ luminescence. Analysis of the predicted relaxation and energy transfer pathways allows to explain the role of the PDTC ligand in the sensitization process and to assess efficiency of the two complexes as UV-to-visible light converting species.

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## 1-P3. Electrochemical extraction and characterization of recovery tin

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Tin is known to be one of the most valuable and at the same time is one of the most deficient metals due to its low content in the earth's crust and difficulty in obtaining. For these reasons the need for recycling remains an important task. The sources of tin-containing waste are very diverse: concentrators, alloy production, canning, electronics, electrical engineering and more.

In the proposed work, dissolution of tin from used cans in alkaline solutions with the addition of *p*-nitroaniline (p-NA) and its electroextraction from solutions was studied by chemical (gravimetric method, iodometric analysis), electrochemical (electroextraction), and physical (atomic absorption analysis, Mössbauer analysis) methods. Conditions providing a high degree of contaminants removal and complete removal of varnish coatings from the surface of tinned sheet metal are determined. It was found that in alkaline solutions containing 40 g/l NaOH, 15 g/l p-NA at 80°C removed about 95% of the tin coating. Electroextraction of alkaline tin-containing solutions (~80°C) carried out at 2–3 A/dm$^2$ yielded metallic tin with a purity of about 99.5%.

Based on the results obtained in the research, a technology for the production of secondary tin has been proposed including removal of contaminants and varnish coatings from waste, dissolution of tin and its electroextraction from alkaline solutions. Regeneration of secondary tin from tinned waste is essential in overall tin balance. Therefore, despite all the difficulties mainly associated with the collection of this waste, tin regeneration must be expanded.

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## 1-P4. Preparation and painting of aluminium surfaces for marine atmospheres

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This work describes a sequence of stages and results obtained of pretreatment and application of marine atmosphere resistant paint and varnish coatings on the surface of aluminium alloy EN AW 5754 H22.

SEM and EDX analyses were performed to determine character and chemical composition of the films formed during treatment of aluminium surfaces in Cr(III)- and Mo-containing solutions.

The following coating layers were applied electrostatically on the obtained films:

– Layers of powder paint consisting of Interpon BPP 330 (primer) and Interpon D1036 (topcoat). Each layer was baked at a certain temperature and duration in a special chamber;

– Liquid paint-varnish layers consisting of Interzone 954 (primer) and Interfine 691 (topcoat), which were air dried at 25°C. All paint materials were manufactured by AkzoNobel Stoneygate Lane Felling, Gateshead, Tyne & Wear, NE10 0JY.

Paint coatings were tested by thickness measurements with combined Fischer Dualscope FMP20 coating thickness gauge, resistance to cracking or peeling off the substrate by bending, adhesion properties by lattice method, and for impact toughness.

Corrosion resistance of combined passive and paint coatings was determined in a model corrosion medium of 3±0.2% NaCl aqueous solution at ambient temperature for 24 h.

In conclusion, a comparative analysis of the influence of pretreatment of chromate and molybdate films in particular on indicators characterizing the properties of paints and varnishes has been made.

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## 1-P5. Dielectric spectroscopy study of $Na^+$-ion conducting PEO/E8/$NaIO_4$ salt-complexed polymer/liquid crystals composite

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We have studied ion-conducting electrolytic material composed of polymer polyethylene oxide (PEO) and the nematic liquid crystal (LC) E8 with added sodium metaperiodate ($NaIO_4$): an ionic compound that acts as ion donor. In the PEO/E8/$NaIO_4$ $Na^+$-ion conducting polymer-ion complexes, PEO and E8 were in the ratio 70:30 wt.%, and the $NaIO_4$ salt was included at a concentration of 10 wt.%. Freestanding films with a thickness of 150 μm of this polymer/LC composite electrolyte produced by solution casting technique were examined. Upon temperature variation from 25 to 50°C the frequency behaviour of both complex dielectric permittivity and complex electric modulus of PEO/E8/$NaIO_4$ were characterized by means of complex dielectric spectroscopy in the range from 1 Hz to 1 MHz of applied electric field. Temperature-dependent behaviour of these key characteristics regarding flexible organic electronics applications were interrelated to the structural properties of the studied electrolyte material. Useful information on dielectric relaxation processes relevant to electric field-responsive applications of the PEO/E8/$NaIO_4$ dielectric was obtained. The results show that the produced $Na^+$-ion conducting polymer/LC composite electrolyte is attractive for practical application in flexible organic electronics and sensories as well as for use in dielectric devices utilizing the unique properties of nematic LCs.

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## 1-P6. Anodization: a simple and versatile method for highly textured surfaces formation

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Anodization could be considered an electrochemical method for the formation of high-textured metal oxide layers by anodic polarization of the substrates at defined conditions. Although this method is well investigated during the 20th century a variety of new fields of applications are known nowadays. Indeed, during the recent decades anodization has appeared as indispensable approach for facile elaboration of microelectronic components, sensors, and alternative energy sources. In this sense, the present poster shows the most important factors, which result in formation of highly textured porous and dense anodic oxide layers. Thus special attention is given to the formation of anodic aluminium oxide (AAO) layers for corrosion protection of lighted transport and aircraft vehicles. Attention is also turned to formation of both porous and dense AAO layers in accordance with electrolyte used, low temperature anodization also known as ‘hard anodization’, and high voltage anodization known as plasma electrolytic oxidation.

## 2-O1. Use of ([$^{18}$F] FDG) as a prosthetic group for indirect radiofluorination

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Positron emission tomography (PET-CT) is used for imaging various diseases. $^{18}$F-labelled fluorodeoxyglucose ([$^{18}$F]-FDG) is a glucose analogue and is the most commonly applied PET radiopharmaceutical for assessment of oncological, cardiac, and neurological diseases. In addition ([$^{18}$F]-FDG) can be used as a suitable prosthetic group for indirect radiofluorination of sensitive macromolecules by forming an oxime or hydrazone bond.

[$^{18}$F]-fluorodeoxyglucose was prepared in Clinic of Nuclear Medicine at St. Marina University Hospital in Varna for clinical routine purposes using nucleophilic radiofluorination. The authors developed a method for oxime formation between [$^{18}$F]-FDG and a bifunctional tetrazine derivative under mild conditions and in a clinical setting. Synthesis was carried out in a weak acidic environment of pH 4–4.3 at 70°C in the presence of *p*-methoxyaniline as a catalyst. Reaction progress was monitored by radio thin layer chromatography. Marked products had a radiochemical yield (uncorrected for radioactive decay) between 30 and 80%.

Further, [$^{18}$F]-FDG-modified tetrazine derivative will be used for a bioorthogonal cyclooctane click reaction.

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## 2-O2. Bis(dichlorotriazine)-substituted reactive dyes containing stabilizer fragment as a decision to solve ecological problems

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One rather successful decision to solve ecological problems is synthesis of reactive dyes. In contrast to other classes, coloration with these dyes is due to the formation of covalent (chemical) bonds with the material that guarantees durability of the colour on physical factors. Most important of these materials are the dichlorotriazine dyes. However, they have a serious disadvantage. During coloration because of their high reactivity and closely spaced chlorine atoms, part of the dye is being lost in the bath. This additional problem was successfully solved by synthesis of homobifunctional dyes containing two or more active groups located in different parts of the dye molecule.

In the last decade, much attention has been paid to protective properties of textiles against UV radiation originating from sunlight. Use of 4,4′-diaminostilbene-2,2′-disulphonic acid in the preparation of UV-absorber derivatives of s-triazine has been reported and introduction of this residue in dye molecule may increase its UV-protection properties.

Having in mind aforementioned three bis(dichlorotriazine)-substituted reactive dyes containing a residue of 4,4′-diaminostilbene-2,2′-disulphonic acid as bridging group between two identical chromophores were synthesized. The prepared dyes were evaluated on cotton and compared with commercial dichlorotriazine dye. Exhaustion and fixation degree was assessed. Optical properties L*, a*, b*, C*, and h* from the CIELAB colour space of the resulting textile samples have been examined. Photostability of dyes and dyed fabrics samples was investigated. Performed studies indicated that textile samples with uniform colouring and similar colour shades were obtained with all reactive dyes. Introduction of stabilizer fragment in dye molecule increased the photostability within 20–25%.

## 2-P1. Ultrasound-assisted synthesis of inulin esters with capric acid and evaluation of its physicochemical, antimicrobial, and anti-complementary properties

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This study aimed to perform 'green' synthesis of inulin caprates by ultrasonic irradiation and to evaluate its physicochemical properties and biological activities. Esterification reaction was performed in the presence of NaOMe catalyst and absence of solvent. Inulin esters were characterized by FTIR and NMR spectroscopy. Additionally, melting point, water activity, foam ability, foam stability, and surface activity of inulin caprates were evaluated. Antimicrobial potential of inulin ester was tested against sixteen microorganisms (Gram-positive and Gram-negative bacteria, yeasts, and fungi). Moreover, anti-complementary activities of initial inulin and its esters were evaluated. Inulin esters with capric acid were obtained with degree of esterification 0.30–0.60 with hydrophilic-lipophilic balance (HLB) above 10. The resulting inulin ester showed promising foaming properties within concentration region 0.5–2%. Increasing concentration of inulin caprates led to a decrease in surface tension. The prepared foams in concentration 1.5 and 2% were characterized by foam stability of 50–60% up to 60 min. Inulin caprates (10 mg/ml) showed strong inhibitory effect against *Bacillus subtilis* ATCC 6633, *Bacillus cereus*, *Escherichia coli* ATCC 25922, moderate effect against *Staphylococcus aureus* ATCC 25923 and *Listeria monocytogenes*, and slight to moderate effect against yeast and fungi. This ester was inactive against the growth of *Proteus vulgaris* 6380.

## 2-P2. Design, synthesis, and anti-coronavirus activity of novel amides containing isoquinoline heterocyclic system

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COVID-19 pandemic is the most significant event in the recent history of humankind, which changed the life of billion people worldwide. Being at the end of the last wave of the pandemic, new waves are not ruled out in the future and thus the need of efficient treatment has not yet diminished. SARS-CoV-2 is not the only virus that migrates from animals as more than 60% of existing human infectious diseases are zoonotic and more than five new human diseases appear every year [1]. These alarming facts show the need of discontinuous research of new biologically active compounds, especially those with potential antiviral activity.

