6th ICABC 2026

26-29 March 2026-Antalya-Turkey

With the sponsor of the

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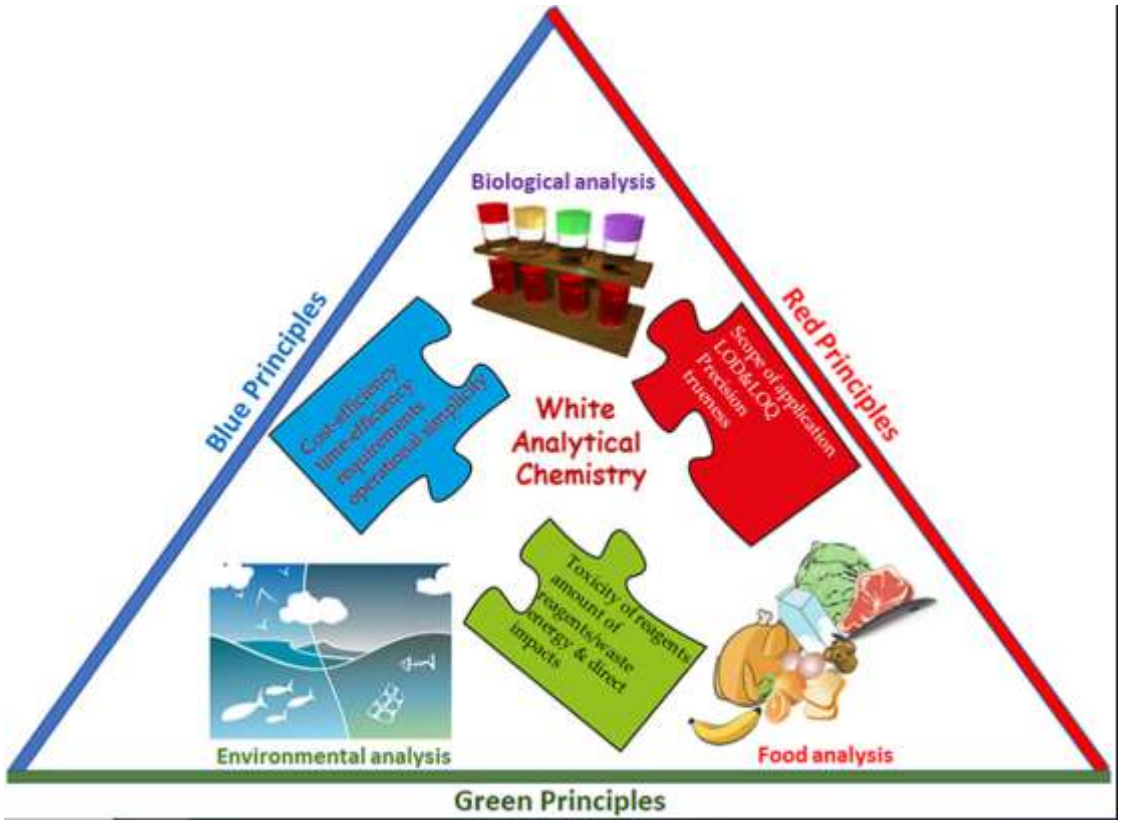
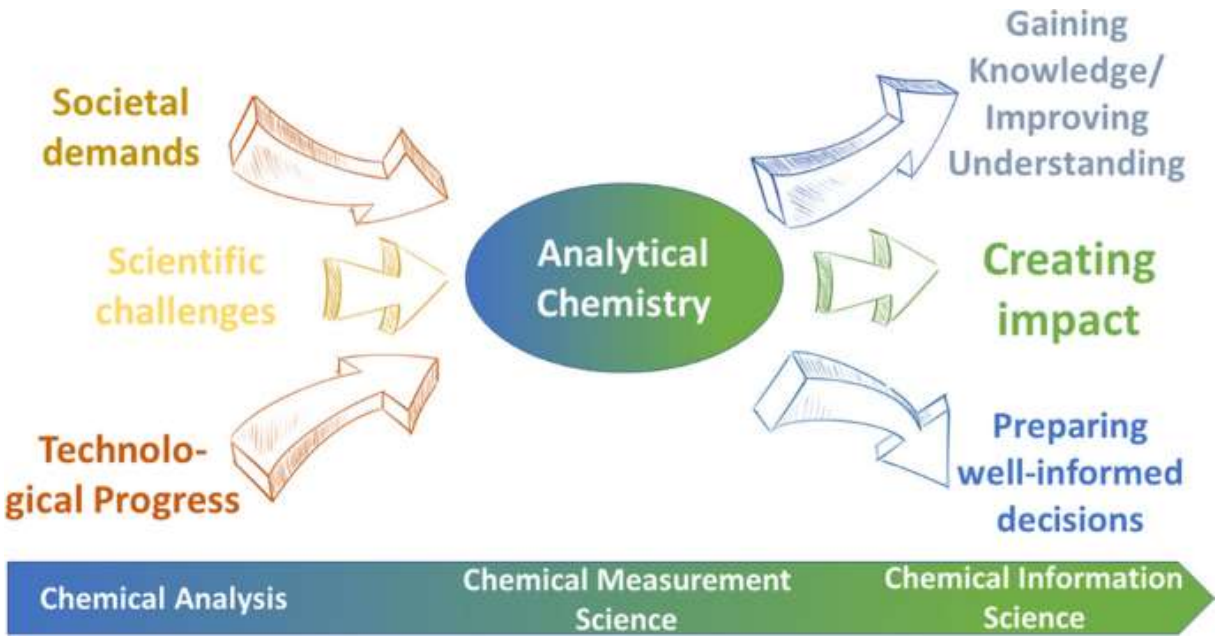
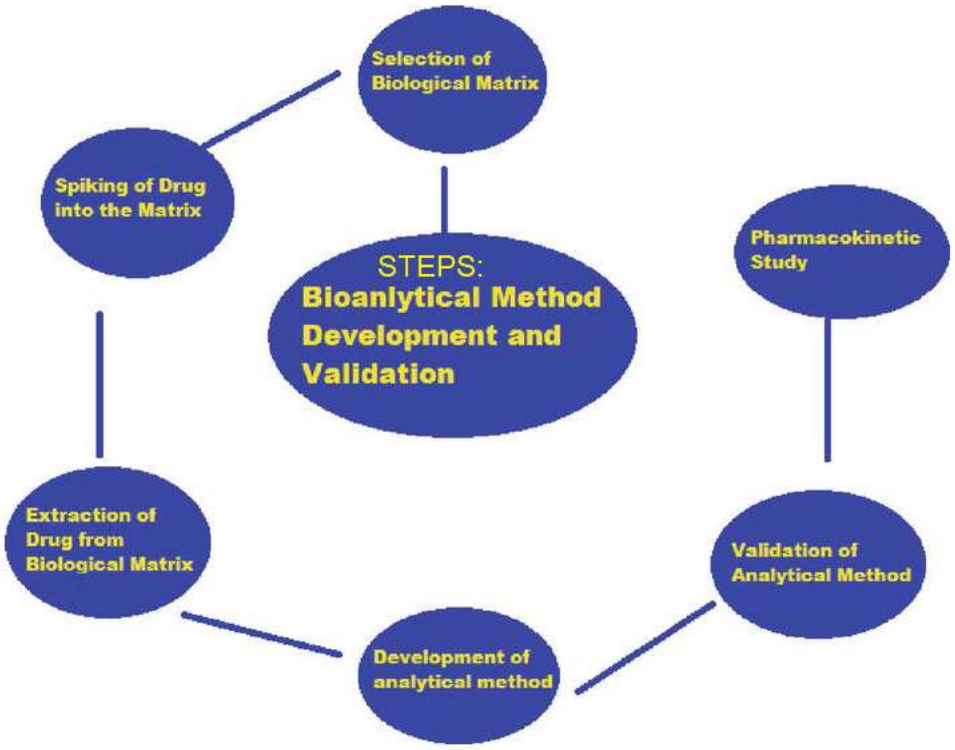
6th International Congress on Analytical and Bioanalytical Chemistry

BOOK of ABSTRACT



26-29 March 2026-Antalya-Turkey


Societal demands
Scientific challenges
Technolo-gical Progress
Analytical Chemistry
Gaining Knowledge/ Improving Understanding
Creating impact
Preparing well-informed decisions
Chemical Analysis
Chemical Measurement Science
Chemical Information Science


Selection of Biological Matrix
Spiking of Drug into the Matrix
STEPS:
Bioanlytical Method Development and Validation
Pharmacokinetic Study
Extraction of Drug from Biological Matrix
Validation of Analytical Method
Development of analytical method

Preface

The organizing committee of the **6th ICABC 2026** would like to welcome all participants to the "**6th International Congress on Analytical and Bioanalytical Chemistry** ", will be held **in Antalya Kamelya Collection Hotel** between 26-29 March 2026. The **ICABC** meeting was started seven years ago (in 2019) and covers all areas of Analytical and Bioanalytical Chemistry as well as applications of Chemical and Biochemical Analysis.

The scientific congress program consists of **11** sessions that include **15 invited and 25 oral** presentations as well as **48 posters** to be presented in the respective sessions. In addition, researchers of Academia (**48 universities and Institutes from 11 countries**) and Research Institutes will present up-to-date developments on analytical and bioanalytical chemistry as well as applications to a wide range of environmental, biological and food matrices.

We strongly believe that the discussions and the exchange of ideas among the participants during the 4 days of the meeting will make **6th ICABC** a brilliant platform to initiate new research collaborations, particularly in favor of the young scientists participating in the conference.

We wish you all to enjoy this conference and have a pleasant to joining, hoping to meet you again during the next **ICABCs**.

With our best regards
The Chair (on behalf of Organizing Committee)
Prof. Dr. Mehmet YAMAN
Firat University, Science Faculty, Department of Chemistry, Elazig-Turkey

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INVITED SPEAKERS

Arturs VIKSNA-Latvia U/LV
Erwin ROSENBERG-Wien Tech. U/AT,
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Sevinç Kurbanoğlu-Ankara U/TR
Friedle Scheller (Potsdam U/DE)
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Sezgin Bakirdere (Yildiz Tech. U/TR)
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Hakan Kaygusuz-Altınbas U/TR
Elif Tümay Özer- Uludag U/TR
Özlem Söğüt- Ege U/TR
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Sevinç Kurbanoğlu-Ankara U/TR
Hakan Kaygusuz-Altınbas U/TR
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Chair

Prof. Dr. Mehmet YAMAN-Firat U/TR.

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GENERAL INFORMATION

Introduction

The **6th International Congress on Analytical and Bioanalytical Chemistry** will be held on 26-29 March 2026 in Antalya-Turkey is a four-days scientific meeting covering all areas of Analytical and Bioanalytical Chemistry and applications of Chemical and Biochemical Analysis. The international congresses have provided an excellent framework for the presentation of new concepts, instruments, methods, and applications in the area of modern chemical and biochemical analysis. Researchers and scientists from Universities, Research Institutions, State Organizations, and the Industry come together during the meeting to present and discuss the current state of the art in those areas. At the same time, it provides the grounds for the graduate and postgraduate students to present their projects, discuss scientific collaborations with other groups, as well as to explore employment opportunities.

I strongly believe that young researchers will have chance to improve their knowledge in deep of the analytical and bioanalytical chemistry by coming together with experienced scientists including invited speakers and scientific committee members.

6th ICABC 2026

Topics

To promote collaboration among analytical and bioanalytical (including biochemists, food engineering, molecular biology and genetics and similars) scientists from different countries, "6**th ICABC 2026**" will provide adequate opportunities.

The topics include all areas of analytical and bioanalytic chemistry in applications such as, but not limited to, environmental, biological and food matrices, environmental protection, biochemical studies, drug characterisation, method innovation and validation, instrumental development and applications, sensors and nanobiosensors, chromatography, spectrometry and electrochemistry.

The congress covers determination of inorganic and organic components in environmental, biological and food matrices as well as the following subjects: Food Safety: Omics analysis including GMO, all studies on interactions between metabolic disorders and foodstuffs.

The main aim and theme of the congress is to enlighten the innovations and current trends with analytical and bio analytical chemistry (including organic and food chemistry).

Location of Conference

6th ICABC 2026 will be held in Antalya-Kamelya Colletion Hotel, Turkey

Papers presentation

Scientific program will include Invited Speakers, which will provide an up-to-date presentation of modern trends of Analytical and Bioanalytical Chemistry as well as of related subjects of chemical and biochemical analysis-interest. Contributed papers describing original research work will be presented as oral and poster in order to promote efficient discussion on new scientific ideas and results. All presentations should be in English. Oral and poster presentation will be accepted if at least one of the authors is registered and present at the conference for personal communication.

Note: *The authors are responsible for the scientific content and details of the abstracts.*

OPENING SPEECH

Dear reputable Professors, Colleagues and Participants,

On behalf of the Organizing Committee, it is our great honor and privilege to welcome you to this edition of the **6th International Congress on Analytical and Bioanalytical Chemistry (6th ICABC)**.

This congress has, over the years, grown into one of the foremost international forums for scientific exchange, innovation, and collaboration in the fields of analytical and bioanalytical chemistry.

The present edition continues a proud tradition of bringing together eminent scientists, researchers, academics, and industry professionals from across the globe.

This congress reflects the remarkable breadth and depth of contemporary research in our discipline — from fundamental advances in separation science, spectroscopy, and electroanalytical chemistry, to cutting-edge developments in biosensing, clinical diagnostics, environmental monitoring, and pharmaceutical analysis.

The scientific program of this congress has been carefully designed to reflect the most pressing challenges and promising opportunities in analytical science. It features plenary lectures delivered by distinguished international experts, invited speakers, oral communications, and poster presentations — all of which represent the highest standards of scientific excellence and originality.

We are deeply grateful to the members of the Scientific Committee as well as to all the authors and presenters who have entrusted us with their latest research. Our sincere thanks also go to all those who have contributed to making this event possible.

We trust that the congress will provide an exceptional opportunity for fruitful scientific discussions, the forging of new collaborations, and the inspiration of future discoveries. We extend our warmest welcome to all participants and wish everyone a stimulating and memorable experience.

Statistical Information about the Congress

The scientific conference program consists of **11** sessions that include **15** invited and **25** oral presentations as well as **48** posters. The participants are of **48** universities and Institutes from **11** countries.

Yours sincerely,

Prof. Dr. Mehmet Yaman-
Chair

6th International Congress on Analytical and Bioanalytical Chemistry (6th ICABC)

26 March, 2026, Antalya

Closing

Distinguished colleagues and esteemed speakers,

As we draw this congress to a close, it is both a privilege and an honor to stand before this remarkable assembly of scientists and scholars who represent the very forefront of analytical and bioanalytical chemistry.

Over the course of these days, we have witnessed an exceptional exchange of knowledge—from cutting-edge advances in separation science and mass spectrometry, to transformative developments in biosensing, sensors and all of the analysis species.

The breadth and depth of the science presented here is a true reflection of the vitality and ambition of our discipline.

I wish to extend our sincerest gratitude to each and every speaker and presenter who shared their expertise and their passion with such clarity and generosity.

Equally, our deepest appreciation goes to the the organizing team, and all supporting staff whose tireless efforts made this congress possible.

A congress of this caliber does not happen without extraordinary dedication behind the scenes.

Looking ahead, it is clear that analytical and bioanalytical chemistry stands at a pivotal moment. The convergence of miniaturization, digitalization, and biological complexity opens frontiers that were unimaginable only a decade ago.

The challenges before us — in clinical diagnostics, environmental monitoring, food safety, and personalized medicine — demand precisely the kind of rigorous, innovative science that has been on display here.

Let us leave this congress not only enriched by what we have learned, but energized by the connections we have forged. Science advances fastest when borders — geographic, disciplinary, and institutional — are bridged by collaboration.

We look forward to welcoming you again at our next congress. Until then, let us carry the spirit of this meeting into our laboratories, our classrooms, and our communities.

Thank you.

CONFERENCE PROGRAM

6th International Congress on Analytical and Bioanalytical Chemistry (6th ICABC 2026)

26-29 March, 2026, Antalya/Turkey

	26 March, 2026
16.30 17:00	➢ **Welcome Ceremony Session** ➢ **Prof. Dr. Mehmet Yaman (Chair)** **Prof. Dr. Seref GUCER** (on behalf of continuation committee) *Honorable*
	Session 1- Chairs: Prof. Dr. Malgorzata Grabarczyk-Dr. Usama Alshana-
17:00-17.30	***Inv. 1: Prof. Dr. Mutay Aslan-Akdeniz U/TR*** The Role Of Ceramide And Cellular Signaling Pathways In The Efficacy Of Anti-Proliferative Compounds
17:30-18:30	**OP1: Emad A. Khudaish-** Sultan Qaboos U/OM A sensing platform based on electrochemically reduced graphene oxide for biological and pharmaceutical determination of estradiol
	OP2: Amir Abbas Matin-Azarbaijan Shahid Madani U/IR Mesoporous Monolithic Membranes for Solid Phase and Thin Film Microextraction
	OP3: Didem Aydın-Selcuk U/TR Optimization of Green MOF Synthesis Using Deep Eutectic Solvents for Catalytic Dye Degradation
	OP4:Gamze Emir Günay-Canakkale Onsekiz Mart U/TR MWCNT-Fc-2APP-GOx/CPE Based Bioanode Design for Enzymatic Biofuel Cells: Electrochemical Characterization and Performance Evaluation
	OP5: Ayşe Hanbeyoğlu-Cumhuriyet U/TR - Green Extraction for Polyphenols from Anthemis arvensis L. Flowers Using Deep Eutectic Solvent
	OP6: Teslime Erşan- Canakkale Onsekiz Mart U/TR Flow Injection Amperometric Determination of L-Cysteine based on its Electrocatalytic Oxidation at bis-(Neocuproine)copper(II) Complex Modified Screen-Printed Carbon Electrode
19:00	**Dinner**
	27 March, 2026
	Session 2- Chairs: Prof. Dr. F. Nil Ertaş-Prof. Dr. Agnieszka Nosal
09:00 09:40	***Inv. 2: Prof. Dr. Frieder W. Scheller-Potsdam U/DE*** Bio (mimetic) Electroanalysis: From Dropping Mercury Electrode to MIP Arrays
09:40 10:30	**OP7: Jolanta Kochana**-Jagiellonian U/Pl Electrochemical biosensing of estrogens
	OP8- Konrad Rudnicki- Lodz U/PL Electrochemistry at the Interface between Two Immiscible Electrolyte Solutions in Safeguarding Food Quality Control
	OP9- Emilia Powałka- Lodz U/PL Electrochemical determination of amphetamine in street drug samples at the electrified liquid-liquid interface
	OP10- Aleksandra Grzeszczak- Lodz U/PL Electrochemical studies of the activity of food colorants at the polarized liquid-liquid interface

	OP11: Çiğdem Yengin-Ege U/TR Modeling the disposal of sunitinib malate in aqueous media by Response Surface Methodology (RSM)
10:30 10:50	Tea/Coffee break
10:50 11:50	***Session 3-*** Chairs: ***Prof. Dr. Mustafa Ersoz- Prof. Dr. Cecylia Wardak*** ***Inv. 3: Prof. Dr. Arturs Viksna-*** *Latvia U/LV* Quantification Of Calcium And Phosphrous Ratio In Apatites **Inv. 4: Prof. Dr. *Elif Tumay Ozer-*** *Bursa Uludag U/TR* An Overview of Solid Phase Extraction as a Separation and Concentration Method
11:50- 12:10	**OP12- Usama Alshana**-Sultan Qaboos U/OM Edible oil-based dispersive liquid–liquid microextraction prior to HPLC-DAD for the determination of parabens in human milk, baby food and personal care products
	OP13-Yiğit İnan - Kent U/TR Influence of in vitro human digestion simulation on the phenolics contents and biological activities of the methanol extracts from Turkish Cistus species
12:10 14:00	**Lunch**
14:00- 14:40	**Session 4 -** Chairs: **Prof. Dr. Aysem Arda-Prof. Dr. Aysu Yarman** **Inv. 5: *Prof. Dr. Sezgin Bakırdere-*** *Yıldız Techn. U/TR* Novel Analytical Strategies for the Analysis of Complex Matrices
14:40- 15:10	**OP14- Buse Tuğba Zaman**-Yıldız Techn. U/TR Monitoring Heavy Metal Pollution of Antarctic Region by Using Fecal Samples
	OP15- Nursu Aylin Kasa-Istanbul Medipol U/TR Simultaneous determination of selected pharmaceutical active ingredients in Arctic surface water samples by liquid chromatography tandem mass spectrometry after preconcentration using the developed DES-based LPME method
	OP16- Kübra Karakebap-Alanya U/TR Microwave-Assisted Synthesis and Implementation of $CoFe_2O_4$@Bi_2S_3 Magnetic Nanoparticles for Lead Determination in Synthetic Wastewater
15:10- 15.30	*Tea/Coffee break*
	Session 5: Chairs: **Prof. Dr. Mutay Aslan- Dr. Agnese Araja**
15:30- 16:40	**Inv. 6: Prof. Dr.*Arunas Ramanavicius-*** *Vilnius U/LT* Development of conducting polymer based molecularly imprinted polymers **Inv. 7: Prof. Dr. *Ozlem Sogut-*** *Ege U/TR* Chemistry Etched In Our Skin: Hidden Chemical Truth Behind Tattoo Colors
16.40- 17.20	**OP17- Dilşad Özkan Arıksoysal**-Ege U/TR The Electroanalytical Applications of Aptamer or DNA-based Nano-Biomolecular Interactions with Sensors
	OP18- Andrzej Leniart- Lodz U/PL Atomic Force Microscopy as a tool for evaluating electrochemical sensor morphology
	OP19- Sevda Akay Sazaklioğlu-Ankara Medipol U/TR A Rapid Electrochemical Determination of Donepezil Hydrochloride Based on Carbon Screen-Printed Electrode
	OP20- Enes Alegöz-Balıkesir U/TR Development of Preconcentration and Speciation Method for Cr(III) and Cr(VI) Ions in Aqueous Samples Using Sudan III Modified Magnetic Nanoparticles
17:20- 17.30	*Tea/Coffee break*
17:30- 18:30	***Session 6***–Chairs:***Prof. Dr.Sławomira Skrzypek-Dr. Nagihan Ayhan Poster Presentations 1 (P25-48)***
19:00	**Dinner**
	28 March, 2026
	Session 7- Chairs: **Prof. Dr. Emad A. Khudaish- Prof. Dr. Pınar Kara**