In search of new active antiviral compounds we decided to design novel heterocyclic compounds, based mainly on tetrahydroisoquinoline and pyrrolo[2,1-a]isoquinoline, combined with different pharmacophoric nitrogen containing heterocycles. The later functionalization of the main heterocyclic moiety with incorporation of other *N*-heterocycle through amide bond formation is believed to lead to the desired biological activity. Investigation of the antiviral effect and cytotoxicity of the newly synthesized structures toward Human Coronaviruses 229E, OC43 and SARS-CoV-2 showed promising results for some of the compounds tested.

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## 3-O1. Synthesis and characterization of organic-inorganic hybrid membranes modified with gold nanoparticles

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Sol-gel approach was applied for preparation of thin membranes based on hybrid organic-inorganic polymer matrices modified with pre-synthesized gold nanoparticles (AuNPs). Aqueous dispersion of AuNPs was preliminary synthesized by green chemical reduction method and dispersed at low NPs concentration by sonication into three hybrid matrix solutions: PVA-PEG-$H_3BO_3$ (M1), PVA/PEG/pre-hydrolysed TEOS (M2), and PVA/PEG/$H_3BO_3$/pre-hydrolysed TEOS (M3). Optically transparent hybrid membranes with and without AuNPs were fabricated by the solution casting technique. Structure, morphology, and optical properties of pre-synthesized nanoparticles and membranes prepared were studied by XRD, SEM, TEM, and AFM observations, FTIR and UV-Vis spectroscopy, and TG and DSC analyses. Swelling behaviour and mechanical properties of membranes were also characterized. It was found that all the studied characteristics were strongly influenced by matrix components. Gold nanoparticles completely aggregated in the porous polymer-borate hybrid film. The most homogeneous distribution of nanoparticles was observed in M2 dense hybrid film containing silica. Sorption behaviour of the most frequently determined trace toxic elements was studied with PVA/PEG/TEOS (M2) and PVA/PEG/TEOS/ AuNPs membranes within pH 3–9. Results obtained by ISP-MS undoubtedly confirmed higher extraction efficiency of PVA/PEG/TEOS/AuNPs membrane ensuring quantitative sorption of all studied trace elements at established optimal conditions.

## 3-P1. The theory for disperse structure of real crystals as a predecessor of the non-classical crystallization theories

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Commonly accepted classical theory for crystal growth developed by Kossel and Stranski describes crystallization as a layer-wise deposition of atoms, ions, or molecules on the surface of a crystal nucleus [1]. Based on experimental data, at the same time D. Balarew developed the idea for colloid chemical growth of real crystals, viz. that clusters of about 0.01-μm size (nanoparticles) aggregate into a disperse structure of real crystals [2]. For many reasons this theory remained in forgetfulness.

However, in the last two decades an increasing number of examples were observed, which classical models could not explain. Finally, it was proven that the crystals could also grow by attachment of nanoparticles, a process known as non-classical crystallization [3]. Therefore, D. Balarew was perhaps the first scientist who determined the ability of the nanoparticles to form crystals through oriented attachment.

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## 3-P2. Study on the equilibria of complex formation of cobalt(II) with 4-(2-thiazolylazo)resorcinol and Nitron

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Cobalt is a typical transition and complex formation metal essential from biochemical point of view. Cobalt complexes with chelating ligands containing N, O, and S donor atoms were studied because they have industrial, biological, pharmacological, and medical applications. Ion-associated complex formed between Co(II) anionic chelate 4-(2-thiazolylazo)resorcinol (TAR) with the cation of 1,4-diphenyl-3-(phenylamino)-1H-1,2,4-triazole (Nitron, Nt) in the liquid-liquid extraction system Co(II)-TAR-Nt-$H_2O$-$CHCl_3$ was studied. Optimum conditions for complex formation and extraction of the ion-associated complex were established by spectrophotometry. Beer's law validity was checked and some analytical characteristics were calculated. Reagents molar ratio was determined by independent methods. On this basis, reaction scheme and general formula of the complex were suggested. The association process in aqueous phase and extraction equilibria were investigated and characterized quantitatively. Equilibrium constants of the processes were calculated by independent methods.

## 3-P3. Synthesis of layered copper-zinc hydroxide nitrate nanoparticles

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This study is aimed at developing knowledge about preparation, properties, and thermal decomposition of mixed Zn-Cu nanosized hydroxy nitrates. Novelties could help expand these nanoparticles use as precursors to produce important nanostructured materials for practice. Precipitation of the mixed hydroxy nitrates was carried out at 60°C by (i) pouring 3.6 M KOH into nitrate mixture and (ii) simultaneous dropwise adding copper nitrate and sodium hydroxide to the zinc nitrate solution. Pure $Zn_5(OH)_8(NO_3)_2.2H_2O$, $Zn_3(OH)_4(NO_3)_2$, and $Cu_2(OH)_3NO_3$ as reference compounds were synthesized as well as five mixed Cu-Zn hydroxide nitrates of the following composition: $Cu_{20}Zn_{80}$, $Cu_{40}Zn_{60}$, $Cu_{50}Zn_{50}$, $Cu_{60}Zn_{40}$, and $Cu_{80}Zn_{20}$. XRD, FTIR, SEM, TEM, ICP-AES, and thermal analysis were applied for sample characterization. It was established that $Cu_2(OH)_3(NO_3)_2$ was the host material in the mixed samples in all cases of copper nitrate and zinc nitrate coprecipitation. On the contrary, in the case of mixed Zn-Cu oxides prepared by thermal decomposition of mixed Cu-Zn hydroxy nitrates ZnO was the host material. The composition of the mixed Cu-Zn hydroxy nitrates strongly depended on Cu/Zn molar ratio in stock solution. At a Cu/Zn molar ratio below unity synthesized samples contained $Zn_5(OH)_8(NO_3)_2.2H_2O$ and $(Zn_1Cu_1)(OH)_3NO_3$ while at a Cu/Zn molar ratio above unity they were composed of $Cu_2(OH)_3NO_3$ and $(Zn_1Cu_1)(OH)_3NO_3$.

## 3-P4. Direct mechanochemical synthesis and characterization of $SrWO_4$ nanoparticles

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A single phase of $SrWO_4$ was synthesized by mechanochemical treatment at room temperature. Stoichiometric mixture of $SrCO_3$ and $WO_3$ of 1:1 molar ratio was subjected to intense mechanical treatment in air using a planetary ball mill (Fritsch–Premium line–Pulversette No 7) at a milling speed of 500 rpm applying two different ball to power ratios (10:1 and 20:1). Phase and structural transformations were investigated by X-ray diffraction (XRD) and infrared (IR) spectroscopy. Morphology and optical properties of the obtained products were analysed by TEM analysis and UV-Vis spectroscopy. One hour milling time was sufficient for $SrWO_4$ formation using ball to power ratio of 20:1, while 5 h milling time was necessary for ball to power ratio of 10:1. Well-resolved absorption bands at 830 and 410 $cm^{-1}$ in the IR spectra confirmed phase formation of $SrWO_4$. Crystallite size of the $SrWO_4$ phases calculated from XRD and the TEM observation was in the range within 16–25 nm. The UV-Vis absorption spectra showed one strong peak at 210 nm and the calculated optical band gaps (Eh) were in the range of 4.72–4.92 eV.

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## 3-P5. Optical, photocatalytic and antibacterial properties of $TiO_2/TeO_2/B_2O_3$ nanopowders prepared by sol-gel technique

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In the $TiO_2$-$TeO_2$-$B_2O_3$ ternary system melt quenched glasses have been obtained with high $TeO_2$ content (over 60 mol.%) and microheterogeneous structures observed in a wide concentration range. In this study, $TiO_2$ rich compositions were selected which are difficult to be prepared by the melt quenching method. Moreover, there is no data for gel formation in this ternary system. Transparent and monolithic $TiO_2/TeO_2/B_2O_3$ gels were obtained. All gels were synthesized using a combination between organic and inorganic precursors by varying component content. Titanium butoxide, telluric(VI) acid, and boric acid were used as precursors. Differences in decomposition degree of Ti butoxide in the presence of $H_3BO_3$ and $H_6TeO_6$ acids were observed. Phase transformations of the gels obtained in the temperature range 200–700°C were investigated by XRD. Composite materials containing an amorphous phase and different crystalline phases (metallic Te, α-$TeO_2$, anatase, rutile, and $TiTe_3O_8$) were prepared. Thermal stability of the gels in the temperature range 150–600°C was investigated. IR results showed the short-range order of the amorphous phases, which are part of the composite materials consisting of $TiO_6$, $BO_3$, $BO_4$, and $TeO_4$ structural units. Since free $B_2O_3$ amount was not detected in the three-component amorphous compositions, a better connectivity between the building units as compared to binary $TiO_2$-$B_2O_3$ compositions is suggested. UV-Vis spectra of the as prepared gels exhibited a red shift of the cut-off due to the presence of boron and tellurium units. Gel microstructure was verified by scanning electron microscopy (SEM). Photocatalytic tests showed that the samples exhibited photocatalytic activity toward Malachite green organic dye. The composition exhibited good antimicrobial activity against *E. coli K12*.

## 4-O1. Diversity in the coordination chemistry of polyether ionophore antibiotics

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The polyether ionophores used as coccidiostatics in the veterinary medicine recently have attracted the scientific attention due to their promising potential as therapeutics in the treatment of various malignancies. Moreover, the effectiveness of these antibiotics was reported to be influenced by the neighbor metal cation environment assuming the formation of coordination species of diverse composition and structure.

In this study, the achievements in the field of the complexation chemistry of polyether ionophores are reviewed as well as the structures and properties of their metal-based derivatives. The antibiotics Lasalocid, Monensin and Salinomycin are able to form hetero- or homometalic complex species, binding metal ions of various oxidation state. The properties of the novel compounds were studied by a plethora of spectroscopic methods, including X-ray diffraction on single crystals. Monensin and Salinomycin were found to form isostructural coordination compounds with a number of divalent metal ions, that why the effect of the cation which it may render on the bioactivity of the parent ligands was evaluated at *in vitro* conditions using Gram-positive microorganisms and human/animal cancer cell lines. The *in vivo* acute toxicity data (white mice) combined with the growth inhibition and cytotoxicity effects of the target compounds revealed that some complexes of Monensin and Salinomycin can be treated as promising metallodrugs which possess stronger activity against the bacteria strains and cancer cells, but are less toxic in the studied animal model compared to the commercially used antibiotics.