09.00-10:10	***Inv. 8:*** ***Prof. Dr. Erwin Rosenberg-****Wien Techniq U/AT* Comprehensive Two-Dimensional Gas Chromatography as a Tool for the Development of Sustainable Aviation Fuels **Inv. 9:** ***Dr. Magdelona Borowska-*** *Warsaw Techn. U/PL* Single-particle microwave-induced plasma optical emission spectrometry for nanomaterial characterization
10:10-10:30	*Tea/Coffee break*
10:30-11:30	**Session 8-** Chairs: **Prof. Dr. Amir Abbas Matin -Prof. Dr. Yusuf Dilgin** ***Inv. 10:*** **Prof. Dr.** ***Resat Apak-****Istanbul Cerrahpasa U/TR* A critical look at the sensitivity and selectivity of current colorimetric reagents and nanoprobes ***Inv. 11:*** **Dr.** ***Hakan Kaygusuz-****Altınbas U/TR* Simulation of Biological and Physicochemical Systems with Lattice Model
11:30-12:15	**Panel:** 1-**Commercialization potential of academic research outputs, possible challenges and solutions.** **2-Free** **Moderator:** **Prof. Dr.** ***Durisehvar Ozer Unal*** **Panelists:** ***Dr. Sławomira Skrzypek-Dr. Resat Apak-Dr. Erwin Rosenberg-Dr. Robert Pietrzak***
12.15-14:00	Lunch
14.00-15.10	**Session 9-:** Chairs: **Prof. Dr. Jolanta Kochana- Dr. Konrad Rudnicki**
	Inv. 12: ***Prof. Dr. Mustafa Soylak-****Erciyes U/TR* New trends in microextraction techniques
	Inv. 13: **Prof. Dr.** ***Mustafa Tüzen-****Gaziosmanpasa U/TR* Green Extraction Techniques for Organic and Inorganic Species in Different Matrix Media
	OP21-Hasan Karadağ-Adıyaman U/TR Effect of (2-Chlorobenzyl)(4,5-Dihydro-1H-İmidazol-2-yl)Amine Hydroiodide and (4-Methylbenzyl)(4,5-Dihydro-1H-İmidazol-2-yl)Amine Hydroiodide on Glutathione Reductase Activity
15:10-15:20	Tea/Coffee break
15:20-16:30	***Session 10 –*** Chairs: ***Prof. Dr. Cemile Özcan-Prof. Dr. Feyzullah Tokay*** ***Poster Presentations 2(P1-24)***
16:30-17:30	**Session 11-** Chairs: **Prof. Dr. Almira Ramanaviciene- Prof. Dr. Sema Bagdat** ***Inv. 14:*** **Dr.** ***Livia Alexandra DINU-*** *(IMT-Bucharest)/RO* Bioinspired doped graphene nanozymes for efficient environmental electrochemical sensing ***Inv. 15:*** **Dr.** ***Sevinç Kurbanoğlu-****Ankara U/TR* The Rise of Immobilized Biomaterials from Enzymes to Aptamers in Electrochemical Biosensors
17:30-18:10	**OP22-F. Nil Ertaş-** Ege u/TR Challenges in Pheromone Analysis Used in Biotechnical Control Studies
	OP23- Feyza Gülyüz-Munzur U/TR Determination of tetracycline by Nd-MOF based electrochemical sensor
	OP24- Meltem Saylan-İstanbul Health and Technology U/TR Determination of Manganese at Trace Levels by Natural Deep Eutectic Solvent Assisted Liquid Phase Microextraction in Samples Collected from Antarctic Region
	OP25- Miray Öner-Alanya U/TR A Novel Analytical Approach for Manganese Determination in Chia Seeds (Salvia hispanica L.) via Dispersive Solid-Phase Extraction based on Using NiCr2O4 nanostructures
18:10	***Closing***
19:00	**Dinner**
09:00-10:30	**29 March, 2026** **Seaside walking**

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INVITED SPEAKERS (IS)

IS1- The Role Of Ceramıde And Cellular Sıgnalıng Pathways In The Effıcacy Of Antı-Prolıferatıve Compounds

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Objectives
Our laboratory has long focused on deciphering the biochemical logic by which sphingolipid mediators orchestrate cancer cell fate. Building on this foundation, the present work explores how two bioactive molecules—thymoquinone (TQ) and 7-ketositosterol (7-KSS)—reshape sphingomyelin/ceramide metabolism and regulate major cellular signaling networks in breast (MCF-7) and liver (HepG2) cancer cells. This integrative effort aims not only to define mechanistic pathways but also to illuminate broader principles governing ceramide-driven anti-cancer responses.
Materials and Methods
Across a series of studies that reflect our laboratory's established expertise in lipidomics and signaling biology, we evaluated the concentration- and time-dependent effects of TQ and 7-KSS on cancer cell viability using MTT assays. Comprehensive LC-MS/MS profiling was employed to quantify sphingomyelins, ceramides (CERs), and sphingosine-1-phosphate (S1P). Key stress- and survival-associated genes and proteins—including NF-κB, GRP78, and phosphorylated ERK1/2—were characterized through qPCR, immunofluorescence, and Western blotting. Apoptotic signatures were assessed using TUNEL assays and flow cytometric detection of annexin V and propidium iodide.
Results
Our findings reinforce a central theme that has emerged from our lab's long-standing research program: shifts in the intracellular balance between ceramide and S1P are decisive regulators of cancer cell destiny. Both TQ and 7-KSS induced a robust accumulation of long-chain ceramides (C16–C24) while significantly lowering S1P levels, thereby reprogramming the lipid rheostat toward apoptosis. TQ not only elevated cleaved caspase-3 levels but also suppressed NF-κB activity and induced GRP78 expression, suggesting a coordinated activation of ER stress and apoptotic pathways. In parallel, 7-KSS markedly decreased p-ERK1/2 and p-NF-κB p65, illuminating convergent inhibition of pro-survival signaling cascades. These molecular alterations collectively translated into a pronounced increase in apoptotic cell death.
Conclusions
This body of work underscores the power of targeting sphingolipid signaling to disrupt cancer cell proliferation. By integrating lipidomic, transcriptional, and proteomic insights, our studies demonstrate that TQ and 7-KSS can recalibrate fundamental survival pathways through ceramide-centered mechanisms. More broadly, these findings contribute to an emerging paradigm—championed by our laboratory—that positions sphingolipid metabolism as a fertile arena for developing next-generation anti-cancer strategies. Continued exploration of this biochemical landscape promises not only refined therapeutic targets but also a deeper understanding of how cells interpret and execute life-or-death decisions.

Keywords:
Thymoquinone; 7-ketositosterol; ceramide; apoptosis; ERK

IS2- Bio (mimetic) Electroanalysis: From Dropping Mercury Electrode to MIP Arrays

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Introduction
In this talk, the evolution of protein electrochemistry from protein-covered mercury electrodes to electrosynthesized protein MIPs will be presented.

Elucidation of the interfacial behavior of globular proteins at metal electrodes and establishment of direct electron transfer of heme proteins
The establishment of polarography on the basis of mercury electrodes (DME) by J. Heyrovský opened the electroanalytical determination of low-molecular-weight reducible substances such as drugs and metabolites. Furthermore, the electroactivity of cytosine in nucleic acids allowed electrochemical communication with the DME, whereas no direct electron transfer (DET) with redox centers in proteins has been established due to the "shielding" of the protein framework. However, adsorption of proteins at the electrode gave rise to "catalytic hydrogen currents," and Brdička postulated the possibility of indicating "cancer proteins." However, starting in the seventies, we established direct electron transfer at "modified" solid electrodes for different redox centers in native proteins, e.g., heme, flavin, selenocysteine, MoCo, PQQ, and copper centers, which mimic the redox reactions in metabolism and energy conversion.

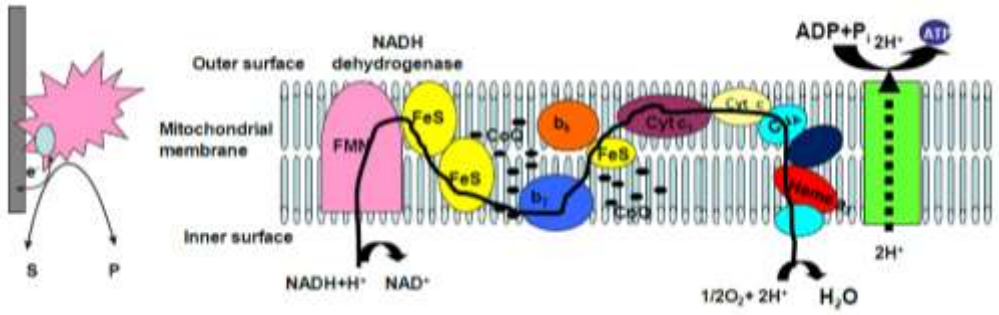

Fig.1 Schematic representation comparing direct electron transfer of a redox protein at an electrode with electron transport in the respiratory chain (Yarman et al. 2011).

Enzyme systems in sensors
Electrochemical indication of oxygen consumption by the enzymatic conversion of metabolites such as glucose, lactate, and glutamate allowed the precise determination of these substances in clinical samples. The direct spatial integration of the enzyme with the electrode in "enzyme electrodes," introduced by L. Clark, resulted in excellent analytical performance and reduced reagent costs through the reusability of the biocatalyst for thousands of samples. This concept forms the basis of laboratory analyzers (Yellow Springs Instruments, Fuji Electric, and the ZWG of AdW Berlin) and led to the development of non-invasive online glucose monitors. This breakthrough in biosensor technology by Adam Heller improved the quality of life of millions of diabetic patients and remains by far the most significant commercial success.
In parallel with the commercialization of mono-enzyme electrodes, we coupled sequential, parallel, and cyclic enzyme-catalyzed reactions with electrodes, thus mimicking the network of cellular metabolism. These principles expanded the spectrum of measurable analytes, improved

specificity, enhanced sensitivity by five orders of magnitude, and extended the measuring range into the picomolar range.

Molecularly Imprinted Polymers as recognition elements

In order to substitute antibodies and enzymes in analytics and therapy, biomimetic receptors based on nucleotides (aptamers) or fully synthetic polymers (molecularly imprinted polymers, MIPs) have been developed. As early as 1931, the Russian scientist Polyakov proposed the first polymer with molecular memory that mimics the function of antibodies. Complementary binding sites resembling the "lock-and-key principle" of biomolecular recognition are formed by templating the target molecule within a polymer matrix.

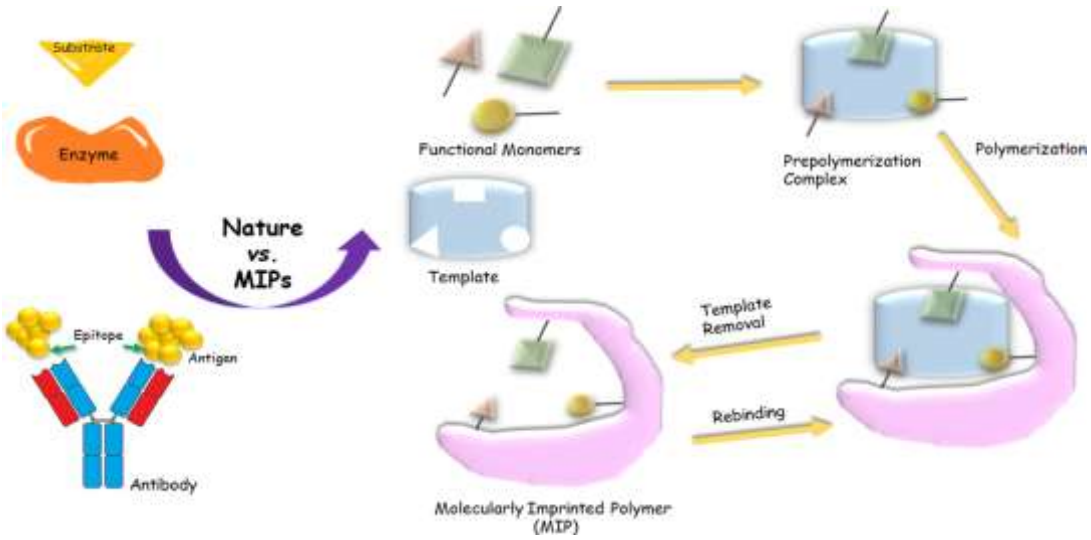

Fig.2 Schematic representation of molecularly imprinted polymers (MIPs) in relation to antibodies and enzymes (left) and a general workflow of MIP synthesis (Yarman et al. 2021).

Following Mosbach's concept of noncovalent molecularly imprinted polymers, we synthesized binding and catalytically active MIPs. Over the last ten years, our work has focused on the development of MIPs for the recognition of proteins, including cytochrome c, ferritin, transferrin, human serum albumin, hemoglobin (Hb), and its glycosylated form (HbA1c), as well as particularly for enzymes, i.e., laccase, tyrosinase, acetylcholinesterase, butyrylcholinesterase, hexameric tyrosine-coordinated heme protein, cytochrome P450 BM3, and cytochrome P450cam. In MIP electrosynthesis, we applied either the whole protein, a subunit, or an epitope as the template and pioneered the fully electrochemical "epitope approach" for protein MIPs.

Conclusions

Bioelectro-Analysis allowed to reduce reagent cost and opened up the route to online measurement of metabolites like glucose.

The straightforward synthesis using one to six functional monomers and the simple integration into sensors represent significant advantages of MIPs compared with enzymes or antibodies. Furthermore, MIPs can be synthesized against toxic substances and targets with low immunogenicity and allow multi-analyte measurements via multi-template synthesis. Their affinity is sufficiently high for protein biomarkers, DNA, viruses, and cells.

Keywords: Enzyme electrodes, Coupled enzyme reactions, Molecularly Imprinted Electrodes

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IS3- Quantification Of Calcium And Phosphrous Ratio In Apatites

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Different compounds of calcium phosphates are essential materials in medical implants because of its unique properties and hydroxyapatite (HAp) is the most widely used of the calcium phosphates[1]. Further advances in calcium phosphates and a better understanding of mineralized tissue depend on precise, but simple chemical analysis.

The most important HAP quality parameter is the Ca/P molar ratio. Its requires to need accurate control of the chemical composition and Ca/P ratio should be fixed within a narrow interval. There is a a lot of methods for determining this ratio, both multi-element methods and single analysis methods, including classical. Today, inductively coupled plasma optical emission spectrometry (ICP-OES) and photometry are most used methods. These methods are well-established and easily accessible, but there are some limitations and difficulties for an effective introduction into a routine apatites analysis. For example, despite the relative accuracy and simplicity of ICP-OES and photometry, plasma gas costs are high and relatively high energy consumption. Photometry is problematic for simultaneous quantification of both elements and time consuming.

TXRF offers simple sample preparation with a relatively short analysis time, allows multi-element determination with good of accuracy, offers semi-quantitative determination of elemental impurities, has low hardware maintenance costs, requires small sample amounts and low energy consumption and does not require expensive reagents. A portable benchtop TXRF is available from several producers. All the factors listed correspond to the principles of green chemistry. This is attractive for routine calcium and phosphorus analysis for the quality control laboratories. The main goal of the current research was to develop new total reflection X-Ray fluorescence (TXRF) method for the fast and simple simultaneous quantification of Ca and P in apatite's.

A certified reference material with known Ca and P content was used for the TXRF validation. TXRF results were compared against classical and modern methods including gravimetry, photometry, titrimetry, ICP-OES, flame atomic absorption spectrometry and wavelength dispersive X-ray fluorescence. The developed TXRF method consisted of two parts: sample preparation and quantification of method. In the sample preparation stage mainly was optimized the solubility of HAP in the acidic media and the crystallization process of the HAP solution together with internal standard on a quartz sample holder. Usually for the quantification of TXRF method gallium is used as an internal standard. To increase the method accuracy potassium dihydrogen phosphate was used as a quantification agent. By using potassium dihydrogen phosphate, two quantification methods were simultaneously applied: the internal standard (for calcium) and standard addition (for phosphorus) methods.

The study concludes that optimized sample preparation, including the use of vacuum drying and potassium dihydrogen phosphate as a combined quantification agent, significantly improved TXRF method precision and accuracy by overcoming limitations related to phosphorus quantification.

Keywords: hydroxyapatite, calcium, phosphorus, classical and instrumental analysis methods, TXRF.

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IS4- An Overview of Solid Phase Extraction as a Separation and Concentration Method

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Qualitative or quantitative determination of certain analytes present at low concentrations in food, environmental, and biological samples is of importance for the environment and public health. To determine the selected analyte at sufficiently low concentrations using conventional techniques such as gas or liquid chromatography, certain pre-separation and concentration techniques are required. Sample preparation before instrumental analysis is one of the most important and critical steps. The main objectives of sample preparation methods are (1) separation of the analyte from the matrix medium and/or (2) enrichment of the analyte at low concentrations. One of the methods frequently used in analytical applications for this purpose is the solid-phase extraction (SPE) method. SPE is a well-known sample preparation technique, which allows for isolation of the analytes from the sample or removal of the interferents from the matrix without using huge amounts of organic solvents. One of the major advantages of SPE technique is the availability of wide range of different materials. In addition to commercially available sorbents such as silica-based sorbents (modified with C8, C18, -phenyl, -NH_2 and –CN groups), carbon-based sorbents (graphitized carbon black, porous graphitic carbon) and porous polymeric sorbents, which are commonly used in the SPE method, numerous studies have been reported in recent years on the synthesis of micro or nano-sized sorbents with superior properties (selectivity, affinity and increased surface area, removal of sorbent by application of magnetic field, etc.) and their use as SPE materials, in parallel with developments in materials science[1]. The common aim of these studies is to achieve better reproducibility and selectivity in analyte determination, to reach lower detection limits, and to reduce costs by reusing the sorbent without losing its effectiveness[2]. Many pollutants that threaten the environment and human health (endocrine disruptors, antibiotics, etc.) can be successfully determined by chromatographic techniques by enriching them in the sample preparation step with SPE procedures applied with new generation sorbents. Because, there is still a huge interest in searching for new materials characterized by high selectivity and capacity, which could provide an alternative to typical ones used in SPE. The basic principles of SPE as well as current and possible future applications in Analytical Chemistry will be presented and briefly discussed during the lecture.

Keywords: Solid phase extraction (SPE), chromatography, separation, enrichment

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IS5- Novel Analytical Strategies for the Analysis of Complex Matrices

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As a result of the growing population, there has been a global demand for water and different food samples. However, due to limited resources, millions of people face serious threats to their food and water security. In contrast, water resources and the environment are polluted with many toxic substances in many areas such as the production, distribution, use, and disposal of chemicals. The sensitive and accurate determination and removal of these pollutants from water resources is crucial for establishing clean water sources to form the basis of a healthy society. It is not enough to simply determine these pollutants with high accuracy and sensitivity; it is also very important that the analytical method used offers environmentally friendly solutions with an economic and sustainable approach. In the analytical methods developed, low solvent use and fast and high recovery have made microextraction methods stand out as strategies suitable for this purpose in recent years. These methods, which provide a wide variety of solvents and high extraction efficiency against many analytes, have become even more popular in recent years with increasing developments. The spray-assisted droplet formation-based liquid phase microextraction (SADF-SPME) method, presented as an effective liquid phase microextraction technique using a simple nasal spray bottle waste as a spray apparatus, has introduced a new understanding to the definition of 'environmentally friendly analytical method' with the aim of contributing to waste recycling (Dikmen et al., 2020). In addition to the environmentally friendly approach, different analytical techniques can be used to increase the accuracy of the applied method in complex environmental, food, and biological samples. The matrix matching calibration technique is based on eliminating the possible interference effects of organic and inorganic analytes in samples that cannot be analyzed directly, particularly due to their complex nature and trace analytes. With this approach, it is possible to increase the accuracy of the developed method without the need for an external sample preparation procedure (Bodur et al., 2024; Büyükpınar et al., 2021). Another analytical strategy in sample analysis is the isotope dilution-mass spectrometry (IDMS) method. In this method, uncertainties between measurements are eliminated through gravimetric calculations during the sample preparation stage, while the accuracy of the method is increased by adding the analyte's isotope to the sample solution at known ratios and based on the isotopic ratio between the analyte and the isotope (Bodur et al., 2020). The data obtained using these methods enable the detection of pollutants with high accuracy and sensitivity, providing preliminary information in many areas ranging from the purification of water sources from these pollutants to protective and preventive health measures.

Keywords: *Analytical methods; microextraction; spray assisted; matrix matching calibration technique; isotope dilution mass spectrometry*

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IS6- Chemistry Etched In Our Skin: Hidden Chemical Truth Behind Tattoo Colors

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Tattoo is an application, which is widely used today, by injecting products consisting of coloring and auxiliary substances into the skin to create a permanent mark on the skin or a visual design. Tattoo inks are not classified as pharmaceutical or cosmetic.

The body is directly exposed to the toxic substances contained in the ink due to the injection of tattoo ink into the skin. Pigments may accumulate in the lymph nodes or other systems[1].

Tattoo inks contain many components. The pigments in tattoo inks are not specifically manufactured for tattoo application. These components include polycyclic aromatic hydrocarbons (PAHs), heavy metals, and primary aromatic amines (PAAs) that are inadvertently added to the ink or produced in the skin through different processes such as cleavage, metabolism, and photodecomposition [2].

Titanium, barium, aluminum, and copper are commonly used as colorants in tattoos; trace amounts of antimony, arsenic, cadmium, chromium, cobalt, lead, and nickel may be found in pigment inks using non-metallic colorants [3]. Some nano-sized metal oxides (aluminum oxide, titanium oxide) can also be used to achieve the desired color, transparency, or fluorescence. Common components of red inks are mercury and cadmium. Yellow inks generally contain lead, cadmium, and zinc. Orange inks generally contain cadmium. Common components of green inks are lead, chromium, and copper, while white inks generally contain lead, zinc, and barium [4].

In Turkey, as in the rest of the world, tattooing has become widespread, with individuals even getting tattoos that cover large areas of their bodies. It is observed that the dyes used are imported from abroad and obtained through online orders. There is a need for manufacturers and practitioners to be educated about tattoo safety, and for the public to be warned about potential tattoo risks, so that the issue is taken more seriously. Many European countries have regulations in place to protect consumers. In Turkey, measures and improvements to address existing shortcomings in this area are necessary.

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IS7- Bioinspired doped graphene nanozymes for efficient environmental electrochemical sensing

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In recent years, nanomaterials have attracted increasing attention as artificial enzymes (nanozymes) due to their high catalytic activity toward a wide range of organic compounds and biomarkers. In parallel, electrochemical sensing has emerged as a powerful analytical approach because of its inherent advantages, including high sensitivity, fast response, low cost, and suitability for point-of-care and on-site environmental monitoring through device miniaturization. Although enzyme-based electrochemical sensors offer excellent selectivity, their practical implementation is often hindered by complex immobilization procedures, loss of enzymatic activity, limited long-term stability, strict storage requirements, and high production costs, which restrict their large-scale use in environmental monitoring applications.

The discovery that inorganic nanomaterials can exhibit enzyme-like catalytic behavior has challenged the traditional view of bio-inert materials and has driven the rapid development of nanozyme-based sensing platforms. Among these, bioinspired doped graphene nanozymes stand out due to their large specific surface area, high electrical conductivity, defect- and heteroatom-rich structure, and exceptional structural tunability. Graphene-based nanozymes functionalized with metallic nanoparticles or inorganic redox-active nanophases have demonstrated remarkable catalytic efficiency, enabling non-enzymatic electrochemical detection of environmentally and biologically relevant analytes. Carbon paste, screen-printed, and microfabricated electrodes modified with graphene or graphene quantum dots decorated with noble metal nanoparticles have been successfully applied for the sensitive and selective detection of bisphenol A, catechol, glyphosate, quercetin, dopamine, and other emerging pollutants in complex matrices.

Building on this framework, recent advances are highlighted through the development of a peroxidase-mimicking nanozyme based on Prussian blue nanocubes electrodeposited onto sulfur-doped graphene. The controlled electrochemical synthesis of ~50 nm Prussian blue nanocubes on screen-printed carbon electrodes resulted in a highly active PBNCs–S-Gr nanocomposite, exhibiting excellent catalytic performance toward hydroquinone oxidation. The sensor achieved a low detection limit of 0.33 nM, high sensitivity, a wide linear concentration range, and reliable recovery values (92.1–98.9%) in real surface water samples, underscoring the synergistic effect between doped graphene and inorganic nanozymes.

Overall, this work demonstrates how bioinspired doped graphene nanozymes can overcome the limitations of natural enzymes while offering scalable, robust, and cost-effective electrochemical sensing platforms. By integrating advances in nanomaterials engineering, electrochemistry, and device miniaturization, these systems hold strong potential for next-generation environmental monitoring, agricultural control, and biomedical applications, paving the way toward reliable and portable analytical tools for real-world deployment.

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IS8- Comprehensive Two-Dimensional Gas Chromatography as a Tool for the Development of Sustainable Aviation Fuels

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Sustainable aviation fuels (SAFs) produced via the Fischer–Tropsch (FT) process are a key strategy to decarbonize aviation, but their complex composition makes property optimization and certification challenging. Comprehensive two-dimensional gas chromatography (GC×GC) has emerged as a powerful technique to resolve the chemical complexity of jet fuels and link composition to critical performance properties[1].

In this work, 80+ surrogate and blend jet fuel samples were analyzed using cryogenic modulation GC×GC-MS with a reversed column configuration (mid-polar in the first dimension, non-polar in the second). Chromatographic data were processed with the GC Image software package for peak identification, compound grouping, and relative quantification by chemical class and carbon number. These compositional data were then used as input variables for multivariate regression models to predict key fuel properties[2].

Multiple linear regression models were developed and evaluated using a split into a training- and test data set, combined with venetian blind cross-validation to assess robustness. Initial models achieved root mean square errors of prediction (RMSEP) of 7.6 kg/m^3 for density and 0.76 MJ/kg for heating value, demonstrating the general feasibility of composition-based property prediction. However, these errors remain above the typical accuracy thresholds of standard analytical methods (approximately 0.35 kg/m^3 for density and 0.35 MJ/kg for heating value relative to average fuel values), indicating that further refinement is required. Ongoing work explores alternative pre-processing strategies and both linear and nonlinear regression approaches to reduce prediction errors and improve model reliability.

The development of composition-based prediction models for SAF properties offers a promising route to accelerate formulation, screening, and quality assessment while reducing experimental workload. Such models can support the rational design of FT-derived SAFs that meet regulatory specifications and performance targets, thereby facilitating their broader implementation in aviation.

Keywords sustainable aviation fuels; property prediction; QSPR; chemometric modelling; quantitation

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IS9- Single-particle microwave-induced plasma optical emission spectrometry for nanomaterial characterization

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The development of modern technologies in electronics, biomedicine and agriculture has increased the demand for reliable methods to characterize nanomaterials. Many functional nanomaterials are produced in powder form, which is difficult to analyze using conventional techniques. Most established characterization techniques, including single-particle approaches, rely on stable suspensions of nanoparticles and are therefore poorly suited for materials that cannot be dispersed without aggregation or dissolution. So, nanopowders remain challenging to analyze, particularly with respect to particle size and chemical composition at the single particle level. At present, there is a clear lack of analytical methodologies capable of directly characterizing individual nanoparticles in the solid, powder state. This highlights the need for analytical methodologies capable of single-particle characterization of nanopowders without prior dispersion.

This study presents the application of single-particle microwave plasma optical emission spectrometry (SP-MWP-OES) as a multipurpose, time-resolved analytical technique. SP-MWP-OES enables real-time characterization of individual nanoparticles by combining pneumatic nebulization based on fluidized bed system with a helium microwave plasma source and time-correlated optical emission detection, achieving a temporal resolution ranging from 1 to 50 ms [1,2]. This configuration allows simultaneous multi-element detection from individual particles, providing comprehensive information on particle size distribution, dispersity, agglomeration state and chemical composition.

Several case studies demonstrate the capabilities of SP-MWP-OES. The determination of particle size distributions and elemental compositions of engineered nanomaterials is shown, including selenium nanoparticles synthesized using a microwave-assisted approach. Correlations between elemental signals provide insight into both core and surface compositions, which is particularly important for the analysis of core-shell structures and surface functionalization. In addition, SP-MWP-OES proves to be effective for the characterization of complex nanopowders, such as indium-tin oxide composites, yielding information on stoichiometry, compositional heterogeneity and material purity. Particle size calibration in SP-MWP-OES can be performed either by nebulizing nanopowders of known size, as demonstrated for selenium, which enables a direct correlation between signal intensity and particle size, or (when monodisperse standards are unavailable) by using nanopowders with microscopy-verified size distributions to establish a relationship between emission pulse intensity and particle diameter. Size detection limits (LOD_{size}) depend on the elemental sensitivity and spectral interferences, reaching approximately 5 nm for In_2O_3 and ZnO, ~52 nm for selenium nanoparticles and higher values of ~85 nm and ~250 nm for Fe_3O_4 and SiO_2, respectively.

SP-MWP-OES is a powerful analytical tool that enables comprehensive characterization of nanopowders. It provides insights not only into the average elemental composition of nanomaterial samples but also into chemical composition and purity of individual particles, while eliminating the need for sample preparation.

Keywords: microwave plasma, single particle analysis, optical emission spectrometry, nanoparticle

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IS10- A critical look at the sensitivity and selectivity of current colorimetric reagents and nanoprobes

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Spectroscopy, combined with sensors and nanotechnology, serves as a cornerstone for analytical chemistry, providing a gate to the molecular world. It is useful for both identifying and quantifying chemical substances through matter-light interactions. Spectrophotometry, often combined with simple colorimetric kits and cellular phone applications, offers a low-cost, precise and accurate tool for characterizing matter, but may suffer from interference problems arising from chemical deviations from Beer's law, overlapping bands due to competitive absorption, sample matrix complexity, and temperature/solvent/pH effects. This presentation will shed light on the pros and cons of common colorimetric reagents, either used alone or in combination with sensing nanomaterials, in terms of their selectivity and sensitivity. The last quarter of the presentation will be devoted to open discussions from the floor to ensure that the voices of young researchers are clearly heard.

To mention some examples; the efficient use of common reagents measuring antioxidant activity/capacity, such as the electron transfer (ET)-based FRAP reagent (ferric-tripyridyl triazine), ET- and hydrogen atom transfer (HAT)-based (mixed mode) DPPH and ABTS radicalic reagents, peroxidase substrates such as tetramethyl benzidine (TMB) and *o*-phenylene diamine (OPD) will be evaluated, with their advantages and limitations, such as pH and electronic configuration restrictions and steric hindrance. In our search to revive old colorimetric reagents with a novel approach, Griess diazotization reagent (1879) in the form of *p*-aminothiophenol (p-ATP) was derivatized on gold nanoparticles (AuNPs) to measure nitric oxide (NO), nitrite, and nitro-explosives after hydrolysis. 5,5'-dithio-bis-(2-nitrobenzoic acid), known as the Ellman reagent (1959), was also functionalized on AuNPs to measure free sulfhydryls and protein thiols. Silver mirror reagent, $Ag(NH_3)_2^+$ OH^-, known as the Tollens' reagent (1882), was used for the quantification of reducing sugars and for "all-in-a-tube" detection of the nitro-explosives: RDX and TNT [1].

Our widely used CUPRAC (cupric ion reducing antioxidant capacity) method [2], which later evolved into an integrated series of measurements for antioxidant characterization, such as the measurement of reactive O,N-species and enzymes, is an ET-based assay with a wide linear range which minimizes chemical deviations from Beer's law with its single product chemistry (cuprous-neocuproine chelate). The CUPRAC reagent−functionalized AuNPs sensor was prepared by using heparin as the electrostatic stabilizer, catalyzing the detection of slow-reacting antioxidants [3]. CUPRAC was applied to oxidase enzyme substrates by measuring the H_2O_2 produced from magnetite NPs−immobilized enzyme-substrate reaction [4]. Nanosensing optrodes are typically produced by incorporating various reagents on/in metal and metal oxide nanoparticles and quantum dots. The integration of nanotechnology has greatly contributed to colorimetric sensor design due to the superb physico-chemical properties of nanomaterials, including the effects of size, geometry, specific surface area, surface plasmon resonance (SPR) absorption and nanozyme catalysis. As for possible mechanisms of analyte detection with colorimetric/fluorometric sensors, a wide spectrum of physico-chemical interactions between analytes and nanoprobes may be significant, such as (photo)induced electron transfer, H-atom transfer, charge transfer, radical scavenging, donor-acceptor, Lewis acid-base neutralization,

electrostatic, dipole-dipole, π-π stacking, ion-π [5], π–hole [6], hydrogen bonding and supramolecular interactions [7]. The operating mechanism of optical nanosensors involves the formation and growth of noble metal nanoparticles including derivatized nanoparticle-analyte binding, aggregation and disaggregation of nanoparticles, displacement of active constituents by complexation or electrostatic interaction, and miscellaneous mechanisms. Especially aggregation/disaggregation sensors requiring relatively few nanoparticles may display unexpectedly high sensitivity, even going down to femtomolar range [7]. α-MnO_2 nanorods were passivated with ethylenediamine utilizing charge transfer and oxidase-mimicking activity for ultrasensitive triple-mode colorimetric determination of trinitrotoluene (TNT) [8]. Heteroatom-doped carbon quantum dots (CQDs) have been used as dual-mode nanoprobes for ultra-sensitive and selective determination of picric acid [9]; however, the exact mechanism of CQDs sensing remains to be yet established.

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IS11- Simulation of Biological and Physicochemical Systems with Lattice Model

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Various approaches exist for simulating physical and biological systems, differing in mechanism, scale and timesalce. Utilizing lattices in Ising model and stochastic modeling is a useful and hybrid method for simulating different physicochemical and biological systems. The model can be defined on lattices of both two-dimensions and three-dimensions. 2-D are useful for easy computation; where 3-D lattices are preferred for more realistic modeling of the systems. It is possible to model different systems from electroosmotic flow [1] to epidemic modeling [2] where the results represent the realistic behavior of the system. This method is also highly versatile, enabling the simulation of highly diverse systems across different domains. In this talk, an introduction to Ising Model will be delivered and Monte Carlo methods with a modifed Metropolis algorithm will be explained. Subsequently, example applications to various physical, chemical, and biological systems—such as the movement of analytes in a liquid matrix or polymerization behavior—will be demonstrated.

Keywords: Lattice model, simulation, Monte Carlo method

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[2] COVID-19 modeling based on real geographic and population data, Turkish Journal of Medical Sciences, 53, 333-339

IS12- New trends in microextraction techniques

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The t microextraction of traces organic and inorganic species from environmental samples is a necessity prior to their spectroscopic detection due to their low levels and influences of matrix components. In recent years, solvent microextraction and/or microsolid phase extraction has been developed as an environment friendly alternative method to other separation and preconcentration techniques. The microextraction techniques are low the consumption of organic solvents, accurate and precise. In this presentation, the solvent microextraction and/or microsolid phase extraction strategies for the separation and preconcentration of organic and inorganic species from real samples established by our research group have been discussed.

Keywords: Microextraction; Separation; Preconcentration; Nanocomposites; Green Solvents.

IS13- Green Extraction Techniques for Organic and Inorganic Species in Different Matrix Media

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Green extraction techniques are very important for the separation, preconcentration and determination of organic and inorganic species in different matrix media. Direct determination of organic or inorganic species in food, water and environmental samples is a big problem because of very low concentration of analytes, which may be lower than the detection limit of instruments and the interfering effects of the matrix components. These problems can be solved by using separation and preconcentration methods. Environmentally friendly and green extraction techniques have recently great interest due to their simplicity, cheap, high efficiency and reduced exposure of toxic chemicals to the environment. A new and green vortex-assisted liquid phase microextraction procedure based on deep eutectic solvent was developed for the determination of arsenic in water, honey and rice samples by using hydride generation-atomic absorption spectrometry (1). Dispersive solid-liquid extraction method was developed based on organic polymers followed by deep eutectic solvents elution; application in extraction of some pesticides from milk samples (2). A magnetic solid phase microextraction method was performed on Escherichia coli immobilized to magnetic conductive carbon black (Vulcan XC-72) for the determination of cadmium in water and food samples (3). Sensitive determination of Brilliant Blue FCF in some food samples was developed by using hydrophillic deep eutectic solvent-assisted magnetic nano gel-based dispersive solid phase microextraction (4). A new, fast, green and reliable extraction of ibuprofen from real samples was performed by using vortex-assisted magnetic nanofluid based liquid phase microextraction method (5). The optimized method was applied to different water samples including drinking water, tap water, canal water and wastewater. In this presentation above studies will be discussed. Some examples from micro solid phase extraction, deep eutectic solvent extraction, switchable solvent extraction, and magnetic nanofluid based microextraction will give.

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IS14- Development of conducting polymer based molecularly imprinted polymers

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Conducting polymer based molecularly imprinted polymers (CP-MIPs) represent a rapidly advancing class of smart materials that integrate molecular recognition with intrinsic electrical conductivity. Traditional molecularly imprinted polymers (MIPs) provide high selectivity through template-directed cavity formation, however, their limited signal transduction capabilities restrict direct sensing applications. The incorporation of conducting polymers such as polyaniline (PANI), polypyrrole (Ppy), and Poly(3,4-ethylenedioxythiophene) (PEDOT) overcomes this limitation by enabling real-time electrochemical signal generation.

This presentation focuses on computational design [1,2], synthesis, template removal [3] and characterization [4] of CP-MIPs fabricated via electrochemical polymerization in the presence of target template molecules. The imprinting process creates highly specific binding sites complementary in size, shape, and functional group orientation to the analyte. Upon template removal, the resulting cavities enable selective rebinding, which modulates the polymer's electrical properties and facilitates sensitive detection. Key parameters influencing performance - including monomer selection, template-monomer interaction strength, crosslinking density, film thickness, and doping conditions are systematically optimized. Advanced characterization techniques such as cyclic voltammetry, electrochemical impedance spectroscopy, and scanning electron microscopy are employed to evaluate conductivity, morphology, and binding efficiency.

The developed CP-MIPs demonstrate enhanced selectivity, rapid response times, and low detection limits for chemical and biological analytes. These materials show strong potential for applications in biosensors, environmental monitoring, pharmaceutical analysis, and wearable diagnostics. The integration of molecular imprinting with conductive matrices provides a versatile platform for next-generation intelligent sensing technologies.

Keywords: *Conducting polymer, molecularly imprinted polymers, polyaniline (PANI), polypyrrole (Ppy), and Poly(3,4-ethylenedioxythiophene) (PEDOT), Pulsed Amperometric Detection, Cyclic Voltammetry, Differential Pulse Voltammetry.*

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IS15- The Rise of Immobilized Biomaterials from Enzymes to Aptamers in Electrochemical Biosensors

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The field of electrochemical biosensing has witnessed a paradigm shift driven by the evolution of biorecognition elements and immobilization strategies. This study provides a comprehensive overview of the transition from classical enzyme-based platforms to advanced aptamer-based architectures. While enzymes have long been the gold standard due to their high specificity and catalytic power, issues regarding stability and cost have necessitated the exploration of robust alternatives[1]. Initial focus is placed on enzyme immobilization techniques, demonstrating how stabilizing enzymes on electrode surfaces enhances manufacturing productivity and operational longevity. Specifically, the critical role of enzyme inhibition in therapeutic drug monitoring is highlighted, using Tyrosinase-based sensors for melanin synthesis regulation as a primary case study[2].

However, the "rise" of biomaterials extends beyond enzymes. The narrative subsequently examines the emergence of aptamers-synthetic oligonucleotide sequences-as powerful rivals and complements to enzymes. The study compares the performance of enzymatic systems against aptasensors in terms of sensitivity, selectivity, and stability under varying environmental conditions. By analyzing the trajectory from enzymatic catalytic detection to aptameric affinity binding, this work elucidates the future direction of electrochemical biosensors in medical diagnostics, environmental monitoring, and food safety, emphasizing the synergistic potential of these immobilized biomaterials.

Keywords: Electrochemistry, Enzyme, Aptamer, Biosensor, Immobilization

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ORAL PRESENTATIONS (OP)

OP1- A sensing platform based on electrochemically reduced graphene oxide for biological and pharmaceutical determination of estradiol

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A sensing platform based on electrochemically and chemically reduced graphene oxide at glassy carbon electrodes (GCE) symbolized as (EC-RGO/GCE) and (C-RGO/GCE), respectively, were fabricated for potential application of estradiol (E2). The functionalized surface materials were characterized using Fourier transform infrared (FTIR), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (XRD), electrochemical impedance spectroscopy (EIS) and X-ray photoelectrons spectroscopy (XPS) and cyclic voltammetry (CV). The synergistic effect of surface materials promotes the catalytic efficiency of the developed sensor for E2 detection at low concentration ranged between 0.14 μM and 2.66 μM. The EC-RGO showed a prominent sensing activity by decreasing the detection limit (DL3σ) of E2 into 2.5 times and elevated the surface sensitivity by 4 times compared to C-RGO. The proposed EC-RGO sensor was tested for potential application to E2 detection in pharmaceutical (tablets) and biological (plasma blood) samples with tolerable recovery percentages.

Key words:
Reduced graphene oxide; Electrochemical deposition; Estradiol hormone; Voltammetric detection.

Acknowledgement:
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OP2- Mesoporous Monolithic Membranes for Solid Phase and Thin Film Microextraction

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In recent years, thin-film microextraction (TFME) has emerged as a powerful sample preparation technique due to its high sensitivity, rapid kinetics, and compatibility with high-throughput analytical systems. In this study, novel polymeric and mixed-matrix membrane-based TFME methods were developed and applied for the extraction and determination of estrogenic hormones and pharmaceutical compounds in aqueous and biological samples. In the first part of the research, a polyvinylidene fluoride (PVDF)-based membrane was fabricated using a two-step casting (TC) method combined with phase inversion for high-throughput liquid-phase TFME (LP-TFME). This membrane was successfully applied for the extraction of estrone (E1) and 17β-estradiol (E2). Quantitative analysis was performed using high-performance liquid chromatography with ultraviolet detection (HPLC-UV). The developed method exhibited low limits of detection (0.16–3.30 μgL^{-1}) and a wide linear dynamic range (0.5–150 μgL^{-1}), demonstrating excellent analytical performance. In the second part, a highly porous PVDF membrane was prepared via a three-step casting method followed by phase inversion and applied for solid-phase TFME of antifungal drugs including ketoconazole, clotrimazole, and miconazole. The method provided rapid extraction, good linearity (1–250 μgL^{-1}), and low detection limits (0.33–3.30 μgL^{-1}) across different matrices. The high porosity of the membrane significantly enhanced extraction efficiency and analytical sensitivity. In the third study, a novel mixed-matrix membrane was developed by incorporating a covalent organic framework (COF), Schiff base network-1 (SNW-1), into the PVDF matrix. This membrane was applied for the simultaneous extraction of anticancer drugs dasatinib and erlotinib. The proposed method enabled rapid and efficient extraction from aqueous, plasma, and urine samples, with limits of detection ranging from 0.33 to 3.30 μgL^{-1} and satisfactory linearity (1–150 μgL^{-1}). All fabricated membranes were thoroughly characterized using FESEM, AFM, ATR-FTIR, nitrogen adsorption–desorption analysis, and porosity measurements to evaluate their morphology and structural properties. Furthermore, all methods were implemented using a 64-well plate format, enabling high-throughput analysis with an extraction–desorption cycle time of only 0.78 minutes per sample. Overall, the developed TFME methods offer significant advantages, including high sensitivity, rapid analysis, low solvent consumption, and suitability for complex matrices. These features make the proposed approaches promising tools for environmental, pharmaceutical, and bioanalytical applications.

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OP3 Optimization of Green MOF Synthesis Using Deep Eutectic Solvents for Catalytic Dye Degradation

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Abstract: Environmental pollution caused by textile dyes represents a significant challenge for sustainable water management due to their toxicity and resistance to conventional treatment methods. In this study, zeolitic imidazolate framework-8 (ZIF-8) was synthesized using natural component-based deep eutectic solvents (DESs) following green chemistry principles. The catalytic performance of DES-assisted ZIF-8 materials was evaluated for the removal of selected textile dyes, including methylene blue and Congo red, from aqueous solutions. The synthesized materials were characterized by FT-IR, SEM, XRD and UV–Vis spectroscopy. Key analytical parameters such as pH, catalyst dosage, dye concentration, contact time, and temperature were systematically optimized to achieve maximum removal efficiency. Dye degradation was quantitatively monitored using UV–Vis spectrophotometry. The results demonstrate that DES-synthesized ZIF-8 exhibits enhanced catalytic activity and efficient dye removal under optimized conditions. This study highlights the analytical applicability of green solvent-based MOFs as sustainable catalysts for wastewater treatment.

Keywords: Deep eutectic solvents; ZIF-8; Catalytic removal; Analytical optimization

Introduction

Water pollution caused by industrial activities has become a critical environmental concern, particularly due to the discharge of dye-containing wastewater from textile industries. Synthetic dyes such as methylene blue and Congo red are widely used because of their high stability, vivid coloration, and resistance to biodegradation. However, these properties also make them difficult to remove using conventional wastewater treatment techniques, resulting in persistent contamination of aquatic environments[1].

Traditional physical and chemical treatment methods, including coagulation–flocculation, membrane separation, and adsorption, often suffer from low efficiency, secondary pollution, or high operational costs. In recent years, catalytic approaches have attracted increasing attention due to their ability to degrade dye molecules rather than merely transferring them between phases. Among advanced catalytic materials, metal–organic frameworks (MOFs) stand out due to their high surface area, tunable pore structures, and adjustable chemical functionalities[2].

The use of deep eutectic solvents (DESs) as green alternatives to conventional organic solvents has emerged as a sustainable strategy in MOF synthesis. DESs can act as reaction media and structure-directing agents, improving MOF properties while minimizing environmental impact[3]. This study focuses on the synthesis of DES-modified ZIF-8 and its analytical evaluation in the catalytic removal of textile dyes from aqueous systems.

Materials and Method

Deep eutectic solvents were prepared by mixing choline chloride as the hydrogen bond acceptor with urea or ethylene glycol as hydrogen bond donors at defined molar ratios. The mixtures were heated under continuous stirring until homogeneous, transparent liquids were obtained and then cooled to room temperature.

ZIF-8 was synthesized using the prepared DESs via different synthesis routes. Zinc nitrate hexahydrate and 2-methylimidazole were used as metal precursor and organic linker, respectively. The reaction mixtures were subjected to controlled temperature and stirring conditions, followed by solvothermal treatment or precipitation, depending on the synthesis method[4]. The resulting products were separated by centrifugation, washed with ethanol, and dried at 80 °C.

The structural and surface properties of the synthesized materials were characterized using Fourier-transform infrared spectroscopy (FT-IR), scanning electron microscopy (SEM), and XRD. Catalytic dye removal experiments were performed using aqueous solutions of methylene blue, methyl orange and Congo red. The effects of pH, catalyst dosage, initial dye concentration and contact time were systematically investigated. Dye concentrations were monitored using UV–Vis spectrophotometry in the range of 200–800 nm, and removal efficiency was calculated based on changes in absorbance values.

Results and Discussion

FT-IR spectra confirmed the successful formation of ZIF-8 structures, with characteristic vibrational bands corresponding to imidazole rings and Zn–N coordination bonds. SEM images revealed well-defined crystalline morphologies with relatively uniform particle size distributions, indicating that DESs effectively influenced crystal growth and surface features.

Catalytic performance tests showed that DES-synthesized ZIF-8 exhibited significant dye removal efficiency for all of them methylene blue, methyl orange and Congo red. The removal efficiency was strongly dependent on solution pH, with optimal performance observed under neutral conditions. Increasing catalyst dosage enhanced dye degradation up to an optimum level, beyond which no significant improvement was observed, indicating effective utilization of active sites.

Higher initial dye concentrations led to a gradual decrease in removal efficiency, attributed to the saturation of catalytic active sites. Time-dependent studies revealed rapid degradation within the initial stages of the reaction, followed by a slower approach to equilibrium. UV–Vis spectra confirmed a continuous decrease in characteristic absorption peaks of the dyes, indicating effective degradation rather than simple adsorption.

The enhanced catalytic activity of DES-modified ZIF-8 can be attributed to improved surface properties, increased accessibility of active sites, and stronger interactions between dye molecules and the MOF structure. These results demonstrate that DESs play a critical role in tailoring MOF properties for analytically optimized catalytic applications.

Conclusion

DES-assisted synthesis of ZIF-8 provides an environmentally friendly and analytically effective approach for textile dye removal. The optimized catalytic system exhibits high removal efficiency and stability, highlighting its potential for sustainable wastewater treatment applications.