## 4-O2. Atomic absorption analysis of copper and zinc and spectrophotometric analysis of antioxidant activity in serum of women with impair bone density

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There are few and contradictory analyses for changes in serum concentrations of Cu and Zn, and for changes in antioxidant activity in violation of bone homeostasis. The aim of our study was to elucidate the relationship between serum Cu and Zn concentrations and changes in bone density, and to determine how these changes affect total antioxidant activity (AOA) in women with reduced bone density. The study included 66 menopausal and postmenopausal women from Sofia. Four groups with different bone density, measured by DEXA, were formed: with osteoporosis; with osteopenia; general group of patients; control group.

Blood serum Cu and Zn levels were measured by flame atomic absorption analysis. The results show a higher level of serum Cu and Zn in patients with osteopenia and osteoporosis compared to the group with normal bone density.

T-test showed statistical significance of the results for Cu when comparing the mean values between the groups with osteopenia, osteoporosis and the general group *vs* controls, but not for the results of Zn.

The ratio of serum Cu/Zn concentrations was determined, which shows a regular change with the degree of the disease. There is a significant difference between osteoporosis and controls, $P = 0.037$.

Spectrophotometric ABTS test determined the total AOA% of serum. The analysis of the results indicates that patients with lower bone density have higher AOA%, higher Cu and Zn concentrations, higher Cu/Zn ratio values.

## 4-P1. ICP-OES: Influence of plasma operating conditions on detection limits

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Control and optimization of the plasma operating conditions is of prime importance for determination of trace elements and especially for improving detection limits in pure solvent and true detection limits in the presence of different matrix. Radial viewing 40.68 MHz inductively coupled plasma optical emission spectrometry (ICP-OES) was applied for determination of trace elements in environmental materials. The line intensity ratio Mg II 280.270 nm/Mg I 285.213 nm (Mg II/Mg I) was measured to evaluate robustness of the plasma operating conditions. Excitation conditions from non-robust to robust were varied accordingly to minimize the detection limits in the determination of trace elements by using selected prominent lines with different spectral characteristics in the presence of 'pure' and complex matrices. The operating conditions were affected by different constant and variable parameters: incident power, carrier, and sheathing gas flow rates. It was found that the excitation conditions in ICP were modified by varying incident power and sheathing gas flow rates for an optimal value of the carrier gas flow rate, by this the aerosol formation and transport processes are the same under different excitation conditions in inductively coupled plasma. A relationship between Mg II/Mg I ratio values and excitation temperature in ICP was obtained. The lowest possible detection limits in pure solvent and the true detection limits in the presence of 'pure' and complex matrices were achieved.

## 4-P2. Study of mine tailings from Bulgarian industry as precursors for geopolymer materials

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The use of mine tailings in geopolymerization and refractory technologies as a source of raw materials is currently in the focus of research interest. This study is a part of project aimed at developing innovative processing techniques that could be able to make mine tailings and industrial wastes suitable for replacing concrete based on ordinary Portland cement, reducing the requirements of primary raw materials, waste generation, and landfilling. Improvement of currently developed materials could be achieved by obtaining ambient cured geopolymers with 100% recycled raw materials and self-flowing refractories (high temperature lining) of low or ultra-low cement content.

This study presents results of valorisation possibility of high-volume mineral residues from mining activities in Bulgaria for development of geopolymers with low $CO_2$ footprint suitable for 3-D printing applications. Considering specific applications, mine tailings from different sources in Bulgaria need to be characterized in view of their use as precursors of geopolymer obtaining. Al, Si, Ca, and S content as well as reactive activity in alkaline media were studied. Additionally, the mobility of heavy metals and their fractionalization in the material were tested applying different approaches for sequential extraction. Results obtained showed that material from the studied mine tailing contained relatively high concentrations of Al and Si and moderately low concentration of S. Thus, the studied mine tailing appeared to be a suitable precursor for application in geopolymer technology. The sample contained relatively low Ca concentration, which could be overcome by blending the reactive mixture with appropriate source of Ca. Results of heavy metals sequential extraction can be used in a further study of heavy metal encapsulation in geopolymer matrix to estimate characteristics of environmentally friendly materials.

Acknowledgement: Support by Bulgarian National Science Fund, project 'RecMine - Environmental footprint reduction through eco-friendly technologies of mine tailings recycling' ERA-MIN 3 program, is acknowledged.

## 4-P3. Detection of hydroxyl and carboxyl derivatives of marine biotoxins in mussel samples from Bulgarian coast of the Black Sea

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Marine biotoxins are produced by diverse microorganisms and accumulate in filter-feeding shellfish and can develop into a food safety risk. Recently a pectenotoxin-2 (PTX2) and yessotoxin (YTX) dominated profile was established in mussel samples from Bulgarian coast which was associated with the specific characteristics of the Black Sea. The aim of this study is to investigate the presence of derivatives of both pectenotoxin-2 and yessotoxin in mussels (*Mytilus galloprovincialis*). The study included 17 samples harvested in the period February – July 2021. Liquid chromatography tandem mass spectrometry (LC-MS/MS) was applied for determination of the marine biotoxins and its derivatives. Limit of detection of PTX2 (100 pg/µL) and YTX (1000 pg/µL) were calculated 3.73 pg/µL and 100.00 pg/µL, respectively. The analogues PTX2-seco acid (sa), (m/z 894/213-11.70), an isomer of PTX2-seco acid (iso-PTX2-sa) (m/z 894/213-11.90) and hydroxy-YTX (m/z 1176/981-11.70) were detected in the mussels. The levels of PTX2-sa (5.94 – 125.43 pg/µL) were higher than of iso-PTX2-sa (5.00 – 59.14 pg/µL). Hydroxy-YTX were found in the range 108.19 – 316.37 pg/µL. The presence of these metabolites could be explained by the transformations that the toxins undergo during the extracellular digestive process in mussels. The main transformation route is the esterification with fatty acids of different chain lengths.

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## 4-P4 Theoretical sizing study of silver-based nanoparticles by spICP-MS using ionic calibration strategy

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A calibration strategy based on ionic standards was used for determination of diameters and associated uncertainty of four types of Ag-based nanoparticles (NPs): AgCl, AgI, $Ag_2S$, and $Ag_2O$.

For the purposes of analysis, a set of Ag ionic standards were measured. Solution concentration was calculated so to ensure delivering of silver mass (at $t_d$ = 5 ms) equivalent to NPs diameter between 20 and 100 nm. Since we have already validated the ionic calibration strategy for Ag NPs, and the Ag-based NPs have lower melting and boiling points, this gives us a reason to assume that Ag-based NPs would behave similarly and losses due to incomplete evaporation and/or ionization are not expected. Therefore, characterization of all mentioned NPs can be accomplished by measuring only the signals for Ag. Using the signal noise associated with introduced Ag mass, $Ag_{mass}$ uncertainty was first calculated. In order to obtain the limits of confidential interval, the obtained uncertainties were recalculated as standard uncertainties for corresponding masses and then transferred to uncertainties of individual AgNP's diameter (mean ± $U_c$). The mean value of evaluated confidential intervals was used as a criterion for estimation of spICP-MS size resolution, and nanoparticle clustering in PSD. Since NPs' properties are strongly dependent on shape and composition we propose two models to calculate the size of spherical silver NPs and cubic $Ag_2O$ NPs.

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## 4-P5. New pyrene containing complexes with anticancer activity

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Herein, we report on the synthesis and structural characterization of pyrene-containing complexes of Cu(II) and Pt(IV). While the former are complexes of pyrene-bearing Schiff base, the Pt(IV) complexes are analogues of cisplatin with one or two pyrene substituents in the axial position. The cytotoxicity profile of all three complexes has been studied on a panel of human tumour cell lines as well as healthy cells, and compared with that of cisplatin. Furthermore, studies on their reactivity with biomolecules relevant to the treatment of cancer have also been performed based on NMR measurements. Proteomic analysis was done on chemosensitive and cisplatin-resistant leukemic cells (HL-60). Platinum uptake by the cells treated with the studied compounds have been evaluated in different cell fractions by means of ICP-MS, applying procedures used in our previous studies on metallosupramolecular capsules [1]. The data show very promising results for the cytotoxicity of the Pt(IV) prodrugs in the nanomolar concentration range.

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1. A. Ahmedova, R. Mihaylova, S. Stoykova, V. Mihaylova, V. Mihaylova, T. Paunova-Krasteva, L. Mihaylov, S. Stoitsova, D. Nihtianova, G. Momekov, D. Momekova, M. Yoshizawa, Eur. J. Pharm. Sci., 155 (2020) 105545.

## 4-P6. Hyphenation of PVG to MSIS-MP-AES for trace determination of mercury

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For the first time, UV-C induced vapour generation of mercury was combined with multimode sample introduction system (MSIS)® used as a gas liquid separator and microwave plasma atomic emission spectrometry. A homemade instrumental set-up based on mercury UV-C lamp (253.7 nm) and external Gilson peristaltic pump. The main parameters affecting the method sensitivity for Hg determination were optimized- the type and concentration of photo reductant (HCOOH, $CH_3COOH$ and mixture of these acids), the UV-C irradiation time of reaction mixture in the photo reactor, the $N_2$ gas flow carrier rate in MSIS (the most critical parameter), the plasma viewing position and stabilization time. The results achieved with model solutions of Hg under optimized conditions have shown the method capability of reaching instrumental limit of detection below 1 ppb, which considerably improves the performance of MP-AES for trace mercury analysis.

## 4-P7. Sample preparation techniques for multielement analysis of solid waste materials using LA-ICP-MS method

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For decades, ICP-MS is one of the most preferred methodя for elemental analysis worldwide because of its low detection limits, good accuracy and reproducibility, and the possibility for simultaneous concentration determination of more than 70 elements in a wide concentration range. ICP-MS with laser ablation (LA-ICP-MS) is a popular and convenient method for analysis of solid samples, such as geological and archaeological, for which solid certified reference materials (CRM) are available. One of the difficulties to apply LA-ICP-MS for waste sample analysis is the lack of CRM of appropriate geometry necessary for instrument calibration and quality control. Commercially available waste CRMs are limited in powdery form. This requires preliminary pellet preparation in a suitable binder material as well as uniform particle size and homogeneous distribution in samples' and standards' pellets.

We investigated suitability of different compounds used as a binding material in pellet preparation. Stability and homogeneity of the obtained tablets were studied by measuring signals of the studied elements using intensity *vs.* time method. Concentrations of a maximum number of elements were determined. A possibility of using internal standard was considered to eliminate effect of sensitivity drift and improve reproducibility and accuracy.

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## 4-P8. Determination of element and anionic composition of surface waters and sediments by analytical methods: a comparative study

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Anthropogenic pollution and environmental protection are a global problem. The increase in population, industry, traffic, agriculture, landfills of various waste materials and wastewater cause environmental pollution. Concentrated polluters of surface water are usually wastewaters from households, industrial facilities, and large urban agglomerations, which are located near rivers or lakes. Pollutants can be chemical substances such as metals, inorganic nutrients, radionuclides, organic waste, pathogenic microorganisms, and suspended solids. Surface waters are carriers of large quantities of various waste materials. Sediments are part of the environment that provides essential environmental information and is increasingly recognized as a carrier and potential source of contamination of aqua systems. Chemical analysis of surface water and sediments provides an efficient tool for water-quality management. Numerous investigations have been performed to establish environmental changes of surface water and sediments using different instrumental methods as AAS, ICP-OES, ICP-MS, XRF, and INAA depending on the number of elements to determine and detection limits of the methods.

An optimized ICP-MS method for determination of macro, micro, and trace elements in surface waters is demonstrated. Possibilities of several analytical methods for analysis of sediment samples were studied using stream and lake certified reference materials: ICP-MS after acid digestion, and non-destructive LA-ICP-MS and XRF after pellet preparation. A method for determination of anionic composition of surface waters by ion chromatography is also presented.

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## 4-P9. Ion imprinted polymers for uranium determination by solid phase extraction

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Uranium is abundant chemical element and occurs as three natural isotopes $^{238}U$, $^{235}U$, and $^{234}U$, which are radionuclides of low specific activity. Natural uranium is present in the environment because of leaching from granites and other mineral deposits. In the present study ion imprinted polymer for uranium sorption was synthesized using 4-(2-pyridylazo)resorcinol (PAR) as a ligand via dispersion polymerization and characterized by SEM for polymer particle morphology and shape and nitrogen adsorption-desorption studies of particle surface area and total pore volume. Kinetic experiments performed showed that complexation between U(VI) ions and PAR chelating ligand incorporated in a polymer matrix was the rate limiting step. Investigations by Freundlich and Langmuir adsorption isotherm models showed that sorption process occurs as a surface monolayer on homogeneous sites. High extraction efficiency of synthesized sorbent toward U(VI) allowed development of analytical procedure for U determination in surface and ground waters based on solid phase extraction and ICP-OES/ICP-MS measurements. Recoveries achieved in different type of waters varied between 88 and 95%. Analytical procedure proposed for U determination in surface waters is characterized by low limits of detection/quantification 0.05/0.15 (ICP-OES) and 0.003/0.001 (ICP-MS) μsg/L as well as by good repeatability (varied within 5 to 9%) which ensures its application for routine control of U content in water bodies in national monitoring. Validity and versatility of the proposed analytical method was also confirmed by parallel analysis using Alpha spectrometry.

## 5-P1. Cobalt-manganese oxides supported on ion-exchanged clinoptilolite for catalytic *n*-hexane oxidation

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Catalysts based on Co-Mn are most effective and economically advantageous for removing volatile organic compounds (VOCs). A combination of mixed cobalt-manganese oxides deposited over clinoptilolite is expected to have high catalytic activity.

The zeolite used in this work was obtained from a deposit located in Eastern Rhodope Mountains, Bulgaria. Raw clinoptilolite was modified into H-form by ion exchange. Co-Mn catalysts with ion exchanged clinoptilolite as carrier were prepared by the method of wet impregnation from aqueous solutions of ($Co(NO_3)_2.6H_2O$ and $Mn(NO_3)_2.4H_2O$). Prepared catalysts were characterized by powder XRD, TPR, XPS, and in the reaction of total oxidation of *n*-hexane. XRD analysis showed that the natural material contains 89 wt.% clinoptilolite and about 8 wt.% opal-cristobalite. The main structure of the ion-exchanged carrier is clinoptilolite. In all investigated catalyst samples XRD analysis revealed the existence of mixed metal oxide $CoMnO_3$ phase. In 15Co5Mn sample, $Co_3O_4$ was determined as well whereas additional phase in 5Co15Mn sample was $MnO_2$.

All investigated samples demonstrated catalytic activity in complete oxidation of *n*-hexane. The best activity of 15Co5Mn sample is explained by co-existence of $Co_3O_4$ phase together with mixed oxidation states of Co and Mn with a Co to Mn ratio close to 1:1 on the surface as determined by XPS.

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## 5-P2. Nano-sized cobalt oxide supported on $Al_2O_3$ and $SiO_2$ for preferential CO oxidation in hydrogen reach gases: influence of the support and preparation method

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Preferential CO oxidation (PROX) is a simple, efficient, and economic method for CO removal. Catalysts so far proposed for the PROX process are based mainly on noble metals such as Pt, Rh, and Ru deposited on different supports with or without any promoter. Non-precious metal catalysts are considered a potential alternative for the CO PROX reaction. In this connection, Co-based catalysts have shown a promising catalytic performance.

$Co_3O_4$ nano-sized particles were supported on silica or alumina by two methods: hydrothermal procedure (HT) and impregnation (I). Prepared samples were characterized by X-ray diffraction (XRD), X-ray photoelectron spectroscopy, and temperature-programmed reduction. Finely divided weakly interacting cobalt oxide particles were formed on the surface of the silica-supported catalyst prepared by hydrothermal method. In addition to $Co_3O_4$ phase, a superficial Co-Al spinel-like phase was formed on the surface of alumina-supported sample as these phases predominate when the sample is obtained by impregnation. The most active sample in the PROX reaction is the one supported on Co-$Al_2O_3$-HT. This could be related to finely divided $Co_3O_4$ strongly interacting with the support and presence of $Co^{2+}$ ions on the catalytic surface. $Co^{2+}$ ions could be sites for oxygen adsorption and formation of active oxygen species.

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## 5-P3. Comparison between photocatalytic efficiency of pure and silver ion fixed ZnO thin films for degradation of Methylene Blue

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Nanostructured ZnO thin films were fixed with different $Ag^+$ concentration ($1\times10^{-2}$, $1\times10^{-3}$, $1\times10^{-4}$ M) in the presence and absence of UV illumination for the first time. The samples were prepared by sol-gel method on glass substrates using dip-coating technique. The films were characterized by means of scanning electron microscopy and X-ray diffraction. The surface was with characteristic ganglia-like structure and hexagonal crystalline structure. Further, the Ag-fixed films were tested for photocatalytic decomposition of Methylene Blue in aqueous solution upon UV illumination. Comparative experiment with pure ZnO films was also provided. Experimental results revealed that the pure films showed a lower photocatalytic activity in Methylene Blue dye decolourization than those fixed with silver. Silver inclusion has played a vital role in defect concentration and Schottky junction at the metal-metal oxide interface. An optimal silver concentration ($1\times10^{-2}$ M) was established which shows the highest photocatalytic efficiency. Nevertheless, all films exhibited a substantial activity under UV light, which is promising for developing new ZnO photocatalysts fixed with $Ag^+$ by the sol-gel method.

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## 5-P4. Silver co-catalytically modified $TiO_2$ films for enhanced photodegradation of Methylene Blue

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Titania films were prepared by sol-gel method using titanium isopropoxide, monoethanolamine, and 2-methoxyethanol. The thin films were deposited by dip-coating technique. Silver ions of different concentration were deposited into the films using UV-light illumination. Physicochemical characterization was performed by scanning electron microscopy, X-ray photoelectron spectroscopy, ultraviolet-visible spectroscopy, and electron paramagnetic resonance experimental techniques. Surface structure (porosity and thickness) of the co-catalytically modified films was identical with a pure $TiO_2$ film, which was favourable to enhance photocatalytic activity. Formation of metal silver and $Ag^+$ clusters has been supported by all used experimental techniques for as prepared and used catalytic samples. The photocatalytic properties of pure and silver co-catalytically modified $TiO_2$ films were evaluated by measuring Methylene Blue degradation by UV-light illumination. $Ag^+$ concentration and the presence of UV-light illumination at the fixing process were investigated during the bleaching process. A maximum catalytic efficiency was observed for co-catalytic films of $10^{-2}$ M $Ag^+$ concentration. It was found that the rate constants increased in the order: $TiO_2/Ag,10^{-4} < TiO_2/Ag,10^{-3} < TiO_2 < TiO_2,Ag10^{-2}$.

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## 5-P5. Hydrogen production via water-gas shift reaction over Ni-Al layered double hydroxide promoted by Au, Cu, or Re

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Water-gas shift (WGS) reaction is well-known industrial process targeting hydrogen production. Designing well-performing and economically profitable WGS catalysts is the key toward production of pure hydrogen for application in fuel cell processing systems. Promotional role of Au, Cu, or Re in the WGS performance of Ni-Al formulations derived from hydrotalcite precursor was analysed on the basis of deep characterization by BET, XRD, UV-vis, XPS, and TPR measurements of as-prepared and WGS-tested samples. Additionally, modification by ceria was examined. One of the challenges aimed at improving catalyst economic profitability is reducing dependence on the use of precious metals. The goal of present work is to compare the promotional effect of Au, Cu, and Re on WGS performance of NiAl LDHs.

WGS results revealed that catalyst behaviour was strongly dependent on promoter type. The best performance exhibited gold-promoted Ni-Al layer double hydroxide modified with ceria. This system showed a superior catalytic activity as 99.7% CO conversion at 220°C that correlated well with significantly enhanced reducibility of support.

Promotion by gold of $CeO_2$-modified Ni-Al formulation derived from hydrotalcite precursor outperformed WGS activity of Cu- and Re-promoted analogues. However, deactivation resistance of Re-containing sample and enhanced activity of Cu-based sample after tests at different reaction conditions leave open area for future investigations addressing improved catalyst performance by tuning $Re^{4+}/Re^{7+}$ redox structures or optimizing catalyst composition.

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## 6-O1. The potential of CCS and CCU technologies in mitigating climate change

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Anthropogenic greenhouse gas emissions emitted into the atmosphere from various sources (energy production, industries, transportation and others) are the principal cause of climate change. Carbon dioxide concentration in the atmosphere hit a record high level of 421.13 parts per million (ppm) on 10th May 2022 that is 2.74 ppm higher than that measured a year before. Combating climate change has been the main goal of governments across the world including European Union member countries. In this talk we stress on the existence of scientific consensus on climate change and its human cause. The global carbon budget, the negative consequences of climate change on human activities, and strategies and global actions taken for climate change mitigation are highlighted. Carbon capture and storage (CCS) and carbon capture and utilization (CCU) are discussed as perspective technologies for achieving decarbonisation scenarios consistent with the 1.5°C and 2°C global temperature targets. In this respect CCS and CCU are essential for Europe to reach net zero $CO_2$ emissions by 2050. The current status of global CCS facilities is briefly presented including their capacity and state of development/deployment. Both CCS and CCU are discussed as essential technologies to economically meet long-term climate targets and for risk mitigation. CCS and CCU are analysed as drivers of economic growth and employment. Finally, the environmental benefits and risks of these technologies and their public perception are highlighted.