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OP4- Electrochemical biosensing of estrogens

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Estrogens, i.e. 17-β-estradiol, estriol, and estrone, are critical regulators of numerous physiological processes in women. Accurate monitoring of estradiol levels is essential for diagnosing menstrual cycle abnormalities, fertility issues, menopausal changes, and osteoporosis risk.

Although a wide range of biosensors for estrogen determination has been described, most systems utilize antibodies as the recognition element. While antibodies provide exceptional specificity and sensitivity, their integration onto sensor platforms (e.g., electrode surfaces) is technically demanding and requires highly controlled conditions[1]. Enzymes, on the other hand, constitute a more accessible and cost-effective alternative without compromising analytical performance.

The aim of this work was to develop an enzymatic biosensor based on horseradish peroxidase, (HRP) immobilized in a matrix containing metal-organic framework JUK-2, designed for the determination of estrogens: 17-β-estradiol, estriol and estrone. Our previous research proved that composite consisted of JUK-2, multi-walled carbon nanotubes and gold nanoparticles acts as hybrid material with mixed ion-electron conductivity, which contributed to its excellent electrocatalytic activity[1]. Catechol (H_2Q) and estrogens are both enzyme co-substrates. In the presence of H_2O_2, HRP catalyzes the oxidation of H_2Q and estrogens[2]. The electrochemical response of the sensor is proportional to concentration of H_2Q and inversely proportional to the estrogen concentration. In order to optimize the composition of the biosensor matrix and the method of the biosensor preparation, cyclic voltammetry and impedance spectroscopy measurements were carried out. In addition, parameters such as pH of the supporting electrolyte, H_2Q concentration and H_2O_2 concentration were optimized. Analytical characteristics of biosensors toward estrogens: 17-β-estradiol, estriol and estrone, was carried out, determining sensitivity, LOD, LOQ, and reproducibility. The biosensor performance was verified by determining the hormone content in a synthetic sample, a biological matrix and a pharmaceutical product.

Keywords: enzymatic biosensor, electrochemistry, estrogens, 17-β-estradiol

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OP5- Electrochemistry at the Interface between Two Immiscible Electrolyte Solutions in Safeguarding Food Quality Control

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Electrochemistry at the interface between two immiscible electrolyte solutions (ITIES) has emerged as an exceptionally versatile platform for studying charge-transfer processes in complex chemical and biological systems. Over the past decades, ITIES-based methods have moved beyond fundamental ion-transfer studies and gained growing attention as a promising analytical tool capable of addressing challenges in environmental monitoring, biomedical diagnostics, and food quality assurance.

In this contribution, we explore the potential of ITIES electrochemistry for the determination of biologically active substances occurring naturally or as additives in food products. By employing well-controlled polarizable liquid–liquid interfaces, we have developed new electroanalytical procedures enabling the direct detection and quantification of these compounds in complex food matrices. The methods rely on ion-transfer voltammetry and interfacial processes, which provide molecular-level insight into the redox and partitioning behavior of analytes at the interface. The obtained results demonstrate that ITIES-based electrochemistry can complement or even surpass conventional electrochemical methods by offering higher selectivity, shorter analysis times, and lower environmental impact due to the reduction of the use of toxic reagents. This work highlights the broad applicability of the ITIES concept for monitoring bioactive components in food, supporting both regulatory compliance and innovation in product development. Ultimately, it provides a foundation for establishing next-generation electrochemical sensing strategies for sustainable and reliable food quality control.

In the presented work, newly developed procedures for the qualitative and quantitative determination of selected biologically significant compounds at the polarized water || 1,2-dichloroethane interface will be discussed. Furthermore, the proposed methods have been successfully applied to the analysis of real matrices – food samples [1,2].

Keywords: electrochemistry, ITIES, food dyes, electroanalysis, food quality control.

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OP6- Electrochemical determination of amphetamine in street drug samples at the electrified liquid-liquid interface

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The interface between two immiscible electrolyte solutions (ITIES) serves as a unique electrochemical platform for studying the transfer of the ionic species between aqueous and organic phases. This methodology has gained significance in analytical chemistry due to its ability to detect redox-inactive ions[1], including various psychotropic substances[2].

The experiments were performed using a classic four-electrode electrochemical cell consisting of an aqueous (sodium chloride solution) and an organic phase (highly hydrophobic salt dissolved in 1,2-dichloroethane). The transfer behavior of selected psychoactive substances was investigated in the presence of a model ion to characterize their electrochemical signatures. Cyclic voltammetry was employed to study the ion transfer of amphetamine, using tripropylammonium chloride to define the standard Galvani potential scale. When applied to real-world street samples, the method successfully determined analyte concentrations ranging from several to over ten percent. These preliminary findings contribute to the creation of an "electrochemical map" aimed at the preliminary verification of complex illicit drug compositions. The study confirms that the classic ITIES configuration is an effective and reliable tool for the quantitative analysis of amphetamine. This fundamental approach provides the necessary groundwork for developing advanced, portable sensors for forensic and quality control applications.

Keywords: ITIES, cyclic voltammetry, amphetamine, illicit drugs.

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OP7- Electrochemical studies of the activity of food colorants at the polarized liquid-liquid interface

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The long-standing use of synthetic food dyes in daily consumed products has raised significant health concerns among customers, igniting a conversation about stricter safety evaluations. These public health concerns have driven research that resulted in the restriction of certain additives, such as Allura Red, due to their potential carcinogenic properties[1].

This study explores the electrochemical activity of selected food dyes: Allura Red, Tartrazine, and Carmoisine at the Interface between Two Immiscible Electrolyte Solutions (ITIES). Experiments were performed within the broad range of pH of the aqueous phase (from 2 to 13), to examine how different chemical environments affect the visibility and position of the signals originating from the target analytes.

The findings indicate that the pH of the aqueous phase significantly influences the intensity of the voltametric signals. Additionally, the analyte concentration plays a crucial role in the electrochemical response of the system. In most instances, a linear increase in signal intensity was observed as the dye concentration increased. This relationship demonstrates that the ITIES-based method is highly effective for the detection and quantitative measurement of these substances.

These results represent a part of a project aimed at improving the quantitative detection of food dyes in real-world samples. The study provides valuable insights for further development of more efficient analytical techniques to enhance food safety monitoring.

Keywords: electrochemistry, ITIES, food dyes, cyclic voltammetry, pH influence

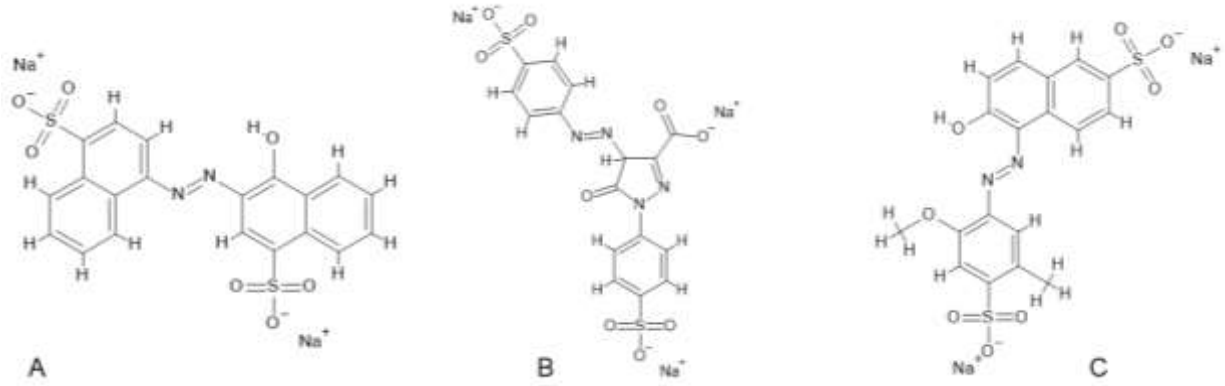

Figure 1. Structural formulas of Carmoisine (A), Tartazine (B) and Allura Red (C).

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OP8- Modeling the disposal of sunitinib malate in aqueous media by Response Surface Methodology (RSM)

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Water is the most essential compound for life, and although water makes up 70% of our planet, only 3% of that amount is potable. Human-caused factors such as rapid population growth, urbanization, increasing pressures from agriculture, industry, and energy sectors, and incorrect water usage strategies have increased water scarcity to a level that negatively affects human health, economic activities, food, and energy resources. Analyses conducted in regions inhabited by approximately 471.4 million people worldwide have detected 61 different active pharmaceutical ingredients and drug active substances in the food chain, and especially in water [1]. This situation increases the incidence of autoimmune diseases. Anticancer drug active ingredients are also considered potential pollutants and pose a chronic risk to living organisms due to their cytotoxic effects [2]. Sunitinib malate (SM), the model compound of our study, is an anticancer drug active ingredient that is a multikinase inhibitor. In our study, the optimization of experimental variables such as voltage (current), pH, Fenton reagent ($FeSO_4$) concentration, and distance between electrodes applied using the electro-Fenton method (EFM) for the removal of SM from tap water samples was performed using Response Surface Methodology (RSM) (Fig 1).

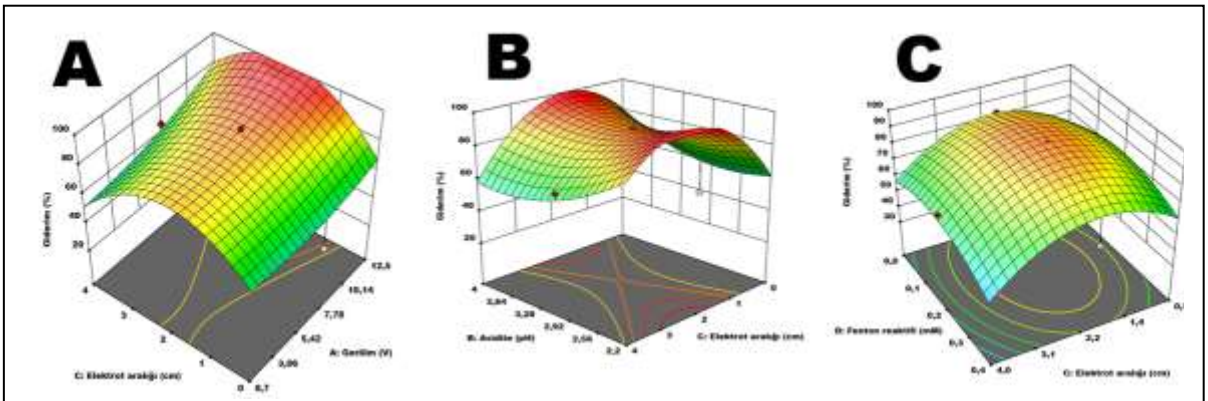

Fig 1. 3D surface graphs of SM disposal% depending on interelectrode distance-potential (A), pH-interelectrode distance (B) and $FeSO_4$ concentration-interelectrode distance (C).

The experimental optimum conditions for the removal of SM by EFM were determined as 10V voltage, pH 3, 0.2 mM $FeSO_4$ concentration, and 20 mm distance between electrodes. Under these optimum conditions, the removal of SM by EFY was studied by dissolving one Sutent (12.5 mg) capsule in 200 mL of tap water from 30 districts of Izmir.

Keywords: Electro-Fenton, Response Surface Methodology (RSM), Sunitinib Malate, Wastewater Treatment

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OP9- Edible oil-based dispersive liquid–liquid microextraction prior to HPLC-DAD for the determination of parabens in human milk, baby food and personal care products

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Parabens, or esters of *p*-hydroxybenzoic acid, are commonly used individually or in combination as antimicrobial preservatives in food, personal care products (PCPs), and pharmaceuticals due to their broad spectrum of action against numerous microorganisms, efficacy, lack of perceptible odor, taste, discoloration, or hardening effect, and stability over a wide pH range[1]. In 2004, intact esters of five commonly used parabens [methyl- (MP), ethyl- (EP), propyl- (PP), butyl- (BP), and isobutylparaben (iso-BP)] were found in human breast cancer tissues at a mean concentration of 20.6 ng g^{-1}. Since then, there has been a growing scientific debate about their use. Although the source of parabens could not be confirmed, it was suspected that dermal absorption from PCPs applied to the breast region over time may have contributed[2]. Despite the widespread popularity and numerous advantages of dispersive liquid–liquid microextraction (DLLME)[3] as a sample cleanup and preconcentration method, the frequent use of harmful solvents and/or the generation of chemical waste has prompted researchers to seek greener alternatives. We have recently proposed the use of edible oils (EOs) as extraction solvents in liquid-phase microextraction (LPME) [4] for being environmentally friendly, renewable, sustainable, biodegradable, non-volatile, affordable, and compatible with various analytical techniques. In this study, a novel analytical method utilizing EOs as green alternative solvents for DLLME, followed by a back-extraction step, is proposed prior to HPLC-DAD for the determination of four commonly used parabens (i.e., MP, EP, PP and BP). Optimum extraction conditions were found as follows: 500 µL of rose oil, 400 µL of acetonitrile within 60 s extraction time. Back-extraction of the analytes into 200 µL of 50.0 mM sodium hydroxide solution within 180 s resulted in an RP-HPLC-compatible extract. The analytes were separated at room temperature in a C18 column [Waters Spherisorb ODS-2, 250 mm × 4.6 mm ID (5 µm)] using a mobile phase consisting of acetonitrile (A) and 1.0% (v/v) acetic acid (B), 60:40 (A:B, v/v) at a flow rate of 0.60 mL min^{-1} and an injection volume of 20.0 µL. DAD was set at 200–400 nm and UV/Vis at 258 nm to monitor the analytes. Limits of detection and quantitation were as low as 0.09 and 0.30 µg mL^{-1}, respectively. Coefficients of determination (R^2) were higher than 0.9951 and percentage relative recoveries (%RR) were found in the range of 80.0–110% for the four parabens in human milk, baby food and personal care products.

Keywords: Baby food, dispersive liquid–liquid microextraction, edible oil, HPLC-DAD, human milk, parabens, personal care products

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OP10- Influence of in vitro human digestion simulation on the phenolics contents and biological activities of the methanol extracts from Turkish Cistus species

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Oxidative stress is one of the significant precursors of various metabolic diseases such as diabetes, Parkinson's disease, cancer etc. Various scientific reports indicated that secondary plant metabolites play an important role in preventing oxidative stress and its harmful effects[1]. In this respect, this study was planned to investigate the phenolic profile, antioxidant and antidiabetic potentials of the aqueous extracts from Turkish *Cistus* species by employing *in vitro* methods. *In vitro* digestion simulation procedure was applied to all extracts for estimating the bioavailability of their phenolic contents. Total phenolic, flavonoid, phenolic acid and proanthocyanidin contents were determined for all phases of digestion. In addition, changes in the quantity of the assigned marker flavonoids (tiliroside, hyperoside and quercitrin) were monitored by High-Performance Thin Layer Chromatography (HPTLC) analysis. Besides the chemical experimentations, biological activity profiles on the digestion phases were carried out. The antioxidant activity potentials of the extracts were studied by various methods to reveal their detailed activity profiles. Metal reducing potential (FRAP and CUPRAC) and free radical scavenging (DPPH and DMPD) assays, and a total antioxidant capacity assay were conducted on all phases of digestion. On the other hand, *in vitro* α-amylase and α-glucosidase enzymes and advanced-glycation end products (AGEs) inhibitory activities of the extracts were determined to evaluate the antidiabetic potentials of extracts. The results showed that methanolic extracts obtained from the aerial parts of Turkish *Cistus* species have rich phenolic contents and outstanding antioxidant and antidiabetic potentials; however, their bioactivity profiles and marker flavonoid contents might significantly be affected by human digestion.

Key words: Turkish *Cistus* species, Antioxidant activity, Human digestion simulation, HPTLC, Diabetes

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OP11- Monitoring Heavy Metal Pollution of Antarctic Region by Using Fecal Samples

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Inorganic pollution originates from natural processes or human activity and commonly present in mining operations, urban runoff, and industrial waste. Living creatures are adversely impacted by exposure to these toxins. The categories of inorganic pollutants that contaminate the environment primarily include heavy metals, trace elements, mineral acids etc., which exist in amounts above acceptable thresholds[1]. The Antarctic continent exhibits unique characteristics owing to its geographical isolation, challenging environmental conditions, and relentless cold climate. However, there is increasing worries among the scientists about the escalating human impact in Antarctica, which may significantly undermine the scientific integrity of its terrestrial ecosystems. Research on heavy metals in Antarctic biota mostly concentrates on creatures such as seabirds, crustaceans, and algae[2]. In order to examine these potential detrimental effects, heavy metals were investigated in fecal samples in the presented study. For this aim, feces samples were collected from seals and penguins in Horseshoe Island, Antarctica collected from the 9. National Antarctica Scientific Expedition (TAE-IX). The samples were analyzed by using inductively coupled plasma mass spectrometry (ICP-MS) system after microwave assisted digestion procedure. Not only toxic heavy metals (Hg, As, Cd, Cr, Ni, Pb) but also essential elements (Mn, Mg, Cu, Co, Se, Zn, Fe, Al, Ca) were determined in the same fecal samples. In the fecal samples, heavy metals differ from 2.63 and 26.92 µg/L, while essential elements were recorded between 6.69 and 17,357.22 µg/L. According to the data obtained, potential contamination risks were highlighted and underscore the need for continued monitoring to protect Antarctic biodiversity.

Keywords: Antarctica, Horseshoe Island, Heavy metals, Penguin and seal feces

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OP12- Simultaneous determination of selected pharmaceutical active ingredients in Arctic surface water samples by liquid chromatography tandem mass spectrometry after preconcentration using the developed DES-based LPME method

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The Arctic ecosystem, known as one of the world's most unique and vulnerable regions, has been facing an increasing threat of chemical pollution in recent years[1]. In previous studies conducted on samples from this region, many pharmaceutical molecules have already been detected[2]. In this study, eight pharmaceutical active ingredients with the potential to contaminate the region in the near future were selected. In this study, DES-LPME method (deep eutectic solvent-based liquid phase microextraction) was developed to enable the simultaneous determination of these analytes in complex matrix samples using a liquid chromatography tandem mass spectrometry system. In developing the DES-LPME method, five different types of DES were initially examined. These are lactic acid: choline chloride, thymol:acetic acid, lactic acid: ammonium acetate, thymol: octanoic acid, and thymol lactic acid. Among these, the best extraction efficiency was obtained in DES composed of thymol:octanoic acid. Each parameter expected to affect the LPME method to be performed using DES composed of thymol-octanoic acid has been optimized with a univariate optimization approach. Afterwards, the analytical performance of the system was evaluated under the optimum conditions chosen as a result of optimization studies. Then, recovery experiments were carried out on surface water samples collected from the Arctic region for the developed method, and high recovery percentages were achieved. As a result, a separation and preconcentration method has been developed that facilitates the simultaneous monitoring of eight pharmaceutical active compounds in Arctic surface water samples with complex matrices.

Keywords: Arctic; deep eutectic solvent; microextraction; pharmaceutical active ingredient

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OP13- Microwave-Assisted Synthesis and Implementation of $CoFe_2O_4@Bi_2S_3$ Magnetic Nanoparticles for Lead Determination in Synthetic Wastewater

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Lead (Pb) is one of the heavy metals that cause significant changes in the development of living organisms. In addition to industries such as cosmetics, paint, glass and mining, it is known to be used in batteries and smelting processes1. Pb has been reported to cause various diseases in the human body. Some of these include accumulation in bones and teeth, causing neurological damage, and spreading to the kidneys and liver2. Therefore, the determination of lead at trace levels with high accuracy and precision has become important. Within the scope of this study, bismuth sulfide nanoparticle was first synthesized using microwave-assisted synthesis and then this nanoparticle was further utilized in microwave-assisted synthesis of cobalt ferrite for surface functionalization. A dispersive solid phase extraction (DSPE) method has been developed using cobalt ferrite@bismuth sulfide ($CoFe_2O_4@Bi_2S_3$) magnetic nanoparticle as a sorbent. Scanning electron microscopy (SEM), X-ray diffraction spectrometry (XRD) and Fourier transform infrared spectrometry (FT-IR) analyses were performed to obtain information about the characteristic structures of $CoFe_2O_4@Bi_2S_3$ nanoparticles. The optimum conditions of the developed method were determined using a single variable optimization approach with three technical replicates. 1.0 mL pH 4.0 buffer solution, 30 mL sample volume, 20 mg magnetic nanoparticle amount, 3.0 minutes orbital shaker and 125 µL 0.5 M nitric acid have been determined as the optimum conditions. To increase the sensitivity of the developed system and enhance the interaction of analytical atoms with light a slotted quartz tube (SQT) apparatus was combined with flame atomic absorption spectroscopy (FAAS). The applicability of the $CoFe_2O_4@Bi_2S_3$-DSPE-SQT-FAAS method to real samples was investigated using synthetic wastewater. As a result, the outputs of this developed method, which are cost-effective, innovative, fast and easy to procedure, have shown the applicability of the method to other examples.

Keywords: $CoFe_2O_4@Bi_2S_3$, dispersive solid phase extraction, flame atomic absorption spectroscopy, lead, synthetic wastewater

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OP14- The Electroanalytical Applications of Aptamer or DNA-based Nano-Biomolecular Interactions with Sensors

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Sensor systems, which are still under development for biosensing purposes, have enabled high-precision detection and the production of miniature devices with the addition of nanomaterials to their components over the last 15 years. Particularly in the last five years, these systems have been mentioned in global sensor/biosensor reports. These reports predict that they will be increasingly used in many fields, including medicine, pharmaceuticals, food, agriculture, and the environment, especially in wearable devices. Accordingly, nanomaterials with carbon or metal structures are particularly preferred in biosensor designs because they increase the surface area to which they are modified and offer advantages such as high conductivity and low cost.

Here, we presented some of current nanobiosensors/diagnostic kits and their electroanalytical applications from our laboratory, which were designed to improve the analysis performance of analytical devices.

Keywords: Electrochemical biosensors; diagnostic kits; Nanomaterials; Signal amplification; Guanine oxidation

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OP15- Atomic Force Microscopy as a tool for evaluating electrochemical sensor morphology

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Atomic force microscopy (AFM) is one of the most important techniques for surface imaging at the micro- and nanoscale and is widely applied in studies of functional materials, including electrochemical sensors. The morphological properties of electrode surfaces, such as topography, roughness, porosity, as well as the distribution and homogeneity of active layers, play a crucial role in determining the performance parameters of electrochemical sensors, particularly their sensitivity, selectivity, repeatability, and long-term stability. For this reason, precise characterization of surface morphology constitutes an essential element in the design and optimization of electrochemical sensors.

Therefore, the aim of this work is to present AFM as an effective tool for the evaluation of electrochemical sensor morphology and to discuss its capabilities and limitations in the context of electrode material studies.

During presentation, the fundamental principles of AFM operation, with particular emphasis on the interaction mechanisms between the probe tip and the investigated surface are described. The most commonly used AFM operating modes, including contact mode, tapping mode, and non-contact mode, are presented, and their applicability to the investigation of various types of materials used in electrochemical sensor construction is discussed.

Representative AFM images of electrochemical sensor surfaces are presented, including glassy carbon electrodes, glassy carbon electrodes modified with carbon nanotubes and additionally with electrochemically generated palladium nanoparticles, as well as carbon paste electrodes. These images illustrate differences in surface structure, grain distribution, roughness parameters (Ra, Rq), and the degree of homogeneity of the active layer, depending on the type of material, the fabrication method, and the applied surface modification.

The relationship between surface topographical parameters and the electrochemical response of the sensors is also discussed, based on measurements performed using techniques such as voltammetry and electrochemical impedance spectroscopy. It is demonstrated that increased roughness and an enhanced effective surface area of the electrode may lead to improved sensor sensitivity. However, this relationship is not unambiguous, and in some cases excessive surface heterogeneity can adversely affect the stability and repeatability of the analytical signal.