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## 6-O2. Influence of applied external voltage on anaerobic digestion with outside integrated microbial electrolysis cell

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An external microbial electrolysis cell (MEC) was integrated into the ethanol stillage anaerobic digestion reactor (AD). AD-MEC system is a promising technology for enhancing biogas production. It accelerated methane production and stabilization the process. A change in applied external voltage could alter microbial metabolism and could affect substrate degradation rate, volatile fatty acid generation, and biogas production.

The effect of applied external voltage on biodegradability, volatile fatty acid content, and methane production from the produced biogas was studied. Four values of external voltage were selected: 0.6, 0.8, 1.0, and 1.2 V. Biogas production kinetics for 15 days was monitored. For voltages of 0.6, 0.8, and 1.0 V, methane yields increased to 84, 88, and 82%, respectively. Higher voltage (1.2 V) did not increase methane content (75%). The best biodegradability was achieved at low voltages (0.6 and 0.8 V): reduction of chemical oxygen demand by 88–89% and purification of wastewater from sulphates. Acetic acid decreased by 96% at 0.6 V, 95% at 0.8 V, starting from 74% at 1.0 V and 65% at 1.2 V.

## 6-O3. Modelling of 1,2-dibromoethane biodegradation under constant electric field

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The study proposes a mathematical modelling approach for intensifying the biodegradation process of 1,2-dibromoethane using bacterial cells of *Bradyrhizobium japonicum* 273l by applying an electric field. The latter considers product inhibition assuming 2-bromoethanol as the first biodegradation product. For quantitative description of the product inhibition stage, the model of Monod-Yerusalimsky and that of Levenspiel have been used. The effect of the electric field was estimated by the kinetic constants in the models for different initial substrate concentrations. Four models were formed: two using the Monod-Yerusalimsky and Levenspiel equations to describe product inhibition process without electric field and the same ones with taking into account the effect of the electric field. Own experimental data were used for validation of the models. The obtained results show that application of constant electric field leads to complete degradation and the concentration of bromide ions in the medium reaches their stoichiometric values. Positive effect of the electric field was proved based on biomass growth and releasing rate of bromine for a certain period.

## 6-O4. Impact of *Spirulina platensis* biomass on the viability of *Lactobacillus delbrueckii* subsp. *bulgaricus* strain during freeze-drying process

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In this work, the protective capacity of *Spirulina platensis* biomass in the preservation of *Lactobacillus delbrueckii* subsp. *bulgaricus* WDCM 00102 was evaluated. *Lactobacillus bulgaricus* was freeze-dried in the presence of *Spirulina platensis* biomass. The freeze-dried samples were kept at 5 and 25°C for different periods. After desiccation, freeze-drying, or storage, samples were rehydrated and bacterial plate counts were determined. According to the results obtained, *Spirulina platensis* biomass assays demonstrated to be highly efficient in the preservation of *L. bulgaricus*. The higher content of *Spirulina platensis* biomass in the commercial products was correlated with their higher protective capacity. *Spirulina platensis* biomass was widely known by their prebiotic properties. However, their role as protective molecules have not been reported nor properly explored so far. In this work the protective capacity of *Spirulina platensis* biomass in the preservation of *L. bulgaricus*, a strain particularly sensitive to any preservation process, was demonstrated.

## 6-P1. Role of ferrous ions in multispecies biofilm formation

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Iron acquisition is of fundamental importance for microorganisms, since this metal is generally poorly bioavailable under natural conditions. Fe is mostly present as a ferric form in soils, strongly limiting its bioavailability, where most bacteria are found tightly packed within multicellular communities named biofilms. Here, using the soil Gram-positive bacterium *Bacillus subtilis*, this research shows that biofilm formation during their interactions with others microbial species are both essential to ensure Fe uptake from the medium and maintain cellular Fe homeostasis. The biofilm matrix appears to play an important role favouring efficient usage of siderophores. Taken together, our results demonstrate a close link between biofilm formation and iron acquisition in *B. subtilis* and *Escherichia coli*, allowing a better comprehension of how bacteria can cope with metal limitation under environmental conditions.

## 6-P2. Complex approach to ecological assessment of Iskar River and its tributaries in the region of Sofia municipality of Bulgaria

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A complex approach including experimental field and laboratory studies and thermodynamic modelling of the chemical species of the elements was applied to assess water quality of the Iskar River and its three tributaries Lesnovska, Kakach, and Blato Rivers within Sofia municipality. The obtained analytical data reveal high concentrations of $PO_4^{3-}$, $NH_4^+$, and $NO_2^-$ ions in all studied water samples, which is an indication of dangerous domestic pollution. Water is pure in terms of Al, Fe, Co, Ni, Cu, Zn, and Cd. Pb and Mn exceed the MAC in the water of Iskar River after Sofia city, and along the entire flow of the Lesnovska River. Thermodynamic modelling showed impaired electrochemical characteristics of the water of the Iskar River after Sofia city and of the Kakach River before its inflow into the Iskar River, which was associated with high content of $NH_4^+$ ions and dominance of the redox pair $NO_3^-/NH_4^+$ and not the $O_2^-/O_2$ couple characteristic of surface water. Thermodynamically calculated chemical species of the main pollutants, Al, Mn and Pb, show that Pb is potentially the most risky element as its dominant species are easily accumulated by plants complexes with fulvic acids, while Mn is dominated by inorganic forms and Al by inorganic hydroxy complexes at pH > 8 or organic fulvic complexes at pH below 8.

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## 6-P3. Occupational risk assessment of carcinogenic exposure in cement production

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Ensuring safe and healthy working conditions reduces the risk of occupational diseases and accidents. Occupational risk assessment is used as criterion for occupational safety. As one of the many conditions for revision are changes in the legislation in this country. Looking at the risk assessment in workplace different stages are applied. The most important are: identifying the work positions/places exposed to a given danger, measuring the specific agent of the workplace, determining the elements of risk, and calculating the risk. Cement production is associated with generation of mutagens at the workplace, such as exposure to respirable crystalline silica and release of exhaust gases from diesel engines defined as elemental carbon. Problem actuality and seriousness of the consequences on the health of the exposed motivate the purpose of this study: occupational risk assessment of carcinogenic exposure in cement production. The three-factor method (consequences, exposure, and likelihood) was applied, and potential danger at workplaces was identified. Results of the analysis indicate a second-degree risk. Risk reduction measures are proposed.

## 6-P4. Characterization of a material based on lemon balm in order to elucidate adsorption mechanism of copper(II) ions

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In the present work an attempt is made to elucidate the mechanism of Cu(II) adsorption on a plant material based on lemon balm. Batch experiments were carried out in order to study the effects of acidity, contact time, and initial metal concentration on Cu(II) removal. Langmuir, Freundlich, and Dubinin-Radushkevich isotherm models were used to explain equilibrium experimental data and calculate maximum adsorption capacity. The mechanism of retention of copper ions on the biosorbent surface was studied by means of SEM, EDS, FTIR, and XPS methods as well as low-temperature nitrogen adsorption. Desorption experiments were also performed. It was proved that the investigated plant material could be used for effective removal of copper ions from real environmental water sample collected from a source near Asarel Medet copper extracting and processing factory.

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## 6-P5. Sustainable recycling of platinum group metals

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Recently, scientists and innovators worldwide focused attention on investigation of recovery or substitution of platinum group metals (PGMs). PGMs are platinum (Pt), palladium (Pd), rhodium (Rh), osmium (Os), iridium (Ir), and ruthenium (Ru). They are widely used in high-tech devices and applications due to their unique properties as high corrosion and oxidation resistance, and high electrical conductivity and catalytic activity. PGMs are widely used in automotive catalytic converters (three-way-catalysts, diesel-oxidation catalysts, for selective catalytic reduction), chemical catalysts, petroleum catalysts, ceramics, electrical and electronical equipment (mobile phones, printed circuit boards, flat screens, hard discs), jewelry, fuel cells, dental implants (corona prostheses), medical applications (orthopedic implants, chemotherapies), pharmaceuticals (drug precursors), investments and criminology (stain for fingerprints and DNA), etc. In this connection, large number of industries depends on PGMs supply. However, this high PGM demand is dependent on PGM ore mining, which takes place in limited geographical areas. The process of primary PGM production is extremely expensive, complex, unhealthy, and challenging for the manufacturers. In result, the European economy is highly dependent on these suppliers and the PGMs price is rapidly growing. The PGM demand is expected to increase further in next years. In order to address this supply challenge, the circular economy principles should be implemented for PGM effective and sustainable recovery. Novel extraction techniques are focused on high recovery rates, but also on increasing cost efficiency and environmental protection. In this study, mechanochemistry was applied as a green and sustainable method for PGM recovery. This allows reaching higher recovery rates together with reduction of energy use and significant decrease of process environmental impact.

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## 7-O1. Enabling bioprinting of 3D tissue models: the polymer chemistry of 3D extrusion bioprinting

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Bioprinting, a form of additive manufacturing, comprises a number of technologies that allow direct generation of three-dimensional objects, typically, in a layer-by-layer fashion through computer-aided design. The most common processing method is extrusion bioprinting in which highly viscous fluids and/or shear-thinning hydrogels, a.k.a. bioinks, are pushed through a narrow nozzle and deposited on a platform or on a previously deposited layer of the bioink.

This study describes the development of a collagen type I biomaterial ink as a commercial product. Collagen is obtained from bovine tendons by a common enzyme-assisted acid extraction, which includes fractionation via salting out and centrifugation, and lyophilisation steps. The purity of the resulting biopolymer is ascertained routinely by differential scanning calorimetry, sodium dodecyl sulphate polyacrylamide gel electrophoresis, and UV-vis absorbance spectroscopy. Next, the rheology of neutral collagen solutions, in which the collagen is sourced from a number of different animals, and its role as a crucial quality control tool, will be discussed in detail. Notably, the well-known dependence of collagen physicochemical properties on animal characteristics like age can result in hydrogels with wide range of shear modulus values from as low as 10 up to about 1000 Pa at shear stress of 1 $s^{-1}$. Further, the report presents optimization of the ink's components to address slow kinetics of collagen fibrillation and reduce gelation time necessary for an application in extrusion bioprinting. Printability of the collagen ink was validated by formulating a collagen-Caco-2 bioink and extrusion printing it to fabricate 3D colorectal cancer models using a commercial extrusion bioprinter. The models were incubated for up to four weeks. Post-printing cell viability was over 95% and clear cell proliferation was observed after as short as three days of incubation.