Attention is also drawn to the limitations of AFM, such as the relatively small scanning area, the time-consuming nature of measurements, and the need for appropriate sample preparation, while emphasizing the rationale for combining AFM with other surface characterization techniques.

The presented results confirm that AFM is a fundamental and effective tool supporting the design and optimization of electrochemical sensors, enabling a better understanding of the relationship between surface structure and analytical functionality.

Keywords

Atomic Force Microscopy, AFM, surface topography analysis, electrochemical sensor

OP16- A Rapid Electrochemical Determination of Donepezil Hydrochloride Based on Carbon Screen-Printed Electrode

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Alzheimer's disease is a type of dementia characterized by a decline in cognitive function, followed by memory loss[1]. Given the need for effective treatment methods, Donepezil Hydrochloride (DPZ) is a commonly used medication in the treatment of Alzheimer's disease[2]. Accurate and sensitive determination of DPZ in both tablets and body fluids is critical due to factors such as the drug's pharmacokinetics and inter-individual metabolic variability. In this study, carbon screen-printed electrodes (CSPE), known for their suitability for mass production, low cost, disposable structure, and compatibility with miniaturized electrochemical systems, were used for the determination of DPZ. The oxidation peak observed in DPV at 0.89 V was followed in the quantitative analysis of DPZ, and the limit of detection was obtained as 2.45 µM. In addition, many vitamins, amino acids, and pharmaceutical additives were screened between -0.5 and 1.2 V range, and the selectivity of the method was determined. In this study, the validity of the developed method for the determination of DPZ using CSPE and the DPV method was evaluated with various analytical performance parameters. The fact that the RSD% values obtained in both intraday and inter-day repeatability studies were below 5% indicates that the method has good accuracy. The absence of any peak belonging to another molecule around 0.89 V in the selectivity studies shows that the method has high selectivity. Recovery studies with Dozyl tablets yielded values in the range of 69–74%, suggesting that the method applies to real samples, but that matrix effects may affect recovery to a limited extent. Overall, the findings indicate that the developed CSPE–DPV method is a reliable and reproducible analytical approach for DPZ determination.

Keywords: Donepezil, Differential Pulse Voltammetry, Carbon Screen-Printed Electrode

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OP17- Development of Preconcentration and Speciation Method for Cr(III) and Cr(VI) Ions in Aqueous Samples Using Sudan III Modified Magnetic Nanoparticles

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The determination of total chromium is inadequate for toxicity assessment due to different roles of its species. Cr(III) is an essential nutrient, however Cr(VI) is classified as a highly toxic Group 1 carcinogen by the International Agency for Research on Cancer (IARC)[1]. The toxicity of chromium varies significantly with its oxidation state. Therefore, accurate speciation analysis is crucial for environmental safety and requires sensitive separation and preconcentration methods due to low concentrations of these species in aqueous matrixes[2].
In this study, a novel magnetic Fe_3O_4 nanoparticles modified with Sudan III were synthesized and characterized using SEM and FT-IR. Experimentally, the parameters that effective on sorption and elution of Cr(III) and Cr(VI) were optimized using multivariate chemometric approach known as Central Composite Design (CCD). The concentration of chromium species was subsequently determined using FAAS. Speciation analysis of the analytes was performed depending on pH. Accordingly, speciation and preconcentration of Cr(VI) was achieved at pH 2, and preconcentration of total chromium was performed at pH 5. The concentration of Cr(III) was calculated by subtracting the Cr(VI) concentration from the total chromium concentration.
Significantly, this speciation procedure relied solely on pH-dependent selectivity, thus eliminating requirement for any auxiliary oxidizing or reducing reagents prior to analysis. The optimized method demonstrated high recovery rates and effective preconcentration factor for analysis. The developed method offers a rapid, cost-effective, eco-friendly, sustainable and greener analytical approach for chromium speciation in environmental water samples.

Keywords: Speciation, chromium, preconcentration, magnetic solid phase extraction, FAAS.

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OP18- Challenges in Pheromone Analysis Used in Biotechnical Control Studies

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Problems related to pesticide residues in food have recently led to increased public interest in, and demand for, ecological approaches to insect control. Mating disruption (MD) is a pheromone-mediated pest management strategy that uses synthetic sex pheromones to disrupt the chemical communication and normal mating behavior of harmful organisms, thereby reducing their reproductive success and damage [1]. MD offers many advantages over insecticides, including specificity, lack of toxic residue on the crop, and no negative effects on human health, and it has been successfully employed for biotechnical control against the grapevine moth (*Lobesia botrana Den.-Schiff*), one of the most important harmful species encountered in viticulture in the Aegean Region [2]. For this purpose, a variety of monitoring traps and passive pheromone dispensers are placed at specific points within the field, and their release kinetics are required to fully understand the efficiency and explain possible heterogeneous results in the field. Therefore, analytical approaches are at the forefront in the development of support materials that enable the long-term use of pheromone capsules and dispensers and provide controlled release.

The present study discusses the challenges in pheromone analysis used against the grapevine moth. Most commonly, the extraction of residual pheromone from aged capsules or dispensers in the field using an organic solvent, followed by its determination by direct injection into a gas chromatograph; however, the headspace (HS) analysis technique can provide sensitive results for volatile components. For this purpose, extraction parameters and device conditions were optimized, and calibration studies revealed that the grapevine moth sex pheromone ((E, Z)-7,9-dodecadienyl acetate) can be determined at the ppb level with good reproducibility (RSD < 10%) using HS/GC-MS [3].

In search of a greener approach, the use of solid-phase microextraction (SPME) in headspace mode has been considered, and the PDMS/DVB fiber was selected as the most suitable based on peak areas and reproducibility. However, the low boiling point of the solvent, hexane, has limited the performance of the fiber, and therefore, the sample volume was reduced to microliter volumes, allowing for a Full Evaporation Technique (FET) in the vial to mitigate this effect. Subsequently, the SPME fiber was immersed in the vial, and after 10 min of extraction, it was injected into the GC-MS system, where the chromatograms were recorded. By this means, a calibration curve can be constructed for a concentration range of ng/mL or pg/cm^3 ranges considering the volume of the vial with an RSD <5%. Consequently, FET-SPME/GC-MS method developed provides a highly sensitive results with very small sample sizes.

Keywords: Mating disruption, monitoring capsule, pheromone, *Lobesia botrana*, gas chromatography, full-evaporation technique, solid phase microextraction

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OP19- Determination of Manganese at Trace Levels by Natural Deep Eutectic Solvent Assisted Liquid Phase Microextraction in Samples Collected from Antarctic Region

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Manganese (Mn) is one of the elements that is abundant in the Earth's crust[1]. Mn occurs naturally in biota and surface waters in different forms. Additionally, this element is known as an essential micronutrient for physiological processes[2]. In this study, a ternary natural deep eutectic solvent (DES) consisting of choline chloride: thymol: ethylene glycol was developed and used for the extraction of Mn ions in collected samples from the Antarctic region to monitor and determine environmental pollution. The developed system was combined with a spray-assisted droplet formation liquid-liquid microextraction (SADF-LLME) strategy. Absorbance measurements of Mn ions were performed using flame atomic absorption spectrometry. All parameters affecting the experimental process (complexation conditions, pH, spray cycle, DES ratio, etc.) were evaluated using a single-variable optimization approach. Under the optimized conditions, the limit of detection and limit of quantification values of the system were determined as 5.5 µg/L and 18.4 µg/L, respectively. The enhancement of calibration sensitivity, calculated by ratioing the calibration slope obtained directly from the FAAS system with the calibration slope of the (SADF-LLME) method, was found to be 64.5 times, demonstrating that the developed method significantly increases the sensitivity of the conventional FAAS system. The proposed method will be applied to evaluate and quantify manganese levels in samples collected from the Antarctic region by the TAE-IX National Antarctic Science Expedition.

Keywords: Manganese, DES, Antarctic Region, Flame atomic absorption spectrophotometry

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OP20- A Novel Analytical Approach for Manganese Determination in Chia Seeds (Salvia hispanica L.) via Dispersive Solid-Phase Extraction based on Using NiCr2O4 nanostructures

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Industrial and agricultural operations frequently introduce heavy metals into the environment. These pollutants are of significant concern due to their inherent toxicity, biological persistence, and tendency to bioaccumulate within living tissues. Among these, manganese (Mn) plays a dual role: it is necessary for brain function and metabolism but becomes neurotoxic in excess, potentially causing genetic mutations and psychiatric issues. Symptoms of overexposure are hallucinations, permanent DNA damage, neurotoxic effects, and depression[1]. To safeguard human health, it is critical to detect Mn at trace levels in agricultural and food samples for food safety and environmental protection. In this study, a precise and accurate analytical strategy was established for determining Mn at trace levels. $NiCr_2O_4$ nanomaterial was synthesized, and FTIR, X-ray diffraction (XRD), and scanning electron microscopy (SEM) were used for characterization. $NiCr_2O_4$ NMs were used as a sorbent for dispersive solid phase extraction ($NiCr_2O_4$ NMs-DSPE) of Mn in chia seed samples, and the determination of the analyte was made by flame atomic absorption spectrometry (FAAS). The pH, mixing time, and type, elution conditions (eluent concentration and volume), and their effect on the preconcentration of Mn were examined. The limit of detection (LOD) and limit of quantification (LOQ) of the developed method were 3.01 µg/L and 12.23 µg/L, respectively. In addition, the developed $NiCr_2O_4$ NMs-DSPE method showed a 67-fold enhancement in calibration sensitivity. The accuracy and applicability of the presented method were confirmed with analyses of two different chia seed samples with a matrix-matching calibration strategy. The percent recovery results for Mn were found to be between 80.0%-112.6%. The recovery results of the developed $NiCr_2O_4$ NMs-DSPE method demonstrated that it has good accuracy and applicability for the selected matrices.

Keywords: Manganese; nanomaterial; dispersive solid-phase extraction; chia seed.

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OP21- Effect of (2-Chlorobenzyl)(4,5-Dihydro-1H-İmidazol-2-yl)Amine Hydroiodide and (4-Methylbenzyl)(4,5-Dihydro-1H-İmidazol-2-yl)Amine Hydroiodide on Glutathione Reductase Activity

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Imidazoles are biologically important compounds. Imidazoles shows diverse pharmacological effects such as anticancer[1], antimicrobial[2], enzyme inhibitors[3]. Glutathione reductase obtained from baker's yeast (*Saccharomyces cerevisiae*) (EC 1.6.4.2) (GR) is an antioxidant enzyme converts oxidized glutathione (GSSG) with β-nicotinamide adenine dinucleotide 2'-phosphate reduced (NADPH) to 2 reduced glutathione (GSH) (Halliwell and Gutteridge, 1999)[4].

In this study, the effects of imidazole derivatives ((2-Chlorobenzyl)(4,5-dihydro-1H-imidazol-2-yl)amine hydroiodide (CBI) and (4-Methylbenzyl)(4,5-dihydro-1H-imidazol-2-yl)amine hydroiodide (MBI)) at concentrations ranging from 0 to 400 ppm (mg/L) on glutathione reductase (GR) activity were investigated.

As the concentration of CBI was increased, no statistically significant change in GR enzyme activity was observed compared to the control group ($N=3$, $P<0.05$). As the concentration of MBI was increased, a decrease in GR enzyme activity was observed at high concentration (400 mg/L) compared to the control group and was statistically significant ($N=3$, $P<0.05$).

MBI inhibited GR activity at high concentrations (400 mg/L). Molecular docking studies indicated that MBI could be a potential inhibitor of GR.

Keywords: (2-Chlorobenzyl)(4,5-dihydro-1H-imidazol-2-yl)amine hydroiodide; (4-Methylbenzyl)(4,5-dihydro-1H-imidazol-2-yl)amine hydroiodide; Glutathione reductase; Imidazole derivatives; Inhibition.

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OP22- Determination of tetracycline by Nd-MOF based electrochemical sensor

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Antibiotics are used to prevent and treat certain diseases in humans, animals, and plants. Tetracycline, a type of antibiotic, is used to treat human and animal diseases. Due to its poor absorption during digestion in humans and animals, this antibiotic is often released into the environment unchanged through feces or urine, causing water pollution[1]. Various methods are used for the detection of tetracycline in different sources, and electrochemical sensors are preferred for tetracycline determination due to their advantages such as allowing for electrode material and configuration, high sensitivity, speed, and ease of use[2].

This study investigates the use of rare earth elements, which are used in many different fields such as health, defense industry, and technology, as electrochemical sensors. In this context, neodymium containing metal organic framework (Nd-MOF) were produced from rare earth elements, and Nd-MOF were immobilized on the gold electrode surface and used as electrochemical sensor for tetracycline determination. The electroactive surface area of the modified electrode was calculated, its surface response was investigated, and validation parameters were also calculated.

Keywords: Neodymium, tetracycline, electrochemical sensor, MOF, rare earth element

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Acknowledgment

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OP23- MWCNT-Fc-2APP-GOx/CPE Based Bioanode Design for Enzymatic Biofuel Cells: Electrochemical Characterization and Performance Evaluation

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Enzymatic biofuel cells (EBFCs) have attracted considerable attention as sustainable energy conversion systems due to their ability to generate electricity from biological fuels such as glucose[1]. In this process, fuel is oxidized at the anode by enzymatic reactions, while oxygen is typically reduced at the cathode[2]. However, the efficiency of these systems is often limited by slow electron transfer between the enzyme active site and the electrode surface. In this study, a novel bioanode based on multi-walled carbon nanotubes (MWCNTs), ferrocene (Fc) as a mediator and electropolymerized 2-aminophenylpyrrole (2-APP) was fabricated on a carbon paste electrode (CPE). Glucose oxidase (GOx) was immobilized onto the modified electrode surface to catalyze glucose oxidation. The electrochemical performance of the developed bioanode was evaluated using cyclic voltammetry (CV) and Electrochemical Impedance Spectroscopy (EIS). EIS results revealed a significant decrease in charge transfer resistance after electrode modification, indicating improved electron transfer kinetics. The developed bioanode exhibited a linear glucose detection range of 0.25-8 mM with a detection limit of 0.071 mM. The selectivity of the developed bioanode was evaluated in the presence of common interfering species such as ascorbic acid, uric acid and dopamine. The interference effects were significantly minimized using a $NaBiO_3$ pre-oxidation treatment, allowing selective glucose detection. These findings indicate that the synergistic combination of MWCNT, Fc as a mediator and 2-APP as a conductive polymer significantly enhances bioanode performance. The proposed MWCNT-Fc-2APP-GOx/CPE bioanode exhibited promising electrochemical properties and it was successfully applied in an assembled EBFC system for real sample analyses, demonstrating its potential as an efficient platform for enhanced electron transfer.

Keywords: Bioanode, enzymatic biofuel cell, multi-walled carbon nanotube, ferrocene, glucose oxidase

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Acknowledgment: *This study supported the Scientific Research Projects Coordination Unit at Canakkale Onsekiz Mart University. Project ID: FDK-2022-4073*

OP24- Green Extraction for Polyphenols from *Anthemis arvensis L.* Flowers Using Deep Eutectic Solvent

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Natural deep eutectic solvents (NADES) are attracting significant interest as environmentally friendly alternatives due to their biodegradability and non-volatility. Consisting of mixtures of charged acceptors and donors linked by hydrogen bonds, NADES enable the design of customised solvents for extracting specific substances thanks to the numerous possible combinations of components and molar ratios[1].

This study investigated the use of carvacrol-based non-aqueous green solvents (NADES) for extracting phenolic compounds from *Anthemis arvensis L*. The extraction process employed ultrasonic-assisted extraction and microwave extraction techniques, and the polyphenols were analysed by high-performance liquid chromatography-ultraviolet (HPLC-UV)[2]. The extraction potential of four carvacrol-based NADES was evaluated and compared with that of methanol, a traditional solvent.

The analysis results showed that the type of solvent and extraction method had a critical effect on yield ($p < 0.001$). The highest total bioactive component yield in the UAE method was obtained with NA2 (Carvacrol:Lactic acid 1:1) at 4270.33 mg/kg. Particularly in Quercetin extraction, the NA2 and UAE combination (3907.05 mg/kg) showed superior performance compared to methanol. While the MAE method generally increased the recovery of phenolic acids (Ferulic acid, Gallic acid), the UAE method was found to be more selective for flavonoids. The NA3 system showed specific affinity for ferulic acid, while the NA2 system showed specific affinity for rosmarinic acid.

As a result, NADES systems based on carvacrol-lactic acid have been found to provide higher yields in the extraction of phenolic bioactive compounds from A. arvensis compared to methanol, the traditional solvent. The findings demonstrate that NADES-based extraction systems are an environmentally friendly and effective alternative for the recovery of plant bioactive compounds.

Keywords: *Anthemis arvensis L.*, NADES, polyphenols, HPLC-UV

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This work received financial support from the Erciyes University of Scientific Research Project (FOA-2025-15072).

OP25- Flow Injection Amperometric Determination of L-Cysteine based on its Electrocatalytic Oxidation at bis-(Neocuproine)copper(II) Complex Modified Screen-Printed Carbon Electrode

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L-Cysteine (L-Cys), distinguished from the 20 standard amino acids by the presence of a sulfhydryl group, is integral to various biological activities, including protein synthesis, cellular signaling, antioxidant defense, and metabolism [1,2]. L-Cys is synthesized in the human body via biosynthesis from methionine and serine, and a shortage in L-Cys can be compensated by ingesting protein-rich foods including meat, milk, dairy products, eggs, garlic, onions, Brussels sprouts, broccoli, oats, wheat, and lentils. The concentration of L-Cys in bodily fluids typically ranges from approximately 200 to 300 µM in a healthy individual, with variances linked to certain disorders [4,5]. There is currently no study in the literature on voltammetric and amperometric determination of L-Cys in the FIA system using a bis-(neocuproine)Cu(II)-modified electrode. This study describes the electrocatalytic oxidation of L-Cys and its amperometric quantification using a flow injection analysis (FIA) system at a bis-(neocuproine)Cu(II) complex/nafion/multiwalled carbon nanotube composite modified screen-printed carbon electrode ($[Cu(Nc)_2]^{2+}$/Nf@MWCNT/SPCE). The electrostatic interaction between the negatively charged Nf (Nafion) and the positively charged complex provides an effective method for the attachment of the redox mediator (complex) to the electrode surface. Cyclic voltammetric (CV) results indicate that L-Cys undergoes electrocatalytic oxidation on the modified electrode at 600 mV, approximately 200 mV more negative than on the unmodified electrode. A broad linear range was achieved from 1 µM to 1500 µM L-Cys, with a detection limit (LOD) of 0.34 µM, as determined by the calibration curve obtained in the FI amperometric studies on the $[Cu(Nc)_2]^{2+}$/Nf@MWCNT/SPCE under optimized conditions. The modified electrode, which was found to exhibit high sensitivity and selectivity to L-Cys, was applied to three different milk samples and yielded satisfactory results.

Key words: L-Cystein, Modified electrode, Flow Injection Analysis, Copper (II)-bisneocuproine complex, Screen-printed electrode

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POSTER PRESENTATIONS (PP)

PP1- Adsorptive stripping voltammetric determination of Ge(IV) employing the complexing properties of chloranilic acid and bismuth-modified carbon-based electrodes

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Before silicon took over as the primary semiconductor material, germanium paved the way for the digital revolution. This element remains a key material in advanced technologies, and its unique properties make it invaluable in the electronics, optical, and photovoltaic industries. Germanium is used in applications such as optical fibres, solar cells, and LED technology. Due to its widespread use, its environmental monitoring is essential.

One of the more sensitive methods used in analytical chemistry is stripping voltammetry, particularly adsorption stripping voltammetry (AdSV), in which transforming the analyte into an electrochemically active complex allows for low detection limits. In our proposed procedures for determining trace Ge(IV) concentrations, we utilized chloranilic acid, which enabled the efficient accumulation of Ge(IV)-chloranilic acid complexes on the working electrode. We employed bismuth-modified carbon-based electrodes as the working electrodes, providing an environmentally friendly analytical tool.

In our studies, we used glassy carbon (GC) and carbon nanotubes mixed with spherical glassy carbon (CNTs/SGC) as carbon-based electrodes. In both cases, the analytical procedure was performed in three stages. In the first stage, the carbon-based electrodes were modified by forming a bismuth film. This process was performed in situ by introducing Bi(III) ions into the analysed solution and then applying a potential of -1.0 V for 20 s for the GC electrode and -1.1 V for 20 s for the CNTs/SGC electrode. After this step, Ge(IV)-chloranilic acid complexes were adsorbed onto the bismuth film at -0.35 V for 30 s for the GC electrode and -0.4 V for 20 s for the CNTs/SGC electrode. Subsequently, in both cases, the voltammogram was recorded as a result of the potential change towards negative values, obtaining the analytical germanium signal, which was the basis for quantitative analysis. Under optimized conditions, Ge(IV) detection limits of 1.2 nM were achieved for the GC electrode and 0.3 nM for the CNTs/SGC electrode, confirming that the use of carbon nanomaterials with a developed surface area allows for increased sensitivity of the assays.

Keywords: germanium, adsorptive stripping voltammetry, bismuth modification, carbon-based electrodes

PP2- Application of resin to eliminate interference in the analysis of environmental waters in voltammetric selenium analysis using a bismuth microelectrode

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Preparation of environmental waters prior to measurement is crucial to the final analytical results; the matrix of such samples can interfere with the analytical signal. In this paper, we propose a simple, inexpensive, and rapid procedure that allows for the preparation of environmental waters prior to voltammetric Se(IV) analysis. The method is based on 2 min. premixing a water sample with Amberlite XAD-7 resin at 50 ◦C. The composition of the 10 mL solution consists of the water sample, 0.1 mol L^{-1} of acetate buffer at pH = 4.0, and 0.5 g of Amberlite XAD-7. Voltammetric analysis of selenium was performed with a bismuth electrode using the following potentials: −2.5 V for 2 s and −0.55 V for 30 s. The voltammogram was recorded by varying the potential from −0.4 V to −1.0 V. The great advantage of the proposed procedure is that the mixing of the sample with the resin at elevated temperature takes place in the same vessel and solution in which the voltammetric measurement is directly performed.

Surfactants such as Triton X-100, sodium dodecyl sulphate (SDS), cetyltrimethylammonium bromide (CTAB), Rhamnolipid and humic substances such as humic acid (HA), fulvic acid (FA) and natural organic matter (NOM) were selected as potential interferents present in environmental waters. It was found that the negative effect on the analytical signal of selenium depends on the content and type of surfactant and humic substances. It was proven that mixing with the resin allows obtaining an undisturbed Se(IV) signal in the presence of Triton X-100, SDS, CTAB and Rhamnolipid at concentrations of 10, 5, 10 and 5 mg L^{-1}, respectively. However, in the case of not mixing with the resin, the presence of 2 mg L^{-1} Triton X-100 and 0.5 mg L^{-1} SDS, CTAB and Rhamnolipid resulted in complete suppression of the Se(IV) signal. Humic substances attenuated the Se(IV) signal, but to a much lesser extent than the surfactants. However, the use of mixing with resin ensures an undisturbed selenium signal in the presence of 5 mg L^{-1} of HA, 10 mg L^{-1} of FA, and 2 mg L^{-1} of NOM.

Keywords: Se(IV), stripping voltammetry, bismuth microelectrode, modification, resin, elimination of interferents

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PP3- Analytical application of laccase based electrochemical biosensors for estradiol determination real samples

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Estradiol is an oestrogen belonging to the group of natural steroid hormones. It plays a significant role in both women and men. It controls many physiological processes, such as the menstrual cycle, metabolism of minerals, carbohydrates, proteins and lipids in women, and affects bones, spermatogenesis and behaviour in men. Estradiol deficiency increases the risk of heart disease and osteoporosis, while on the other hand, this hormone is considered a carcinogen, increasing the risk of ovarian and breast cancer. Estradiol, like other pharmaceuticals, ends up in the environment, which is why the development of cheap and effective methods for monitoring this compound is greatly needed.
This paper presents research on the properties of new enzymatic electrochemical biosensors for the determination of β-estradiol. The receptor layer of the sensor is an enzyme-laccase, which was applied to the surface of the substrate electrode by low-temperature plasma polymerisation. This is a simple, inexpensive and rapid method for obtaining biologically active receptor layers in a short, single-step process that does not require the use of additional reagents[1,2]. Glassy carbon electrodes modified with nanomaterials, i.e. carbon nanotubes, carbon nanofibres, CuO nanoparticles and mixtures of these materials, were used as the substrate material. The best parameters were obtained for a sensor based on a carbon nanofibre/CuO nanoparticle nanocomposite. The analytical usefulness of the proposed biosensor was confirmed by using it to determine oestradiol in pharmaceutical preparations and river water. The analysis was performed using the standard addition method. The correctness of the developed biosensor was verified using the recovery test method.

Keywords: laccase; electrochemical biosensor; oestradiol; nanocomposite.

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PP4- A new, simple and inexpensive potentiometric sensor for determining ammonium nitrogen in natural waters and soils

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Ammonium ions are one of the ions to which we should pay particular attention (especially in agricultural areas). Among other things, their excess causes eutrophication of waters, which leads to the destruction of aquatic environ-ments, but is also unhealthy for humans[1]. One of the methods used to monitor NH^{4+} ion levels is potentiometry, in which we use sensors – ion-selective electrodes (ISEs).
In order to obtain correct measurement results, it is necessary to use a sensor with good analytical parameters. In environmental measurements carried out directly in the field, ion-selective electrodes without internal electrolyte solution, known as solid contact electrodes, work very well. In the case of this type of electrode, obtaining stable sensor readings requires appropriate modification of the substrate electrode by introducing an additional material that improves charge transport at the interface between the polymer ion-selective membrane and the internal electrode[2]. This paper presents research on the properties of ammonium ion-selective electrodes obtained using various internal electrodes: glassy carbon electrodes, glassy carbon electrodes modified with a nanocomposite of multi-walled carbon nanotubes and carbon nanofibres, and a new type of substrate in the form of several hundred gold microelectrodes combined into a single substrate in an orderly manner-gold microelectrode array. All electrodes contained the same membrane containing 3% nonactin, 0.86% potassium tetrakis(parachlorophenyl)borane, 30% polyvinyl chloride and 66.14% bisbutylpentyl adipate (% by weight). The effect of the substrate type on the properties of the electrodes was assessed by determining their analytical parameters, i.e. the slope of the characteristic curve, the linearity range of the calibration curve, the detection limit, selectivity, stability and reproducibility of the potential. A water layer test was also performed and the sensitivity of the electrodes to changes in measurement conditions (light, variable gas content in the sample, redox potential of the sample, solution mixing, calibration direction) was checked. The best parameters were exhibited by the electrode in which the internal electrode was a gold microelectrode array. This electrode was successfully used to determine ammonium ions in groundwater, river water and soils.

Keywords: all solid state ion-selective electrode; gold microelectrode array, ammonium ions, environmental analysis;

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PP5- Determination of acrylamide in food samples using deep eutectic solvent dispersive liquid–liquid microextraction combined with thin layer chromatography and smartphone digital image colorimetry

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Acrylamide (AA) is a prevalent food processing contaminant that forms in carbohydrate-rich foods during high-temperature cooking, e.g., baking, frying, roasting, *via* the reaction of monosaccharides and asparagine at temperatures above 120 ºC by the Maillard reaction[1]. The International Agency for Research on Cancer (IARC) designates AA as a probable human carcinogen (Group 2A), which has been associated with genotoxicity, neurotoxicity and reproductive effects[2]. The presence of AA at low concentrations in food necessitates highly sensitive and accurate analytical techniques. Smartphone digital image colorimetry (SDIC) has recently gained prominence as a complementary analytical technique in chemical analysis due to rapid advancements in mobile technology[3]. This approach offers benefits such as reduced analysis costs and time, enhanced accessibility to instrumentation, simplified analytical procedures, and high adaptability for on-site applications. Nonetheless, for complex samples like food, effective sample cleanup and preconcentration methods are required to maximize selectivity and sensitivity. In this study, A novel analytical method integrating deep eutectic solvent-based dispersive liquid–liquid microextraction (DES-DLLME)[4] with thin layer chromatography (TLC) and SDIC was developed for the determination of AA. The final extract was applied onto a TLC plate positioned inside a custom-made colorimetric box. Images of the spotted extracts were captured and split into their red, green, and blue channels, with the blue channel intensity exhibiting the highest sensitivity and consequently used for quantification of AA. Optimal SDIC conditions included an 8.0 cm distance between the TLC plate and detection camera, illumination at 405 nm wavelength with 100% brightness from a top light source. The most effective DES-DLLME extraction was achieved using 300 µL of a choline chloride/phenol (1:4 molar ratio) DES as the extraction solvent, 400 µL acetonitrile as the disperser solvent, and a 1.0-min extraction time. The method exhibited limits of detection and quantitation of 0.67 and 2.23 mg g^{-1}, respectively, with a coefficient of determination (R^2) exceeding 0.9951 and relative standard deviation below 7.4%. The proposed DES-DLLME-TLC-SDIC method was successfully applied to quantify AA in various food matrices, including baby food, biscuits, coffee, dark chocolate, and potato chips, yielding relative recoveries between 87.5% and 106.3%.

Keywords: Acrylamide; deep eutectic solvent; digital image colorimetry; food samples; liquid–liquid microextraction; thin layer chromatography,

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PP6- Developing novel methods for extracting phenolic compounds from olive oil

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This study investigates the phenolic composition of extra virgin olive oil (EVOO) from the Omani market and optimizes the phenolic extraction process. The addition of 10% (w/v) sodium chloride to the extraction solvent increased phenolic recovery by 20–30%. Feature importance analysis identified solvent polarity, influenced by solvent type, salt concentration, and volume, as the key factor driving extraction efficiency. A validated liquid chromatography–tandem mass spectrometry (LC–MS/MS) method quantified ten phenolic compounds in six commercial EVOO samples. Acid values ranged from 0.01% to 0.11%, and peroxide values were below 12 meq O_2 kg^{-1}, confirming compliance with EVOO quality standards. Total phenolic content ranged from 116 to 250 mg kg^{-1}. Two locally produced Omani oils exhibited phenolic profiles comparable to high-quality Mediterranean EVOOs. Elevated hydroxytyrosol levels indicate phenolic transformation during storage. This study provides baseline data supporting quality control and nutritional evaluation of EVOOs in the Omani market.

Keywords:
Extra virgin olive oil; Phenolic compounds; LC–MS/MS; Salt-assisted extraction; Hydroxytyrosol; Omani market.

PP7-Dispersive solid-phase microextraction prior to HPLC-DAD for the determination of three major curcuminoids in food and pharmaceutical samples

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Curcumin has recently gained interest for the treatment and prevention of numerous malignant diseases including Alzheimer's, diabetes, cancer, allergies and other chronic diseases, due to its antioxidant, anti-inflammatory, anti-microbial, anti-parasitic and anti-cancer properties[1]. Most of the commercially available curcumin-containing foods and pharmaceutical supplements include, in fact, a mixture of curcuminoids, the three major compounds of which are curcumin (C, ca. 77%, w/w), desmethoxycurcumin (DMC, ca. 18%) and bisdesmethoxycurcumin (BDMC, ca. 5%)[2]. The presence of such curcuminoids in complicated matrices necessitates an efficient sample preparation step prior to analysis. Dispersive solid-phase microextraction (DSPME) is now a well-known method for its ease of implementation, high extraction efficiency, short extraction time, significant reduction in the consumption of organic solvents, and low operational cost[3]. To the best of our knowledge, no studies have yet been reported on the use of DSPME for the extraction of curcuminoids in such samples. In this study, DSPME was used prior to high-performance liquid chromatography-diode array detection (HPLC-DAD) for the determination of C, DMC and BDMC in food and pharmaceutical supplement samples. Optimum extraction conditions were achieved using 60.0 mg of C18 as the mass of sorbent, 200 µL acetone as the eluent and 2.0 min for adsorption and desorption time, each. The limits of detection (based on $3S_b/m$) and quantification (based on $10S_b/m$) were found to fall within the ranges of 0.22–1.26 and 0.73–4.20 µg g^{-1}, respectively. Good linearity was obtained with coefficients of determination (R^2) higher than 0.9950. Intraday and interday precision, expressed in terms of relative standard deviation, were less than 4.1 and 4.9%, respectively, while the linear dynamic range was from 0.73 to 25.0 µg g^{-1}. Accuracy was checked by addition-recovery tests and percentage recoveries were found to be within the range of 91.0–110.0%. The proposed method was applied for the determination of curcuminoids in food samples (i.e., commercial mixed standard, curry, herbal tea and turmeric) and a pharmaceutical supplement and satisfactory results were achieved.

Keywords: Curcuminoids; dispersive solid-phase microextraction; food analysis; HPLC-DAD; pharmaceutical

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PP8-Quantitative analysis of protodioscin in Tribulus terrestris food supplements via HPLC

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Tribulus terrestris is a widely consumed herbal supplement used to enhance sexual function and athletic performance. Its major bioactive compound is protodioscin, a steroidal saponin[1,2]. Seven different supplements were randomly obtained from suppliers on the internet, pharmacies, and herbal shops. HPLC analysis demonstrated significant variability in protodioscin concentrations, ranging from 94.55 to 6827.12 µg/g extract. HPLC profiling proved to be an essential tool for quality control, revealing discrepancies between labelled content and actual protodioscin levels, thereby underscoring the need for standardized analytical protocols. The analysis using flame atomic absorption spectrometry (FAAS) revealed an absence of cadmium (Cd) and lead (Pb) contamination in all samples tested. To the best of our knowledge, this is the first study on *T. terrestris* supplements in Türkiye. Despite widespread global use, scientific data remains limited. Therefore, strict analytical monitoring and standardization are urgently needed to ensure consumer safety and product efficacy.

Keywords: *Tribulus terrestris, Food supplements, Protodioscin*

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PP9- Simultaneous Determination of Sitagliptin and Metformin Hydrochloride by a Validated HPLC Method and Evaluation of Nitrosamine Impurities

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Diabetes characterized by hyperglycemia is estimated to affect over 180 million people worldwide, with type 2 diabetes accounting for approximately 90–95% of these cases. Type 2 diabetes results from defects in insulin secretion, insulin action, or both[1]. Sitagliptin and Metformin Hydrochloride are frequently combined in the treatment of type 2 diabetes mellitus, and quality control of such fixed-dose combinations is of increasing analytical importance. In recent years, attention has also focused on potential nitrosamine-related impurities associated with active substances and degradation pathways.

In this study, a high-performance liquid chromatography (HPLC) method was developed for the simultaneous quantification of Sitagliptin and Metformin in pharmaceutical formulations and validated according to the ICH Q2(R1) guideline[2]. Analyses were performed on a Sepax BR-C18 (4.6 × 250 mm, 5 µm) column at 30 °C under isocratic conditions using KH_2PO_4 buffer (pH 4.0):acetonitrile (70:30, v/v), with a flow rate of 1.0 mL/min and detection at 266 nm.

The method demonstrated good specificity, accuracy, precision, linearity, and sensitivity, providing suitable LOD and LOQ values for both analytes. Forced degradation studies were evaluated using a literature-based LC-MS/MS approach, where MeNP, NDMA and NSITA peaks were detected, while other nitrosamine impurities remained below detection limits. In particular, NSITA was identified as a degradation product of Sitagliptin formed under oxidative conditions, and its amount has not previously been reported in the literature.

The developed analytical method is reliable, sensitive, and reproducible for routine quality control, impurity assessment, and monitoring of Sitagliptin degradation and potential genotoxic impurities.

Keywords: Sitagliptin, Metformin Hydrochloride, HPLC, nitrosamine impurities, degradation

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PP10- LC-MS/MS-Based Determination of Gadobutrol Residues for Pharmaceutical Cleaning Validation

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The hazards of gadolinium, widely used in magnetic resonance imaging to detect pathological lesions, should not be overlooked. Due to its pharmacological effects, any contamination from gadobutrol production poses serious health risks. Therefore, it is imperative that gadobutrol residues continue to be completely removed from production equipment. This study aimed to develop and validate a highly sensitive LC-MS/MS method for the quantitative detection of gadobutrol residues on stainless steel surfaces and to apply it in a cleaning validation study in accordance with regulatory guidelines. Swab samples were collected from production equipment surfaces after cleaning procedures. Method validation parameters such as specificity, linearity, precision, accuracy, limit of detection (LOD), and limit of quantitation (LOQ) were evaluated. Recovery studies were performed using spiked stainless steel plates to determine recovery rates. Swab recovery data were incorporated into the analysis of actual equipment samples. The LC-MS/MS method showed excellent linearity ($r^2 \geq 0.9999$) within the range of 5–500 ng/mL. LOD and LOQ values were 2 ng/mL and 5 ng/mL, respectively. Intra- and inter-day accuracy and precision were within acceptable limits. Gadobutrol was found to be stable under short-term storage and autosampler conditions. The recovery rate was calculated as 83%. A sensitive, selective, and robust analytical method was successfully developed and validated for gadobutrol. This study is the first to perform cleaning validation for gadobutrol using LC-MS/MS with such sensitivity. The findings contribute significantly to both cleaning validation and analytical method development literature in the pharmaceutical industry.

Keywords: Gadobutrol, Cleaning validation, LC-MS/MS, Swab recovery, Residue analysis

PP11- Analytical Method Development and Cleaning Validation of Tirofiban Using LC-MS/MS

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Although Tirofiban is a safe drug for the treatment of acute coronary syndromes, it is considered risky for certain patient groups. In situations other than treatment, ingestion of tirofiban from sources such as contamination can pose serious risks. Therefore, purification validation is an important step to minimize the risk of contamination arising from the drug's manufacturing process. This study aimed to develop and validate a highly sensitive LC-MS/MS method for the detection of residual tirofiban on stainless steel surfaces used in pharmaceutical production, and to apply it within a cleaning validation framework. Swab samples were collected from cleaned equipment surfaces following tirofiban production. Method validation was conducted according to regulatory guidelines, assessing parameters such as selectivity, linearity, precision, accuracy, and stability. Recovery studies were carried out using stainless steel plates spiked with known concentrations of tirofiban, and the recovery data were used to evaluate real equipment samples.

The method demonstrated excellent linearity ($r^2 \geq 0.99$) over a concentration range of 5–200 ng/mL. The LOD and LOQ were determined to be 0.1 ng/mL and 5 ng/mL, respectively, with signal-to-noise ratios of 4.3 and 70.7. Intra- and inter-day accuracy and precision values were within acceptable limits. Tirofiban was found to be stable under both autosampler and short-term storage conditions. The swab recovery rate was 82.03%, and no unacceptable residue levels were detected in actual production equipment samples. A selective, accurate, and robust LC-MS/MS method was successfully developed and validated for the detection of tirofiban residues. To date, no cleaning validation study has been reported for tirofiban, making this work a novel and original contribution to both cleaning validation and analytical method validation literature in the pharmaceutical field.

Keywords: Tirofiban, Cleaning validation, LC-MS/MS, Swab recovery, Residue analysis.

PP12- High-Performance Liquid Chromatography based on characterization of fruit quality in peach cultivars grown under arid conditions

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The nutritional properties of fruits are due to the combined action of many categories of molecules. Studies on molecular nutrition, therefore, requires analytical methods that can cope with diverse molecular groups, including metabolites that may be currently unknown. Fractionation and identification protocols are crucial to validate identified compounds, and can be adapted from methodologies developed. High-performance liquid chromatography (HPLC) is a powerful tool for product composition testing and quality controlling. HPLC has become an important means to improve food quality and to understand the bioactivity. For fruit analysis and quality evaluation, HPLC focuses on the analysis of target compounds(carotenoids, phenolics, sugars, and organic acids). Our study summarize a brief evaluation of peach samples extracted from different cultivars grown in diverse environmental conditions using this method. The results showed a significant diversity in terms of the compounds detected par HPLC and confirmed the important role played by genotype in determining the quality attribute parameters, sugar levels, and availability of bioactive compounds. In addition, our results on the content of primary and secondary metabolites corroborate the knowledge on the nutritional value of peach fruits, which act as important protective factors of human health.

Keywords: High-performance liquid chromatography, fruit quality, sugars, acids, carotenoids, nutrition.

PP13- Influence of liquid phase composition and organic additives on the electroreduction of In(III) and Bi(III) ions in mixed aqueous-organic solvent systems

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The electroreduction of metal ions in solutions containing mixed aqueous-organic solvents constitutes a complex electrochemical process. Its course is governed by processes occurring at the electrode/solution interface, such as adsorption and the formation of transient surface complexes, leading to reorganization of the electrical double layer structure. Reliable investigation of these subtle effects requires the use of electrodes that minimize the influence of side processes and undesirable surface reactions.

The electroreduction of In(III) and Bi(III) ions was studied in solutions containing mixed aqueous-organic solvents, in which organic additives with carefully selected properties were introduced to enable "the cap-pair effect" and modulate the electrochemical process[1]. Measurements were performed using electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV), square-wave voltammetry (SWV) and direct-current polarography (DCP). A renewable silver amalgam film electrode (R-AgLAFE) was employed as the working electrode[2].

The obtained results indicate that the presence of organic additives fulfilling the criteria of "the cap-pair effect" leads to significant changes in the electroreduction behaviour of In(III) and Bi(III) ions. It was demonstrated that the composition of the mixed solvent system plays an important role in modulating the kinetics of the electrochemical process and may promote changes in its mechanism. Distinct tendencies corresponding to inhibitory or catalytic effects were observed for the studied metal ions, reflecting their specific interactions with the electrode–solution interface.

The conducted studies confirm that the electroreduction of trivalent ions, such as In(III) and Bi(III), in mixed aqueous–organic solvent systems strongly depends on the composition of the liquid phase, particularly on the nature of the applied solvent, which generally leads to inhibition of the electrochemical process. It was also shown that selected organic additives meeting the criteria of the cap-pair effect influence the kinetics of electroreduction of the investigated metal ions.

Keywords: electrochemical impedance spectroscopy; renewable silver amalgam film electrode; R-AgLAFE, mixed, aqueous-organic solvents

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PP14- Adsorption of Crystal Violet and Methylene Blue on Activated Carbon from Caraway Seed

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Abstract

This study examines the production and adsorption performance of activated carbons derived from caraway seeds using a two-step process involving pyrolysis followed by chemical activation with potassium carbonate. Activated samples obtained at 700 °C (CS-A7) and 800 °C (CS-A8) were characterized to determine their textural, chemical, and adsorption properties. Nitrogen adsorption analyses showed that higher activation temperature significantly enhanced porosity, with CS-A8 exhibiting a larger surface area, greater micropore volume, and a substantially higher iodine number. Acid–base characterization revealed that CS-A8 possessed a more basic surface, reflecting temperature-induced changes in functional group distribution. Adsorption studies using methylene blue and crystal violet demonstrated that CS-A8 achieved markedly higher capacities, particularly for methylene blue (466 mg/g). Langmuir and Freundlich analyses indicated strong monolayer and heterogeneous adsorption behaviors, with higher affinity constants for CS-A8. Overall, the results highlight the effectiveness of potassium carbonate activation in producing high-performance carbons from herbal waste precursors.

***Keywords*:** adsorption, activated carbon, crystal violet, methylene blue

Introduction

Activated carbon is widely used in water purification, gas treatment, and chemical processing due to its high surface area, well-developed porosity, and strong affinity for diverse contaminants. In recent years, growing environmental concerns and the availability of inexpensive renewable feedstocks have shifted attention toward biomass-derived activated carbons. Agricultural and herbal wastes are particularly attractive precursors because they are abundant, low-cost, and capable of producing carbons with desirable textural properties when appropriate activation strategies are applied[1].

Potassium-based activating agents, especially K_2CO_3, are commonly used due to their strong interaction with carbon matrices and their ability to generate well-developed microporosity. During activation, potassium carbonate decomposes to reactive species that intercalate into the carbon structure, promoting pore development. The efficiency of this process depends on factors such as precursor composition, functional groups, and activation conditions[2].

Despite growing interest in fibrous and herbal biomass, the activation behavior of herbal waste-derived carbons prepared through a two-step process (pyrolysis followed by chemical activation) remains insufficiently studied. This work examines activated carbons produced from caraway seeds using potassium carbonate and evaluates how activation conditions influence surface area, pore structure, and adsorption performance toward organic contaminants.

Materials and Method

Activated carbon sorbents were prepared using caraway seeds (CS) as precursor materials. The dried materials were then subjected to pyrolysis at 600 °C for 60 minutes in a nitrogen atmosphere. Following pyrolysis, the materials were chemically activated by mixing with potassium carbonate at a precursor-to-activator mass ratio of 1:3. The mixtures were activated in a nitrogen atmosphere, heated at a final temperature of 700 °C (CS-A7) and 800 °C (CS-A8), and held for 45 minutes. All thermal processes were conducted in a conventional furnace. The resulting activated carbons were washed with 5% hydrochloric acid to remove residual inorganic components, followed by rinsing with boiling distilled water until neutral pH was achieved

Textural properties were determined from nitrogen adsorption–desorption isotherms using an AutosorbiQ analyser. Surface areas were calculated by the BET method. Surface oxygen functional groups were identified using the Boehm titration method. The iodine number was measured according to ASTM D4607-94.

Crystal violet and methylene blue dyes were used as probe molecules. For each test, 20 mg of activated carbon was added to 50 cm^3 dye solutions with initial concentrations of 5–200 mg/dm^3. Samples were shaken for 24 h at 300 rpm. Absorbance was measured at 585 nm for crystal violet and 665 nm for methylene blue using a dual-beam UV-Vis spectrophotometer. Adsorption capacity and isotherm parameters were evaluated using the Langmuir and Freundlich models, while thermodynamic parameters were calculated from standard equations.

Results and Discussion

The textural properties of the two activated carbons derived from caraway seeds (Table 1) show that increasing the activation temperature leads to a substantial improvement in porosity. CS-A8 exhibits a much higher surface area (964 m^2/g) compared with CS-A7 (576 m^2/g), along with greater total and micropore volumes. The iodine number, which reflects adsorption capacity for small molecules, is significantly higher for CS-A8 (1325 mg/g) than for CS-A7 (592 mg/g), confirming the superior adsorption performance of the more intensely activated material.

Table 1. Textural parameters and iodine number of carbons activated by potassium carbonate.

Sample	Surface Area (m^2/g)		Pore volume (cm^3/g)		Average pore size (nm)	Iodine number (mg/g)
	Total	Micropore	Total	Micropore		
CS-A7	**576**	475	0.412	0.260	2.86	592
CS-A8	**964**	790	0.657	0.433	2.73	1325

The acid–base analysis shows clear differences between the two carbons (Table 2). CS-A7 has a lower pH (6.20) and a higher content of acidic oxygen functional groups, giving it a more acidic surface character. In contrast, CS-A8 exhibits a higher pH (8.14) and contains fewer acidic but more basic functional groups. This shift toward basicity in CS-A8 likely reflects changes in surface chemistry caused by the higher activation temperature.

Table 2. Acid-base properties of the obtained activated carbon samples.