## 7-O2. Properties of eco-friendly fibreboard panels fabricated with different adhesive systems based on hydrolysis lignin

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Lignin is the second most common natural polymer, after cellulose. Pulp and paper, and other wood chemical industries generate worldwide significant amounts of residual lignin. Lignin acts as a binder in natural wood. At present, this natural resource is mainly used to produce heat energy. On the other hand, formaldehyde emissions due to formaldehyde binders in the manufacture of wood-based panels are a principal problem. Using lignin as a bio-based binder in producing wood-based panels and particular fibreboard panels will lead to more eco-friendly and safer wood-based products and increase the utilization of natural resources.

This report presents a study to produce eco-friendly fibreboard panels with adhesive systems based on hydrolysis lignin and different auxiliary binders. Phenol-formaldehyde (PF), melamine-formaldehyde (MF), and urea-formaldehyde (UF) resins and magnesium lignosulphonate were used as auxiliary binders. Panels were manufactured at different hot-pressing temperatures. It has been experimentally established that lignin interacts with PF resin, and fabricated fibreboard panels showed properties that significantly exceeded those required by the standard. No such effect was observed when using other auxiliary binders, and the resulting panels manifested unsatisfactory physical and mechanical properties.

## 7-O3. Novel hybrid materials based on polycarboxybetaine methacrylate and calcium phosphates

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Dental caries is one of the most common diseases nowadays. One of the effective methods for prevention of the development of caries is stimulation of the remineralization process, in which hydroxyapatite and non-crystalline calcium phosphates that restore enamel are deposited on the carious spot. Thus, advanced research focuses on the development of new materials with the potential to deliver calcium phosphates in carious lesions to support their remineralization.

Linear macromolecules of polycarboxybetaine methacrylate (PCB) were synthesized by RAFT polymerization and used as a medium for calcium phosphate precipitation. PCB ability to coordinate $Ca^{2+}$ and $PO_4^{3-}$ ions through the charged groups $-N^+R_3$ and $-COO^-$ in the side chains was investigated. Quantitative and qualitative analyses of calcium phosphates obtained in the presence of PCB were carried out using infrared spectroscopy and X-ray spectroscopy and NMR. The resulting hybrid materials were also characterized by dynamic light scattering and differential scanning calorimetry. These materials are expected to demonstrate a good remineralizing ability of artificial carious lesions as they can release in a controlled way calcium and phosphate ions at the site of application.

## 7-O4. Two-layer polyzwitterionic hydrogels capable of changing own shape in a controlled manner

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Polyzwitterions (PZI) are a class of polymers with a specific zwitterionic structure. Each PZI monomeric unit possesses an equal number of covalently bonded positively charged amino groups and negatively charged functional groups in the side chain, with the net charge of the PZI being zero under neutral conditions. Dipole-dipole interactions and betaine structure define PZI ability to response to changes in the environment, which results into reversible changes in their properties, i.e. PZI are behaving as ‘smart’ polymers. For example, polycarboxybetaines (PCBs) respond reversibly to changes in the acidity of the medium, while polysulphobetaines (PSBs) are temperature sensitive. Both types of PZI swell better in the presence of salts than water exhibiting an anti-polyelectrolyte effect. Bilayer polymer hydrogels, in which two polymeric layers with different properties are casted one upon the other, is an advanced approach to obtain smart polymeric materials with reversible shape change. These materials find applications such as adaptive optical lenses by changing ‘smartly’ their focal length, ‘smart’ valves and controllers for liquid or particle flow as well as stents in medicine.

In this work, a two-layer PZI hydrogel made up of PSB and PCB layers was obtained for the first time. It was established that a change in pH and/or salt concentration in aqueous environment of the hydrogel caused a change in its shape. This is due to simultaneous quasi-uniform swelling of one or both layers. The ability of PSB/PCB dual-layer hydrogels to respond ‘intelligently’ to changes of environmental parameters within a series of 5 cycles by demonstrating ‘memory’ to regain its shape under the appropriate conditions was presented.

## 7-P1. Conversion of industrial hemp to biofuel and value-added products

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Growing energy needs and the related environmental problems are the reason for the demand for sustainable, economically feasible, and green resources for biofuels and chemicals. In this connection, various types of lignocellulosic biomass have been studied in recent decades. Among them, industrial hemp has great potential with its multifaceted applications: production of paper, textile, biodegradable plastics, building materials, fuels, medicines, etc.

The aim of the present study is to find an appropriate method for pretreatment of industrial hemp biomass. Hemp fraction contains the residue after mechanical separation of long fibres from hemp stems and by enzymatic hydrolysis to establish the conditions for obtaining maximum yield of glucose, which is a potential raw material for the production of hydroxymethylfurfural (HMF). The latter can be converted to biofuels and valuable chemicals. It has been found that the steam explosion method of pretreatment of hemp biomass gives a higher yield of glucose compared to diluted sulphuric acid treatment. Results of this investigation show that the potential of industrial hemp as a source for the production of biofuels and valuable chemicals is similar to straw as a raw material.

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## 7-P2. Preparation and surface characteristics of bioinspired antibacterial polymer coatings with included porphyrin-based photosensitizer

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One of the most common causes of bacterial contamination is pathogen adhesion to various surfaces. This necessitates the development of various antibacterial coating preparation strategies aimed at preventing the spread of nosocomial infections, which are a current and serious social problem. Coatings that catalytically produce bactericides using externally applied stimuli have attracted a lot of research interest in recent years. One such group includes light-activated antibacterial coatings, which have the property of continuous disinfection of the surface, overcoming the shortcomings of other coatings. This process is a result of irradiation of certain compounds (photosensitizers) with visible light and the production of cytotoxic components such as singlet oxygen and free radicals because of ongoing photodynamic processes.

In this work, the preparation and characterization of photoactive antibacterial bioinspired polymer coatings are reported. These polymer based coatings were obtained by deposition of three consequent layers on a stainless steel (SS) substrate. 3,4-Dihydroxy-phenylalanine (DOPA) functionalized P(mDOPA)-co-P(DMAEMA$^{+}$) polycation was employed as a first layer which anchor to the surface by DOPA-metal interaction. The second layer consisted of silver-loaded ortho-quinone functionalized nanogels (Pox(mDOPA)-Ag$^{0}$/PAH). Thus, the covalent attachment of a photosensitizer as a third layer is possible because of quinone/amine reaction. Ethylenediamine derivative of protoporphyrin IX was used as a photosensitizing agent. Porphyrin derivatives are well known for their antimicrobial activity through the production of reactive oxygen species by visible light absorption.

To analyse the surface characteristics of thus obtained bioinspired antibacterial polymer coatings, several methods were applied as transmission electron microscopy (TEM), scanning electron microscopy (SEM) with energy dispersive X-ray analysis (EDX), and nanoindentation. Antibacterial activity of the coatings against Gram-negative *E. coli* strains was also investigated.

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## 7-P3. Hot acid treatment efficiency in hardwood pulp bleaching

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Hot acid treatment and hot chlorine dioxide bleaching are two well-known technologies within the field of bleaching of hardwood kraft pulp. The concept of these technologies is the hydrolysis of hexenuronic acids whose content is relatively high in hardwood kraft pulp. As a result, chlorine dioxide is consumed only by lignin and pulp bleaching is improved.

The aim of the present study is to determine the effectiveness of hot acid treatment and hot chlorine dioxide bleaching on the removal of residual chromophore structures in the pulp and on the consumption of the bleaching agents.

Results of the acid hydrolysis of oxygen delignified pulp show a significant reduction of the Kappa number, which cannot be explained only by removal of hexenuronic acids. Pulp purification of other chromophore structures is probably due to acid hydrolysis. The process is accompanied by a decrease of pulp Kappa number and viscosity, and a slight reduction in yield. The observed dependences were confirmed in complete bleaching sequences close to industrial conditions. It was found that by optimisation of the bleaching conditions and temperature-time dependences of hot chlorine dioxide bleaching, the consumption of bleaching reagents can be reduced without affecting the yield and pulp viscosity. Disadvantages of hot acid treatment are some reduction in the pulp strength properties and higher energy costs.

## 7-P4. Flocculation accelerated by interval suspension addition

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Among the methods for suspension sedimentation and clarification, flocculation is preferable due to its simplicity, facility, efficiency, low prices, and accessible flocculants. It is proved that flocculation efficiency can be increased considerably by the interval suspension addition to the flocculant solution. It is assumed that fresh suspension particles play a role of binding bridges between earlier added suspension particles coated already with flocculant molecules. Experimentally this hypothesis is proved reliability in this work on the flocculation of grape (Rcacitelli) must with the amphiphilic poly(methacrylic acid-co-methyl methacrylate) copolymer with 0.26 mole fraction of the acid monomer units. A 2.46-fold increase of flocculation efficiency was observed upon two-stage must addition and a 1.95-fold rise after a three-stage procedure. Analysis of this self-acceleration is based on the dependence of the flocculation rate as a function of flocculant concentration. The Bayesian approach was used to determine efficiency of different flocculation stages. The model developed could be easily expanded for analysis of multistage flocculation of other suspension-flocculant systems.

## 8-O1. Desired future profession: a factor influencing students' chemistry learning motivation at school

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Students' learning motivation is influenced by numerous factors. The impact of students' professional orientation on chemistry learning motivation has not been studied in Bulgaria. This research aims to determine the influence of the desired students' future profession on their chemistry learning motivation. A survey of 440 Bulgarian secondary students with a questionnaire to measure their chemistry learning motivation was used. It consists of two parts. The first is related to general issues including an issue related to students' professional orientation, and the second part includes 35 statements measuring students' chemistry learning motivation. Career guidance data was processed by conducting a one-way analysis of variance for independent samples (ANOVA), and statistical procedures were performed by SPSS 4. Chemistry-oriented students say that they feel more self-confident and have a higher opinion of the importance of chemistry learning in comparison with the rest. In terms of active learning, there is an unexpected significant difference between the group of 'chemists' and students focused on occupation related to other professions from STEM, whose opinions are closer to those of students majoring in the humanities than to the opinions of the students from the group of 'chemists'. It can be concluded that the future desired profession, which is directly or indirectly related to chemistry is an external factor that strongly influences students' chemistry learning motivation at school.