Sample	pH	Acidic Oxygen Functional Groups (mmol/g)	Basic Oxygen Functional Groups (mmol/g)
CS-A7	6.20	1.21	0.27
CS-A8	8.14	1.01	0.34

Table 3 exhibits the values of constants determined for the linear Langmuir and Freundlich The adsorption data show that CS-A8 performs far better than CS-A7, particularly for methylene blue (MB), reaching an experimental capacity of 466 mg/g compared with 71 mg/g for CS-A7. For crystal violet (CV), CS-A8 also shows higher capacity (50 mg/g versus 8 mg/g). Langmuir model fits are strong for both dyes on CS-A7 and for MB on CS-A8 ($R^2 > 0.96$), indicating predominantly monolayer adsorption. Freundlich fits are also good for MB on both adsorbents, suggesting heterogeneous surface interactions. The higher KL and KF values for CS-A8 confirm its stronger adsorption affinity, especially toward MB, consistent with its superior textural properties.

Table 3. The values of constants determined for the linear Langmuir and Freundlich

Isotherm	Parameter	Sample			
		CS-A7		CS-A8	
	Dye	CV	MB	CV	MB
	q_{exp} (mg/g)	8	71	50	466
Langmuir	K_L (dm^3/mg)	0.102	35.681	0.221	0.336
	R^2	0.994	0.987	0.941	0.963
	q_m (mg/g)	8	71	28	565
Freundlich	K_F (mg/g(dm^3/mg)$^{1/n}$)	17.984	67.036	29.499	261.644
	R^2	0.486	0.948	0.924	0.962
	1/n	0.949	0.221	0.739	0.221

Conclusion

Caraway seed-derived activated carbons exhibit strong adsorption potential, with higher activation temperature greatly improving porosity, surface chemistry, and dye uptake. CS-A8 consistently outperformed CS-A7, particularly for methylene blue, confirming that optimized K_2CO_3 activation is a promising approach for producing efficient, sustainable adsorbents from herbal waste materials.

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PP15- Adsorption Mechanisms of Poly(sodium 4-styrenesulfonate) on Physically Activated Hermetia illucens Pupal Casings

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Abstract

Bio-derived carbon adsorbents are attractive due to their low cost, renewability and efficiency in removing pollutants. Residues from the black soldier fly (*Hermetia illucens*) are promising precursors for activated carbons. In this study, pupal casings were converted into carbon adsorbents by direct CO_2 activation and conventional heating. The materials were characterised by nitrogen adsorption–desorption, showing basic surfaces and specific surface areas up to 170 m^2/g. Adsorption tests were carried out for poly(sodium 4-styrenesulfonate) under different conditions. The adsorption data fitted the Langmuir model, with a maximum capacity of 121 mg/g. Kinetic analysis showed that adsorption followed a pseudo-second-order mechanism. The most effective adsorbent maintained high regeneration potential, reaching 70 % desorption efficiency after two cycles. These findings show that carbon adsorbents from *Hermetia illucens* pupal casings are efficient, reusable adsorbents with potential for sustainable water treatment applications.

Keywords: carbon adsorbents, poly(sodium 4-styrenesulfonate), adsorption/desorption, physical activation

Introduction

Industrialization has considerable environmental consequences, particularly through the generation of wastewater containing various pollutants. These contaminants, present in water bodies, soil, and the atmosphere, pose significant risks to ecosystems and human health. Among treatment techniques, adsorption using activated carbon is widely employed due to its high efficiency, environmental compatibility, and versatility in removing organic and inorganic pollutants[1].

This study explores the development of carbon adsorbents derived from the empty shells of *Hermetia illucens* pupal casings, a biological waste with valuable structural and chemical characteristics. The shells were physically activated using a conventional heating method. The resulting carbon materials were characterized and evaluated for their adsorption capacity towards poly(sodium 4-styrenesulfonate). The study highlights the importance of controlling activation conditions to produce high-performance adsorbents with porous structures and favorable surface chemistry.

Materials and Method

Activated carbons were produced by direct thermal activation of *Hermetia illucens* empty pupal shells using conventional heating for 60 minutes at 700 (A7) and 800 °C (A8) under a CO2 flow of 250 mL/min. Characterization of carbon materials involved elemental analysis, ash content determination, Boehm titration for surface functional groups, and nitrogen adsorption-desorption measurements to evaluate pore structure.

Adsorption experiments used 0.020 g of adsorbent with 50 mL pollutant solution (10–120 mg/L), shaken at 200 rpm for 8 hours at room temperature. Pollutant concentrations were determined spectrophotometrically at 263 nm. Adsorption data were analyzed using Langmuir and Freundlich isotherms and kinetic models including pseudo-first-order and pseudo-second-order. Desorption tests were performed by washing saturated adsorbents with HCl, NaOH, water, and ethanol for 24 hours to evaluate regeneration efficiency.

Results and Discussion

Table 1 shows that A8 carbon had the highest C^{daf} content. Elemental analysis indicated that C^{daf}, N^{daf} and H^{daf} increased with activation temperature. Boehm titration confirmed a high amount of basic surface groups with no acidic groups, and their content rose with activation temperature, likely due to thermal decomposition of oxygen groups.

Table 1. Elemental, ash and oxygen functional groups for the adsorbents used in this study.

Adsorbent	Ash[2]	Elemental analysis[1] (wt. %)					Oxygen groups (mmol/g)[2]	
		C^{daf3}	H^{daf}	N^{daf}	S^{daf}	O^{daf*}	Acidic	Basic
A7	17.8	65.5	2.9	3.4	0.1	28.1	0.00	2.45
A8	13.8	72.6	3.8	4.2	0.1	19.3	0.05	3.43

[1]method error ≤0.3 %, [2]arithmetic mean of the two determinations, [3]dry and ash-free state, *by difference

Table 2 shows that all adsorbents had surface areas of 132–173 m^2/g, with total pore volumes of 0.27–0.31 cm^3/g and micropore volumes of 0.019–0.036 cm^3/g. Regardless of heating method, the materials had low surface areas. Activation at 800 °C increased S_{BET} and generated mesopores for mass transport, but the surface area remained below 400 m^2/g.

Table 2. Textural parameters of carbons adsorbents.

Adsorbent	S_{BET}[1] (m^2/g)	Micropore surface area (m^2/g)	Total pore volume (cm^3/g)	t-plot micropore volume (cm^3/g)	BJH desorption average pore diameter (nm)
A7	132	35	0.27	0.019	7.16
A8	173	76	0.31	0.036	8.25

The adsorption process for samples A7 and A8 is best described by the Langmuir isotherm, which assumes monolayer adsorption on a homogeneous surface with uniform adsorption sites (Table 3). This is supported by high R^2 values (0.995 for A7 and 0.999 for A8) indicating an good fit. The maximum adsorption capacities (q_{max}) of 100 mg/g for A7 and 121 mg/g for A8 closely match the experimental values, confirming the formation of a single adsorbate layer without interactions between adsorbed molecules.

Table 3. Textural parameters of carbons adsorbents.

Isotherm	Parameter	Sample	
		A7	**A8**
	q_{exp} (mg/g)	99	118
Langmuir	K_L (dm^3/mg)	0.011	0.004
	q_{max} (mg/g)	100	121
	R^2	0.995	0.999
Freundlich	K_F ($mg/g(dm^3/mg)^{1/n}$)	52.27	51.12
	1/n	0.198	0.265
	R^2	0.861	0.823

The kinetic modelling of poly(sodium 4-styrenesulfonate) adsorption on samples A7 and A8 was evaluated using pseudo-first-order and pseudo-second-order models. While both models fit the data well, the pseudo-second-order model showed superior correlation coefficients (R^2 = 0.999 for both samples), indicating that chemisorption likely governs the adsorption mechanism. The calculated equilibrium capacities from the pseudo-second-order model closely matched the experimental values, confirming the model's accuracy in describing the adsorption kinetics on these adsorbents.

Table 4. Kinetic modelling for adsorption of poly(sodium 4-styrenesulfonate).

Kinetic models	Parameter	Sample	
		A7	**A8**
	q_t (mg/g)	83	97
Pseudo-first order	k_1 (1/min)	1.30×10^{-2}	7.45×10^{-3}
	$q_{e,cal}$ (mg/g)	79	84
	R^2	0.977	0.985
Pseudo-second order	k_2 (g/mg×min)	9.43×10^{-4}	3.73×10^{-4}
	$q_{e,cal}$ (mg/g)	85	98
	R^2	0.999	0.999

Desorption studies of the most effective adsorbent, A8, were performed using four media: 0.1 M HCl, 0.1 M NaOH, distilled water, and 97 % ethanol. Hydrochloric acid exhibited the highest desorption efficiency (~70 % after two cycles), indicating dominant electrostatic interactions. Ethanol was the second most effective, maintaining stable efficiency (~55 %) over two cycles. Alkaline and neutral media showed lower efficiency, underscoring the need for alternative regeneration methods.

Conclusion

Carbon adsorbents were produced by activating *Hermetia illucens* fly shells using conventional heating. Adsorption of various pollutants followed pseudo-second-order kinetics and Langmuir isotherm, indicating homogeneous sites. Desorption efficiencies reached up to 70 %, highlighting cost-effective, eco-friendly potential for large-scale use.

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PP16- Assessment of Toxic Metal Emissions in E-Waste Processing: A Study of Airborne and Settled Dust

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The rapid accumulation of electronic waste (e-waste) is driven by the diminishing lifespan of electronic devices and an ever-increasing global demand. Due to its structural complexity and diverse material composition, e-waste presents significant processing challenges. Unlike other waste streams, the hazardous constituents in electronics pose severe environmental risks if subjected to substandard recycling or disposal methods. In 2022, global e-waste generation reached 62 million tonnes—a substantial increase from 2010—yet only 22.3% was formally documented as recycled[1]. Unregulated treatment processes facilitate the release of toxic elements, such as Pb, Hg, As, Cr, Co, Cd, and Ni, into the environment. Consequently, unauthorized disposal practices threaten both ecological integrity and public health.

The objective of this study is to quantify the concentrations of metallic elements in surface dust and airborne particulates at an e-waste recycling facility. Samples were collected across three distinct operational areas: the grinding zone (ML), the fluorescent bulb crushing zone (LS), and the manual disassembly zone (DL). The analytical workflow comprised systematic sample collection, chemical pretreatment, and high-precision analysis via ICP-MS (Agilent 8900 ICP-QQQ). Surface dust was manually collected using chemically treated polyethylene brushes, while airborne particulates were captured using a purpose-built cyclone system and deposited onto filters. To ensure complete matrix decomposition, samples underwent microwave-assisted acid digestion using a concentrated mixture of HNO_3, HCl, and HF.

The analysis reveals that Pb exhibits the highest concentration in surface dust across all sampled zones relative to other trace metals (Fig. 1). This distribution pattern is consistent with the extensive use of Pb in essential electronic components, including printed circuit boards, solders, and ceramics. While the concentrations of other metals were lower than those of Pb, the data underscore a significant risk associated with Hg emissions from fluorescent bulb processing. These findings demonstrate that the crushing of fluorescent lamps release of substantial quantities of toxic Hg into the surrounding environment. Furthermore, the variation in element concentrations between surface dust and airborne particulates suggests that specific metals are more prone to becoming airborne during recycling process—potentially due to differences in particle density or mechanical agitation. Although no uniform correlation was identified between specific recycling stages and individual metal concentrations, the results unequivocally indicate that e-waste processing generates significant environmental and occupational health risks.

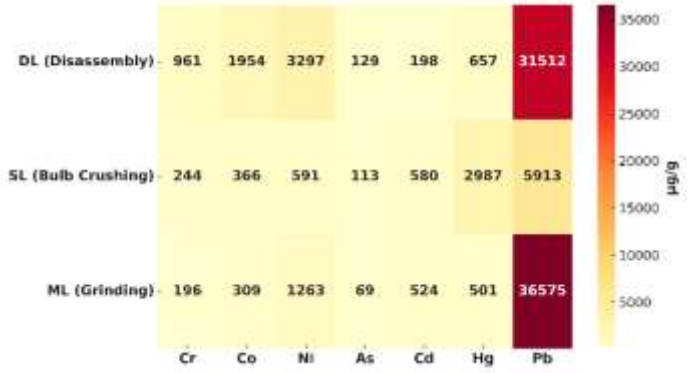

Fig. 1. Concentrations of selected metals (µg/g) in surface dust at three e-waste recycling locations.

Keywords: E-waste, Toxic metals, Airborne dust, Settled dust

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PP17- Potential Effect of Selagibenzophenone B Derivatives on the Ferroptotic Death Mechanism in Castration Resistant Prostate Cancer Cells

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Prostate cancer is one of the leading causes of cancer-related deaths worldwide, and treatment options are limited in advanced stages. Androgen deprivation therapy (ADT) is an effective initial treatment; however, many patients develop resistance to this therapy over time, leading to castration-resistant prostate cancer (CRPC). At this stage, the effectiveness of radical prostatectomy, chemotherapy, and radiotherapy diminishes. Therefore, the need for effective treatment strategies continues. Recently, targeting the selective modulation of programmed cell death pathways, particularly ferroptosis[1], characterized by iron-dependent lipid peroxidation, has gained attention in the development of cancer treatment strategies[2].

In our studies, Selagibenzophenone B (SB) derivatives (SB-7 and SB-9) obtained from the Selaginella plant exhibited high selectivity (selectivity indices of 6.6 and 3.9, respectively) and cytotoxicity in castration-resistant PC3 cells. Among these, SB-7 showed the most potent effect, reducing cell viability to 45% at 7.0 μM dose and causing higher non-apoptotic cell death (31.54%) compared to apoptotic cell death (20.04%). The high rate of non-apoptotic cell death suggested that it may mediate a ferroptotic death. In the ferroptotic mechanism analyses performed, it was observed that this compound increased intracellular iron accumulation (1.3-fold) at the 14 μM dose of SB-7, a ferroptotic cell death mechanism, and increased lipid peroxidation (1.5-fold) at the *lower dose* (3.5 μM). At the same time, it did not significantly alter the activity of GPX4, the primary enzyme in the glutathione pathway. Gene expression analyses revealed that SB-7 and SB-9 upregulated SLC7A11 at low doses, while exhibiting no significant changes in other ferroptosis-related genes. In silico analyses demonstrated that SB-9 and SB-7 interact with GPX4 with binding energies of −7.07 and −6.47 kcal/mol, respectively, while the reference inhibitor I22 (−9.73 kcal/mol) exhibited stronger affinity. LigPlot interaction analysis revealed that SB-9 directly interacts with catalytic tetrad residues (Trp136, Gln81) and surrounding apolar residues (Pro155, Met156, Phe138), whereas SB-7 binds to an alternative site adjacent to the active site (Glu50, Phe92, Tyr96). 100 ns molecular dynamics simulations showed that SB-7 exhibited the most stable binding pose with the lowest RMSD (0.46 nm), while SB-9 (0.84 nm) provided the most uniform RMSF profile around the active site. Analysis of other genes has demonstrated that SB-1, from which SB-7 and SB-9 are derived, increases the expression of autophagy-related genes such as ATG7 and BECN1. This also suggests that it plays a role in other non-apoptotic death pathways, such as ferritinophagy triggered by ferroptosis/autophagy.

In conclusion, SB derivatives induce non-apoptotic cell death associated with ferroptotic stress in CRPC cells; however, it is believed that multiple mechanisms contribute to this effect. The data obtained reveal the potential of SB derivatives as multi-targeted anticancer agents; however, further studies are required to confirm these effects.

Keywords: Selagibenzophenone B derivatives; Ferroptosis; CRPC; anticancer effect

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PP18- How much arsenic can trees accumulate? Time-resolved arsenic speciation from hydroponics to long-term dendroremediation field studies

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Arsenic (As) contamination originating from mining and industrial legacies remains a major environmental challenge, while scalable, low-impact, and ecosystem-compatible remediation approaches remain limited. Trees are increasingly proposed as long-term "biological infrastructure" for the stabilization and partial extraction of As (dendroremediation)[1]. However, implementation is frequently constrained by analytical gaps: total As alone does not capture toxicity, mobility, and detoxification, which are controlled by time-dependent speciation and organ-specific partitioning.

Here, we present key outcomes of our study, which focuses on the analytical tracking of As forms in tree systems, integrating controlled hydroponic exposure with longitudinal dendroremediation observations. Controlled experiments employed *Quercus robur* L. and *Tilia cordata* Mill. (33-day time series) to quantify temporal changes of total As and selected As species in growth solutions and plant organs[2]. In parallel, multi-year studies in *Q. robur* and *T. cordata* under realistic exposure conditions were used to interpret chronic responses and mechanistic tolerance. Analytical workflows combined multi-matrix elemental determination with speciation-resolving separations and targeted biochemical profiling (stress markers), allowing mechanistic interpretation beyond concentration endpoints.

Across experiments, As behaviour was strongly matrix- and organ-dependent. Hydroponics demonstrated that As species can transform rapidly in the growth medium and within plant tissues, with dynamics initiated early and continuing over days to weeks. In *T. cordata*, transformation patterns supported active detoxification routes in roots, including formation of thiol-bound complexes consistent with phytochelatin involvement. Importantly, we detected previously unreported hydrophobic organoarsenic compounds (dimethylarsinoyl lipids) in roots under As(V) exposure, suggesting additional transformation pathways that may be linked to lipid metabolism and/or rhizosphere microbial activity[2]. Alongside chemical speciation, proline showed consistent elevation across organs under chronic As stress, supporting its utility as a robust biochemical marker for monitoring dendroremediation performance over time (with species- and organ-specific patterns). Notably, the longitudinal field observations revealed a pronounced shift in accumulation dynamics over time: during the first four years, *Tilia* exhibited higher As accumulation capacity, whereas in the fifth year, *Quercus* became the stronger accumulator.

These findings demonstrate that dendroremediation assessment and optimization require an integrated analytical strategy that combines (i) total As, (ii) time-resolved speciation in relevant matrices, and (iii) biochemical stress markers. Such a framework strengthens species selection, supports mechanism-based monitoring, and improves comparability between controlled experiments and field-scale applications in contaminated landscapes.

Keywords: arsenate; arsenite; dendrorestoration; phytoremediation; mining wastes

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PP19- Effects of Apigenin on the Physicochemical Characteristics of U-118 MG Glioma Cells and Liposomal Models

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Apigenin, a natural flavonoid commonly found in fruits and vegetables, has potential antitumor effects against glioma cells, but its limited solubility restricts clinical use. Therefore, various drug delivery systems, including liposomes, have been developed to improve bioavailability[1,2].

We investigated the effects of 24- and 48-hour apigenin exposure on the surface charge of human glioblastoma cells (U-118 MG). Additionally, interactions of apigenin with dipalmitoylphosphatidylcholine (DPPC) liposomes were studied, and both empty and apigenin-loaded liposomes were characterized for hydrodynamic diameter, polydispersity index, and zeta potential. All measurements were conducted over a pH range in physiological saline using dynamic light scattering (DLS) and electrophoretic light scattering (ELS).

Exposure of glioma cells to apigenin resulted in dose- and time-dependent changes in membrane surface charge density. Apigenin-treated cells exhibited lower negative surface charge values, particularly after 48 hours of exposure, compared to control cells at pH > 4, whereas no statistically significant changes were observed in the pH range of 2–4. Apigenin did not significantly alter the zeta potential of DPPC liposomes, suggesting efficient incorporation into the liposomal membrane. Both apigenin-loaded and empty liposomes exhibited hydrodynamic diameters between 180-230 nm, indicating uniform vesicle populations with narrow size distributions.

Many of apigenin's biological effects are thought to result from its interactions with cell membranes. Given the need for new anticancer therapies to improve the treatment of malignant gliomas, studying the effects of apigenin on both model membranes and glioblastoma cell membranes could provide valuable insights into its potential as a therapeutic agent.

Keywords: glioma cells, apigenin, liposomes

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PP20- Nanoplastics and Blood Cells: Effects on Porcine Platelets and Erythrocytes

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Nanoplastics have emerged as an environmental and biomedical concern due to their small size and their ability to interact with biological systems[1]. Previous studies[2] have shown that blood cells, including erythrocytes and platelets, can be affected by nanoparticles, influencing their surface properties and function.

Porcine blood was centrifuged to separate platelets and erythrocytes, and both fractions were suspended in 155 mM sodium chloride. Commercially purchased polystyrene nanoplastics were characterized for size using dynamic light scattering (DLS) and for zeta potential using electrophoretic light scattering (ELS) across concentrations of 3–100 μg/mL and at three pH values (2, 7.4, and 9.5). Based on these measurements, three concentrations (10, 30, and 50 μg/mL) were selected for further zeta potential analysis of blood cells suspended in 155 mM NaCl over a pH range of 2–10.

Erythrocyte zeta potential was sensitive to polystyrene concentration at acidic pH (2–6) but remained stable at neutral and basic conditions. Platelet zeta potential showed minimal change at the lowest particle concentration, whereas higher concentrations induced clear, concentration-dependent shifts across pH 4–10. Aggregation of the smallest particle concentration was observed, particularly under acidic conditions; however, the most pronounced effects were on the surface charge of blood cells rather than on particle size. Particles at 30 and 50 μg/mL displayed sizes in agreement with the manufacturer's specification of 24 nm.

These results indicate that erythrocytes and platelets respond differently to polystyrene nanoplastics depending on particle concentration and pH. Overall, higher concentrations of nanoplastics had the most pronounced effects on the surface charge of blood cells, while particle aggregation played a secondary role.

Keywords: polystyrene nanoparticles; blood cells, zeta potential; ELS; DLS

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PP21- Development of Modified QCM Chip for Selective Recognition of Breast Cancer Biomarkers

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Early and reliable detection of breast cancer requires sensitive analytical platforms capable of selectively identifying clinically relevant biomarkers[1]. Quartz crystal microbalance (QCM) sensors offer label-free, real-time detection with high mass sensitivity, making them attractive for biomedical diagnostics[2]. The QCM signal is based on very sensitive registration of mass changes during the interaction of biological recognition elements and selected analytes. Because QCM-chip is based on gold electrodes, which could be applied for the design of electrochemical system. Hence, by this system the QCM-based signal could be verified and/or enhanced by electrochemical signal. During this work the modification of QCM-chip surface by functional materials and nanostructured interfaces in order to design selective recognition system to detect breast cancer biomarkers.

QCM-chip electrodes could be modified by tailored organic, polymeric, and nanostructured layers, enabling stable immobilization of biorecognition elements such as antibodies, peptides, and affinity ligands. Surface engineering strategies should by optimized to enhance binding site accessibility, reduce nonspecific adsorption, and improve sensor stability in complex biological media. There are some indications that the most efficient breast cancer biomarkers should be selected among these CA15-3, CA27-29, HER2 ECD, GP88, HER2, SKBR3 compounds, which show marking potential towards breast cancer. Some proposed QCM modification technologies could provide a platform for breast cancer biomarker detection and open new opportunities for the development of QCM and/or electrochemistry based biosensors for the diagnosis of breast cancer biomarkers.

Keywords: *QCM biosensor; surface modification; breast cancer biomarkers*

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PP22- Modification of MXenes with Antibodies: Advances and Challenges

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MXenes are an emerging two-dimensional (2D) material composed of layered transition-metal carbides, nitrides, or carbonitrides, with a rare combination of properties, including metallic conductivity, hydrophilicity, biocompatibility, large surface area, tunable surface chemistry, rich functional groups, and a layered structure. Since the discovery of the first member of the family, MXene ($Ti_3C_2T_x$) in 2011[1], MXenes have attracted attention and made a substantial impact within the scientific community, opening the door to a wide range of applications. The properties of MXenes establish them as promising platforms for biosensing, targeted therapeutic strategies, and selective biomedical applications[2-3]. However, MXenes themselves do not inherently recognize biological targets (such as proteins or biomarkers present on the cells). Conjugating antibodies onto their surfaces provides highly specific biorecognition, useful for diagnostics and targeted therapies.