## 8-O2. Attitudes of chemistry teachers to application of computer technologies in classes

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Successful integration of digital technologies in teaching depends largely on the skills and positive attitudes of the teachers. This study aims to compare attitudes of Bulgarian chemistry teachers towards application of digital technologies in the classroom before and after distance learning which took place in the last two years. The survey was conducted through an online questionnaire. The respondents give their opinion on the questionnaire, validated in Bulgarian, which contains 35 statements, divided into three groups: (i) usefulness of technology in teacher's own activity; (ii) improving students' learning through digital technology; and (iii) ease of use of computer technology. In 2019, the study involved 48 chemistry teachers, while 49 teachers participated in the study in 2022. Data were processed by non-parametric Mann-Whitney test. The obtained results show statistically significant differences in teachers' opinions for the questionnaire as a whole, first and second groups of statements, and 19 of the statements. It can be concluded that teachers' attitudes towards the application of digital technologies weaken after distance learning despite improvement of their computer technology skills.

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## 8-O3. Increasing cognitive interests and professional competencies through chemical experiment

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Section ‘Metals. Metals from II A (2.) and III A (13.) group of the Periodic Table’ is of exceptional importance as the topics introduce basic concepts, knowledge, and competencies needed in the study of subjects of industry training such as ‘Food Chemistry’ and ‘Organization and methods of technological control’. Specific training is necessary to establish the degree of assimilation and mastery of the basic and acquired knowledge and skills to apply in solving experimental and logical problems. Passive learning of quality reactions, water hardness, magnesium content in dried fruits, demonstration of calcium in bones and others, leads to active learning through students' intoxication (teamwork of two) and performing short laboratory experiments presented in worksheets. Accurate formulation of experimental tasks, instructions, and methods of work requires planning laboratory experiments, conducting experiments, reflecting observations, explanations and equations of proceeded reactions leads to the mastery of specific chemical competencies. Preparing, planning, and conducting short experiments help to develop students' organizational and technical competencies. Students take on the role of researchers by showing high activity and interest. They learn to work by planning their time for work, and this is useful for building technological professional competencies in the selected profession. Through experimental-logical tasks of practical orientation the students realize the importance of the studied content, not only theoretically, but also really practically applicable in the productions and everyday life.

## 8-O4. Hydrocarbons educational products by students from Elisaveta Vazova Vocational Design School in Sofia

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The presentation demonstrates educational products ‘Hydrocarbons’ created by Fashion design, Interior design, Textile design, Graphic design, and Advertising graphic students from Elisaveta Vazova Vocational Design School.

The process of learning about hydrocarbons as the basis of organic chemistry in $9^{th}$ grade can be made pleasant, enjoyable, and entertaining using a project-based approach created on learning by doing.

Our students showed exceptional creativity in finding bonds between alkanes and various plant and animal species, counties, astronomical and astrological objects such as constellations, planets and zodiac signs, supreme gods from the Greek mythology, film series such as ‘Avengers’ from Marvel, 3D mathematical objects such as cubes and polyhedrons, seismology – Medvedev's scale, and popular dishes and cakes.

The students created innovative products, in which alkanes are embedded in a unique way. These products are clocks, calendars, flash cards, greeting cards, posters, educational games, and models.

An interactive game named ‘Hydrocarbons’, which evaluates students' understanding of hydrocarbons was created as well.

## 8-O5. Top emerging technologies in chemistry and education of chemistry and natural science in Bulgaria

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Since 2019, IUPAC has nominated the 'Top Ten Emerging Technologies in Chemistry', highlighting the impact of chemistry on overall life and looking to the future. These technologies have the potential to change the world for the better, and contribute to sustainable development and prosperity of our planet and society. Examples include RNA vaccines and rapid tests, biosensors and sonochemical coatings, artificial intelligence and nanopesticides, and many other well-established commercial products that have completely renewed our society. Emphasizing the great importance of chemistry for the creation of new materials and technologies inspires the new generation of young scientists for creativity, research, finding solutions. Creation of new advanced technologies requires a resource of well-educated and trained specialists in the field of natural sciences.

Along with emerging technologies in chemistry, the following negative trends are observed in Bulgarian school education: diminished interest in studying chemistry; a decreasing number of high school graduates who choose matriculation examinations in natural sciences; there is no echo of emerging technologies in chemistry and they are out of sight of students. There are also negative aspects in university education as about 25% of initially enrolled students manage to complete their higher education. The reasons for these phenomena are complex: difficulties in understanding the material, lack of motivation, poor teaching and more. Every teacher can think about this, however, the connection between chemistry education and new technologies is more than clear.

## 8-O6. Teacher's role in the formation of metacognitive skills in students: a study's results

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Chemistry is a conceptual science and deep understanding is required in order to be a successful student. Metacognition often defined as 'thinking about thinking' is essential to acquire such understanding of chemical concepts, phenomena, and to be able to solve complex problems. Students have to reason about their own cognitive processes, to develop critical thinking, to establish a proper self-assessment, and to realize how important they are in the study process. All of the above is associated with the formation of metacognitive skills. The contemporary teacher must possess such skills himself and to work for their formation in students as described in national and international documents on teachers' professional qualification. To study some of them, we conducted a questionnaire with 27 Bulgarian teachers with different work experience and different education degrees. Analysis of this questionnaire reveals that the majority of teachers make efforts to develop metacognitive skills in their students. For this purpose, they use different methods, approaches, and resources and adapt them according to students' needs. Our results reveal also some deficiencies that are related to activities aimed at forming self-assessment skills. A deficiency is observed in teachers' willingness to empower students to be responsible for their learning, which is something fundamental in modern educational strategies. Unfortunately, the results show that communication with other colleagues is insufficient. Such a communication determines a more favourable, creative, and motivational studying environment.

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## 8-O7. The role of chemistry in the refinement of worsted and thick fabrics

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The lesson we present to you is multidisciplinary: Chemistry and environmental protection and introduction to textile production.

The topic is 'Improvement of worsted and thick fabrics'.

Lesson type is application of knowledge, skills, and practice in a given situation.

The aim is to show integration of knowledge in the general education subject Chemistry and Environmental Protection with the discipline of Practical Training: Introduction to textile production; Practical application of theoretical knowledge in the listed subjects; Formation of skills and practice for teamwork in groups.

By combining innovative with traditional methods, the necessary key competencies in both disciplines were achieved.

The lesson is held in two parts. The students are from $8^{th}$ and $10^{th}$ grades with specialty Finishing and dyeing production and Spinning production

They are divided into technological operational groups. Each group is mixed in order to supplement and upgrade the knowledge of Chemistry and environmental protection and Introduction to textile production. The technology task groups have worksheets and some time to resolve the situation. Each group presents the implementation of the technological operation.

The class ends with homework. The idea of homework is to trace the development of dyeing from our ancestors to the present day.

## 8-O8. Physicochemical experiment for the formation of natural scientific literacy of students in primary school

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In natural sciences, observation and experimentation are a philosophy of learning based on thought processes provoked by our experience. Through it, students and teachers form and further their understanding of the world at different age and educational levels. Therefore, the current task for the modern teacher is to offer his/her students learning that is wide-ranging, interdisciplinary, useful and practically applicable, emotionally intense, rich in impressions and experiences.

The report presents the application of physicochemical experiments as part of STEAM-based learning in regular chemistry and environmental science, physics and astronomy, and man and nature classes. In the course of implementation, a high degree of inter- and transdisciplinarity was achieved. In some of the experiments, data were collected, summarized, and analysed based on the scientific method. Processes and phenomena, an important condition for the existence of which is water, are considered. The results of a survey are presented of students on the classes held.

## 8-O9. The place of microplastics issue in the Bulgarian chemistry curriculum

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The aim of this paper is to discuss where is the place of microplastics issue as part of the environmental education in the Bulgarian chemistry curriculum and to present classroom activities that could be applied. A review of the Human and nature and Chemistry syllabuses and standards for grades 4–12 showed that at the end of certain grade students should be able to recognize harmful substances and impacts that cause major environmental pollutants (e.g. 4th grade). Students should also group the different types of pollutants (e.g. 8th grade) and to comment environmental issues related to the use of plastics (e.g. 12th grade). In this sense, the curriculum gives wide range of opportunities that current, global, and even local environmental problems to be analysed and discussed at school. Lesson plans and classroom activities proposed in this paper are compliant with students' age as well as education type: general or profiled. They learn how plastic materials become microplastic pollution and accumulate in the ocean, animals, and humans. They examine their own plastic use, focusing on what they discard daily, and think about better ways to eliminate or reduce their likelihood of ending up as microplastic pollution. Students will analyse current results on microplastics pollution of the Bulgarian coast. A concluding feedback exercise reveals the depth of perception and comprehension.

Acknowledgements: This work was supported by Maritime Affairs and Fisheries Program 2014–2020 co-financed by European Union through European Maritime Affairs and Fisheries Fund. Project No BG14MFOP001-6.004-0006-C01, contract No МДР-ИП-01-13/25.01.2021 ‘Investigation of priority chemical pollutants and biotoxins and assessment the state of the marine environment’.

## 8-O10. Opportunities for development of science literacy with a 10th grade chemistry textbook in French

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In December 2021, Bulgarian Ministry of Education and Science published on its website an e-textbook by this author entitled: Chemistry and Environmental Protection in French for Grade 10. The topics of this book are presented interactively in French requiring an active response from the student. The e-book aims to teach new skills through refreshing already existing knowledge by giving concise answers to brief questions and by looking for logical connections and possibilities. Authentic texts on practical application of substances and processes, modern trends in the development of science and technology (lithium-ion batteries, composite materials in dental engineering, bio-glass and nanotechnology) including Bulgarian scientific contributions are involved. The texts are followed by questions and tasks in order to develop student's language and science literacy. Multidisciplinary themes are suggested, such as ‘Calories and physical activity’ (Chemistry and Sports), laboratory lesson ‘Enzymes’ (Chemistry and Biology), ‘Eco House’ (Chemistry, Biology, Geography). Section ‘Materials’ provides creative tasks, whose goal is to design a metal gazebo project and children's highchair project with a description of the materials from which all the parts should be made, according to set criteria and because of the properties of different materials presented in the topic. Section ‘Environmental protection’ includes exercises related to reading maps, charts, sheets, solving real life-related cases, developing civil responsibility in relation to norms and institutions that control health and environment.

Acknowledgment: This work was supported by the National Programme ‘Development of textbooks and methodological guidebooks, evaluation and approval of projects of textbooks to support training abroad, textbook and kits projects’, Part ‘Development of textbooks in a foreign language for general education subjects’.

## 8-O11. A STEM lesson in chemistry education

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The STEM (Science, Technology, Engineering, and Mathematics) approach represents interdisciplinary science combining chemistry, physics, arts, and techniques for solving problems, searching for right conclusions, creating products, and finding sustainable solutions. Shared teaching practice is problem-based and sustainable. It has been applied in this school for 3 years. The report presents a model of STEM lesson in chemistry and environment protection designed for 9$^{th}$ grade students. One of the goals was acquiring knowledge about the steps of the engineering design process and creating skills for their application. The goal was achieved through practical teamwork on designing models while studying the topics 'Water' and 'Soaps and synthetic detergents'. The students acquired scientific knowledge and practical skills in the context of implementing engineering design. They also developed problem-solving, critical thinking, creativity, and collaboration skills. The lesson involved 24 students from 9$^{th}$ grade at Prof. Dr. Asen Zlatarov Secondary School in Parvomay town. Before and after implemented activities surveys among students revealed a high degree of interest in the task and increased motivation to work.

## 8-O12. Laboratory exercises in module 4. Challenges and answers

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Experiments for Module 4 'Analytical chemistry' were developed for times when a laboratory or equipment is not available. The goal is for laboratory work in Module 4 to be done with cheap and harmless materials, which will provide more students with the needed lab skills. The experiments use easy to obtain chemical reagents and D.I.Y. equipment but nonetheless fulfil the goals of the experimental work: to show students the chemical principles of the methods, to experience them first hand and to gather data and make conclusions. The reason to develop such modified experiments is the need for budget solution for lab class, which was requested from the author by colleagues dealing with chemistry education.

## 8-P1. Transition from knowledge to skills in teaching chemistry and environmental protection

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Critical thinking, teamwork, sustainability, constant and independent learning, creativity, data-based decision-making, digital skills: these are some of the common 'soft skills' that students need to develop at school and improve at university and be competitive in a working environment.

Chemistry and environmental protection (CEP) curriculum provides wide opportunities for implementation of innovative solutions towards the development of integrated skills that combine ability and competencies in DOS and 'soft skills' of students. Assigning logical tasks and case studies to students from lower secondary and first secondary school stage develops their critical thinking and search for answers based on acquired knowledge.

In the process of developing competitive tasks with creative upgrading of knowledge for the first secondary school stage of the CEP, the effects of joint group work were observed and the idea of a presentation in the form of an environmental story was 'born'. Based on content restructuring and integration of digital skills, the students developed the backgrounds and characters from the book on a graphics tablet, which provoked further development of creative skills. The training tool was presented at the Chemistry Festival 2022 ranking first out of a total of 156 other projects. In another competition, students expressed in paintings and photo stories their views on the environment after 50 years.

Developing projects on topics close to the students, such as energy drinks, cosmetics, environmental protection, discoveries in chemistry and others, helps again students to show creativity, teamwork, knowledge upgrading, and digital skills. Each group chooses how to present their project and presents it to students, teachers, and parents.

Each task, project, or competition aims to develop and improve the so-called 'soft skills' in students, and they learn to transform their knowledge into skills. Participation in competitions and contests helps students to gain sustainability, confidence in speaking in front of audience, creativity, and sometimes teamwork.

## 8-P2. Adaptive chemistry learning via a simple prognostic Baysian model

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During the last decade, Bayesian simulation is a widespread approach to optimization of dynamical systems with dimness medium and circumstances. Chemistry education is an example for such a system. In this work, a simple Bayesian model for a multistage adaptive learning on Chemistry of students. According to it, the posterior probability for adoption of the teaching material by each student is determined using periodical test ratings. In the beginning, the model for learning of two students only is presented. Posterior conditional probabilities for the mark of each student ($P(Hi/A_1)$ (i=1,2)) are calculated. In this case $P(Hi/A_1)$ (i=1,2) are contributions of each student to the achieved mean result of the couple at the first test ($A_1$). For the second stage just these probabilities are accepted as prior entities ($P(H_{12})$ and $P(H_{22})$) for the success of each student. Using them and experimental results of the second test ($P(A_2/H_{12})$ and $P(A_2./H_{22})$), a new mean result ($P(A_2)= P(H_{12})P(A_2/H_{12}) +P(H_{22})P(A_2/H_{22})$ of both students can be determined as well as the posterior conditional probabilities $P(H_{12}/A_2)$ and $P(H_{22}/A_2)$. This recurrent procedure ($P(Hi_2) = P(Hi_1/A_1$; i-1,2)) occurred to expand easily (P(Hi,k) = P(Hi,k-1/Ak-1); i, k = 1,2, …) for a random numbers of students (i) and tests (k). Thus personal students' profiles (P(Hi,k/Ak; i,k = 1,2,…, contributions of i-th student in the mean group result at k-th test), and group ones (P(Ak) k-1,2,… mean group rates in each k-th test) are obtained. They provide very useful information about improvement of teacher-student adaptation and target study of selected subject units.

## 8-P3. The history of chemistry as a basis for active storytelling

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The formation of key competencies of the 21st century requires a significant revision of the traditional education system focused on knowledge reproduction. One of the teaching methods in this case is storytelling. Storytelling in education is based on the narration of stories, which are not only related to the studying subject but also are associated with personal experience of the narrator and the listener. Storytelling is traditionally used during all stages of continuous chemical education starting from school and up to universities. In particular, the history of the development of chemistry as a science, the role of individuals, and the fate of their discoveries always attracts attention. At the same time, it is important to attract students' attention to the work of the national scientists, who worked earlier in the same institutions as the students.

This presentation will consider the experience of preparing case stories for students based on the information about the work of scientists who headed the Department of Inorganic Chemistry of the Belarusian State University from 1921 to 2002. In this case, the teacher sets the story basis, and the students are actively involved in the process of creation and telling. This approach allows connecting theoretical knowledge with life by analysing a specific situation, teaching a practical case containing a problem. At the same time, the students cannot only analyse history, comprehend the meaning of the details described, analyse and simulate various situations, and look for ways to solve the problem, but also create stories on their own, following the task and recommendations of the teacher. The historical approach contributes not only to the integration of interdisciplinary knowledge of students but also lies in the mainstream of the humanization of education and inspires students to become engaged in scientific research with due consideration of the experience of the previous generations.

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Company presentation

# Innovative teaching and learning tools and programs for teachers and educators from T.E.A.M. and Agilent

K. Doktorov

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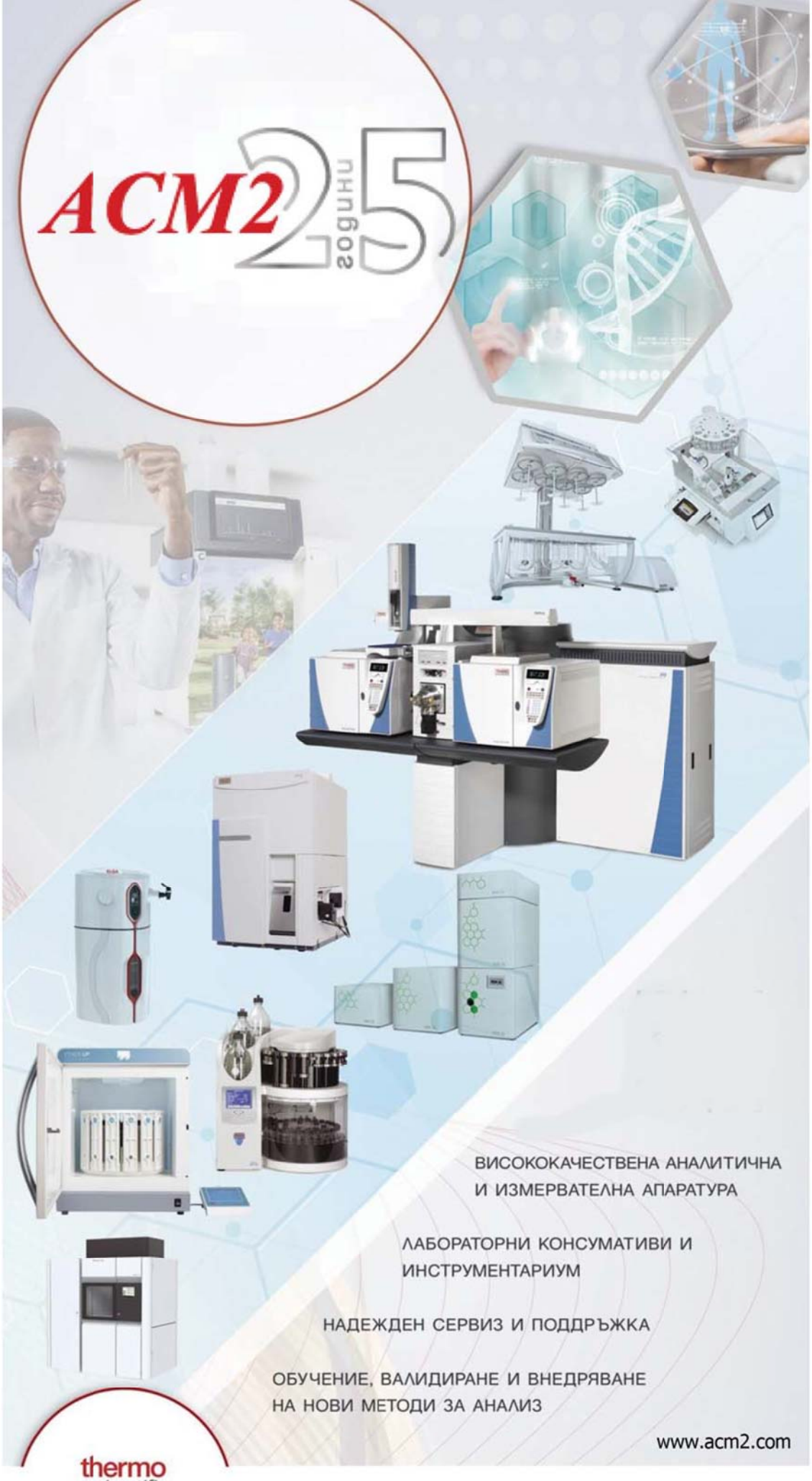
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