This presentation provides an overview of key methods and strategies for modifying pristine or further functionalizing MXenes with antibodies. Special attention is given to MXene-nanomaterial composites. The most commonly employed approaches include simple physical adsorption, covalent immobilization using organosilanes and cross-linkers, MXenes modification with polymers, and bioaffinity-based conjugation. Challenges to control antibody orientation and biological activity remain crucial. New linker molecules and engineered surface terminations may improve the biorecognition efficiency, reproducibility, long-term stability, and biomedical applicability of MXene-antibody conjugates. The growing prevalence of antibiotic-resistant bacteria has created an urgent need for new antibacterial strategies. Thus, the application of MXene-antibody conjugates for biological recognition and photothermal destruction of methicillin-resistant Staphylococcus aureus has high potential.

Keywords: MXene, antibody, conjugation.

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PP23- Void-Free Metallization of High-Aspect-Ratio TGVs Fabricated by Ultrashort Pulse Laser-Induced Etching

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High-aspect-ratio through-glass vias (TGVs) are critical enabling structures for next-generation advanced electronic packaging [1]. However, achieving uniform and void-free copper filling within these high-density features remains a significant technical challenge. Thisresearch investigates a hybrid fabrication approach, combining ultrashort pulse laser-induced etching [2] with a tailored electroless copper deposition process designed for the conformal metallization of TGVs.

The study focuses on the strategic engineering of the deposition environment through the systematic optimization of plating bath additives. By tuning the interaction between surfactants, accelerators, and suppressors, we aim to achieve a favorable mass transport regime and balanced reduction kinetics[3]. This approach promotes bottom-up copper growth, which is essential to eliminate the formation of voids and seams inside deep via structures. Furthermore, the impact of process parameters, including bath temperature, pH, and agitation, is evaluated toenhance the penetration of reactants into the laser-etched microstructures.

Planned cross-sectional analyses using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) serve to validate the integrity of the fill, focusing on uniform microstructure and strong adhesion to the dielectric sidewalls. This work demonstrates that the synergy between precision laser activation and chemical additive optimization offers a scalable and robust pathway for the fabrication of high-performance glass-core substrates.

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PP24- Electrochemical Investigation of Conformational Changes in Poly-L-lysine via Molecularly Imprinted Polymer-Based Biomimetic Sensors

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Poly-L-lysine (PLL) is a positively charged synthetic polypeptide whose secondary structure is highly sensitive to environmental parameters such as pH and temperature, making it a suitable model for investigating protein conformational changes. Conventional spectroscopic techniques used to monitor such structural transitions are often time-consuming and require advanced instrumentation, which motivates the development of alternative biomimetic sensing approaches[1,2]. In this work, a molecularly imprinted polymer (MIP)-based electrochemical platform was developed for the recognition of PLL and for studying structure-dependent interactions under varying environmental conditions.

Electropolymerisation was carried out on a glassy carbon electrode using o-phenylenediamine, and in some approaches a combination of o-phenylenediamine and resorcinol, via cyclic voltammetry within a potential window of 0 to +0.8 V at a scan rate of 0.05 V s^{-1}. Polymer formation, template removal, and rebinding were monitored using cyclic voltammetry (CV) and differential pulse voltammetry (DPV) with the ferri/ferrocyanide redox probe. The imprinting strategy was evaluated under multiple experimental conditions, including pH 7.5 and pH 10.5 as well as temperature-induced conformational changes (e.g., incubation at 40 °C), with the most reproducible electrochemical behaviour obtained at pH 7.5 under ambient temperature.

According to preliminary experiments, the electrochemical response indicated a concentration-dependent binding behaviour after template removal and rebinding. Non-imprinted polymers (NIPs) were used as reference systems and did not exhibit comparable signal evolution, supporting the role of the imprinting process in shaping the electrochemical response. Environmental parameters such as pH and temperature influenced the signal behaviour, suggesting that conformational changes of PLL may affect its interaction with the polymer matrix. Although further optimisation and extended validation are required, the presented results indicate that electrochemically synthesised MIP interfaces may offer a useful biomimetic platform for studying protein-related interactions under varying environmental conditions.

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Acknowledgment
This study was supported by Turkish—German University Scientific Research Projects Commission under the grant no: 2024BF04 and TÜBİTAK-BİDEB 2209/A Program.

PP25- A tele-medicine compatible e-nose platform; a low-cost and a durable biomedical device and a colorimetric sticker compliant with green chemistry standards for the monitoring of food and pharmaceutical preparation spoilage

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Monitoring of food spoilage is an important issue causing numerous global annual cases[1]. Similary due to stability concerns of semi-solid and liquid formulations, spoilage of drug substances is another common issue creating great annual global financial cost, while causing significant health risks for the patients taking the therapy[2]. There are limited number of studies published about point-of-care devices for the solution of these problems. A tele-medicine compatible e-nose based biomedical device (Fig 1) is designed using Arduino UNO R3 development board, Hc-05, DS3231 RTC, MQ-2, RGB, DSTK1578, DHT11 modules and a 0.91″ OLED screen. Arduino IDE (v. 2.3.6) is used for writing compiling and loading related code sketch. Sensitivity and specificity of MQ-2 sensor was found to be appropriate among the entire MQ sensors studied. MQ-2 sensor is calibrated using the threshold values determined in aging experiments of real samples. Entire experimental outcome is stored in microSD card and send to cellular phones simultaneously for tele-medicine purposes using Serial Bluetooth Terminal application (*v. 1.50 for Android*). Ethanolic beetroot extract (15g/20mL) was soaked on 40-60% of glycerol and 12g methyl celluose+Arabic gum aqueous mixture to manufacture the biodegradable colorimetric sticker (Fig 2), which responded successfully to volatile organic amines originated from spoilage of fish tissue and commercial semi-liquid pharmaceutical formulations. As a conclusion, a simple, inexpensive, durable and tele-medicine compatible e-nose platform is designed including a colorimetric sticker compliant with green chemistry norms for the monitoring of food and pharmaceutical preparation spoilage.

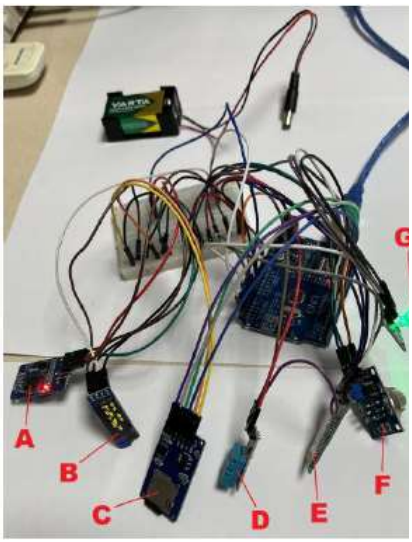

Fig 1. Breadboard prototype of the biomedical device; RTC(A), OLED(B), microSD(C), DHT11(D), HC-05(E), MQ-2(F), RGB(G).



Fig 2. Beetroot based sticker indicating fresh (A) and 24 hours old (B) sardine stored at 0°C and 25°C, respectively.

Keywords: Food and Drug Spoilage, e-nose, tele-medicine, biodegredable sticker

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PP26- Investigation of Degradation of Polyethylene (PE) Microplastics by a Photo-Fenton Reaction; a Response Surface Methodology (RSM) Modelling Approach

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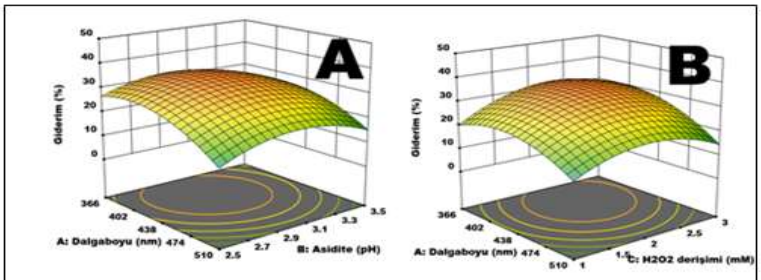
Fig·1. Experimental setup for foto-Fenton experiments (A) and polyethylene microparticles before (I) and after (II) foto-Fenton degredation.¶

Keywords: Microplastics, photo-Fenton, response surface methodology, central composite design¶

It is estimated that 8.3 million metric tons (MT) of plastic have been produced worldwide up to date, and that 6.3 MT of this has become waste by 2015, and that 12.7 MT of plastic entered the oceans from land in 2010 alone. On an annual basis, an average person ingests between 75000 and 120000 microplastic particles through the food chain [1]. There are a limited number of articles on this subject in the literature, and no modeling study has been provided [2]. The subject of this study focuses on the process of eliminating microplastics, which is such an important problem, by the photo-Fenton (PF) method. Optimization of the independent variables of the PF method, namely wavelength, pH, H_2O_2 and Fe_2SO_4 concentration, was carried out, and a central composite design (CCD) based modeling study was conducted using the response surface methodology (RSM) (Fig 1). The 3D graph summarizing the findings for RSM is shown in Fig 2. As a conclusion, relatively higher energy wavelengths (366-402nm), 2mM H_2O_2, 0.2-0.3mM $FeSO_4$ concentrationS, and 2.9-3.3 pH were determined as optimum independent variable ranges.¶



Fig·2. 3D surface graphs of degredation% depending on wavelength&pH (A) and wavelength&H_2O_2 concentration (B).¶

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PP27- Non-invasive Reverse Iontophoretic Electrochemical Immunosensing of Homocysteine Through in-vitro Artificial Skin Model and ex-vivo Wistar Rat Skin

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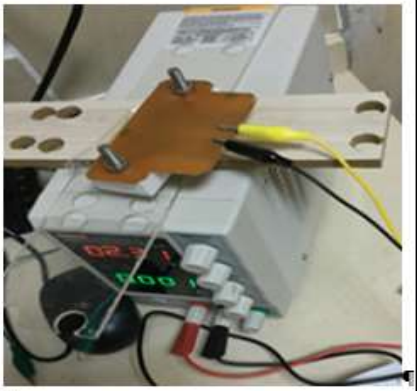

Fig. 1. Experimental setup for non-invasive (reverse iontophoretic) extration

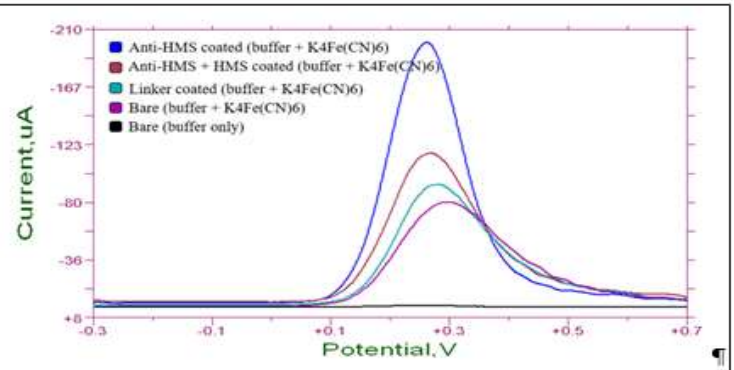

Fig. 2. Representative DPV voltammograms of related immunosensing CPEs.

Heart disease is the leading cause of death worldwide. Future predictions indicate it will remain the most significant cause of death for a considerable time. According to WHO data from 2019, out of 57 million deaths, 17.9 million were due to cardiovascular diseases [1]. Death from acute myocardial infarction (AMI) occurs within the first hour. Intervention within the first six hours of AMI diagnosis is life-saving. This highlights the importance of early diagnosis and monitoring. Our study aimed to determine the homocysteine [2] (HMS) biomarker non-invasively using reverse iontophoresis (RI), a method different from conventional diagnostic methods for myocardial infarction (AMI) such as ECG and blood tests, and to contribute to the early diagnosis of myocardial infarction. Under normal conditions, the HMS level in the blood is 5-15 µmol/L when fasting, while in cases of mild, moderate, and severe hyperhomocysteinemia, the levels are 15-30 µM, 30-100 µM, and ≥100 µM, respectively. Carbon paste electrodes (CPEs) were designed for the electrochemical immunosensor determination of HMS, and DPV and CV measurements were performed; furthermore, extraction was carried out and measured using the RI method. According to calibration findings, linearity was achieved in the concentration range of 3 ng/mL (5-100 µM). Optimization studies were also carried out regarding stability, interference, and incubation site.

Keywords: Acute Myocardial Infarction, Non-invasive Analysis Methods, Reverse Iontophoresis, Cardiac Biomarkers.

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PP28- Electrochemical DNA Biosensor Applications Based on Carbon and Metal Oxide Nanomaterial-Modified Electrodes

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Electrochemical DNA biosensors have attracted significant attention due to their high sensitivity, simplicity, and low cost for biomolecular detection. The development of nanomaterial-modified electrode surfaces has emerged as an effective strategy to improve biosensor performance.

In this study, a pencil graphite electrode (PGE) was modified with graphene oxide (GO), Gd-ZnO, Cu-ZrO_2, Gd-ZrO_2, zeolitic imidazolate framework (ZIF-8), and a water-soluble myofibrillar protein–chitosan (MP-CH) composite for DNA biosensor applications. All nanomaterials were synthesized under laboratory conditions using different preparation parameters. Electrochemical signal amplification was evaluated using cyclic voltammetry (CV) and differential pulse voltammetry (DPV) based on the guanine oxidation signal.

Electrochemical activation procedures and pH optimization were applied to obtain optimal analytical responses. Activation treatments significantly enhanced the electrochemical response of Gd-ZnO, Cu-ZrO_2, and ZIF-8 modified electrodes, while GO, Gd-ZrO_2, and MP-CH modified electrodes showed limited sensitivity to certain pretreatment processes.

Gd-ZnO, Cu-ZrO_2, and ZIF-8 modified biosensors exhibited approximately 40%, 67%, and 37% higher sensitivity, respectively, compared to the bare PGE based on the guanine oxidation signal at around 1.0 V. These results demonstrate the potential of nanomaterial-modified PGE platforms for electrochemical DNA biosensor applications.

Keywords: Electrochemical DNA biosensor; Nanomaterials; Pencil graphite electrode; Signal amplification; Guanine oxidation

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PP29- Magnetic Separation and Preconcentration of Sm(III) Using Eriochrome Black T modified Fe_3O_4

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Rare earth elements (REEs) are of strategic importance in contemporary applications, including high technology, electronics, renewable energy systems, and healthcare. However, their closely similar chemical properties pose significant challenges for selective separation. Magnetic particle-based sorbents provide a promising and efficient approach for the selective separation and preconcentration of REEs. In this study, Eriochrome Black-T modified Fe_3O_4 (Fe_3O_4@EBT) was utilized for solid phase extraction of REEs for the first time. Characterization of the prepared sorbent was achieved using FT-IR and SEM. The target REE was Sm(III) ion and the parameters including pH, initial concentration of analyte, sorbent mass, sorption time, elution time, eluent concentration and volume parameters were optimized with Box-Behnken design method.

Experimental conditions for the simultaneous separation and preconcentration of Sm(III) were given as follow: pH of sample solution 5; sorbent mass 5 mg, sorption time 50 s, initial analyte concentration 15 ppb, elution time 74.1 s, eluent concentration 1.2 mol/L HCl and eluent volume 5.4 mL. The preconcentration factor of the analyte was calculated as 46.30. Detection and quantification limits of Sm(III) were determined as 0.05 µg/L and 0.16 µg/L, respectively. The recovery value of 95.74% was achieved for Sm(III) in experiments conducted using a water based mixed REEs standard. The developed method was successfully applied on various water and soil samples. A high performance solid phase system for selective separation and preconcentration of Sm(III) with Fe_3O_4@EBT sorbent has been developed. The developed method is a reliable alternative in terms of its applicability and sustainability.

Keywords: Rare earth elements, solid phase extraction, eriochrome black T, magnetic particles

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PP30- Murexide-Modified Silica Gel as an Efficient Sorbent for Metal Ion Separation and ICP-OES Determination

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Industrial and agricultural activities release heavy metals into water resources, posing significant risks to both environmental and human health due to their toxicity and potential for bioaccumulation [1,2]. In this study, the aim was to develop a novel solid-phase extraction method based on murexide-modified silica gel for the simultaneous separation and preconcentration of Cd(II) and Pb(II) ions from various water samples. Determination of the target analytes were achieved using ICP OES.

Within the scope of the study, activated silica gel surface was functionalized with the murexide ligand to synthesize a new sorbent for the first time. The characterization of the synthesized sorbent was performed using FT-IR and SEM. The effect of pH, which is one of the most critical parameters affecting the retention of analytes on the sorbent surface, was investigated and the optimum pH value for the sorption of target analytes was determined to be 4. Additionally, optimization of the parameters including sorbent mass, sample volume, shaking time, eluent type, eluent concentration and eluent volume were carried out. The developed method was successfully applied on various water samples.

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PP31- MoS2 and WS2 Nanosheet-Coated Silicon Wafers for Adsorption-Enhanced LIBS Detection of Heavy Metals

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Heavy metals, particularly cadmium, chromium, and lead, are of significant concern due to their potential to cause severe health complications and fatalities in humans, even at low concentrations.[1] According to the World Health Organization (WHO) guidelines for drinking-water quality, the permissible limits are 3 ng mL^{-1} for Cd, 50 ng mL^{-1} for Cr, and 10 ng mL^{-1} for Pb.

MoS_2 and WS_2 are transition metal dichalcogenides (TMDs) known for their two-dimensional layered structures. These materials are characterized by strong covalent bonding within the layers and weak van der Waals interactions between them, resulting in high adsorption capacities. The sulfur groups in TMDs exhibit a strong affinity for metal ions, rendering them effective sorbents for trace-metal preconcentration and environmental remediation. Exfoliation of TMDs into single- or few-layer nanosheets increases the surface area and generates additional edge sites, further enhancing metal adsorption. MoS_2 and WS_2 have demonstrated superior adsorption capabilities for metals such as Hg, Cd, Pb, Zn, and Ni, as determined by techniques including ICP-OES and FAAS.[2] However, their application in metal analysis using laser-induced breakdown spectroscopy (LIBS) remains largely unexplored.

This study builds upon our previous work employing nonmetal substrates in dried-droplet LIBS analysis by coating silicon wafer surfaces with two-dimensional TMDs, specifically exfoliated MoS_2 and WS_2, for the determination of trace metals (Cr, Pb, and Cd). The MoS_2- and WS_2-coated substrates were immersed in low-concentration metal solutions to achieve surface preconcentration, followed by LIBS analysis after drying. The effects of coating thickness on adsorption capacity and metal-ion retention efficiency were systematically investigated and optimized to ensure effective analyte atomization within the laser ablation depth, thereby improving analytical performance. In addition, the concentrations of metals remaining in solution after adsorption were determined using the dried-droplet LIBS methodology[3] on silicon wafer substrates.

Keywords: *Transition Metal Dichalcogenides (TMDs); Laser-Induced Breakdown Spectroscopy (LIBS); Heavy metal adsorption; Trace metal detection.*

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PP32- Functionalized Graphene Oxide for Toxic Metal Adsorption: A Laser–Induced Breakdown Spectroscopic Investigation

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Graphene Oxide (GO) [1] is a derivative of graphene with high surface area, high adsorption capacity, and chemical resistance. Due to the presence of oxygen-containing functional groups such as hydroxyl, epoxy, and carboxyl on its surface, GO exhibits a strong affinity for toxic metals, enabling their efficient removal from aqueous environments. It has been shown in the literature that GO's performance can be further improved through functionalization with carboxylic or sulfanilic acid [2]. In this study, GO and carboxylated GO (GO-COOH) were synthesized, characterized, and applied for toxic metal adsorption studies by LIBS. Studies were performed through the batch method, in which the synthesized materials were immersed in metal solutions, and unbound metal content was determined via dry-droplet LIBS methodology after centrifugation. The adsorption capacities of the two materials were comparatively studied for Cr, Cd, and Pb elements. The batch experiment results demonstrate that GO–COOH exhibits enhanced Cr adsorption compared to GO, achieving removal efficiencies of 80% and 90%, respectively.

Keywords: Graphene Oxide (GO); Functionalized Graphene Oxide, Metal Adsorption, dry droplet LIBS

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PP33- Copper(I)-Assisted Fenton-Like Reaction-Mediated Dual-Mode Detection of Triacetone Triperoxide (TATP) Using Sustainable Carbon Dots

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Triacetone triperoxide (TATP) is a highly powerful improvised explosive that is frequently employed in terrorist activities[1]. Unlike many conventional explosives, TATP lacks a characteristic chromophoric moiety, which makes its detection particularly challenging[2]. To overcome this limitation, a new analytical strategy based on a Cu(I)-driven Fenton-like reaction is introduced, enabling the simultaneous fluorometric and colorimetric determination of TATP within a single reaction tube. The proposed reaction system consists of (i) Cu(I), an acid-soluble precursor metal cation, (ii) oxygen- and nitrogen-doped carbon dots synthesized from ascorbic acid and urea (AU-CDots), (iii) the chromogenic reagent N,N-dimethyl-*p*-phenylenediamine (DMPD), and (iv) TATP, all present in the same medium. Hydrochloric acid (HCl), used to solubilize Cu(I), also promotes the hydrolytic decomposition of TATP, generating hydrogen peroxide (H_2O_2), which subsequently participates in a Fenton-like reaction with Cu(I) to yield Cu(II) ions and hydroxyl radicals (•OH). The generated Cu(II) ions selectively quench the fluorescence of AU-CDots, while the hydroxyl radicals oxidize DMPD to form a colored radical cation ($DMPD^{\bullet+}$). As a result, TATP can be quantified concurrently through both fluorometric and colorimetric readouts. The proposed method achieves limits of detection of 3.0 nmol L^{-1} and 10.0 nmol L^{-1} for the fluorometric and colorimetric measurements, respectively. In addition, AU-CDots demonstrate catalytic activity in colorimetric detection mode. The presence of various potential interferents, including metal cations, anions, camouflage agents, and explosive mixtures, did not significantly influence TATP recoveries, which ranged from 94.9% to 105.3%. Moreover, near-quantitative recoveries (97.5%–105.2%) were successfully obtained from soil samples contaminated with different concentrations of TATP.

Keywords: Triacetone triperoxide (TATP), Fenton reaction, Turn–off fluorescence, DPMD

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PP34- Naked-Eye Detection of Pentaerythritol Tetranitrate (PETN) Using Functionalized Gold Nanoparticles *via* π-Hole–Based Sensing Strategy

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Pentaerythritol tetranitrate (PETN) is a nitrate ester explosive and also an ingredient of military and civilian purpose energetic materials in plastic explosives.[1] PETN is frequently used in terrorist activities and poses a major threat to the society, making its analysis important. Spectroscopic studies reported in literature for the determination of PETN generally involve indirect methods based on PETN hydrolytic degradation to nitrite or nitrate, and do not include a direct determination method. We have designed a direct colorimetric nanoprobe based on gold nanoparticle aggregation involving a π–hole interaction mechanism for the selective, sensitive, and direct determination of intact PETN. The nanoprobe (AuNPs@2NT), synthesized by modifying the surface of nanogold with 2–naphthalenethiol (2NT), was structurally characterized using STEM, AFM, DLS, IR, XRD, and XPS techniques. Here a π–hole interaction occurs between the nitro group of PETN and the aromatic ring of 2NT, and the presence of four nitro groups in the PETN molecule causes the aggregation of several AuNPs@2NT, owing to the potent and directional π-hole character of the nitrate ester. The analytical signal obtained as a result of aggregation can be monitored both with the naked–eye and by UV–vis spectrophotometry, and the detection limit (LOD) of AuNPs@2NT for PETN is 1.62 nmol L^{-1}. AuNPs@2NT, which exhibits high selectivity for PETN among different explosives, can determine PETN with high recoveries (93.9%–106.3%) even in the presence of potentially interfering species. The developed method enables the direct and selective determination of PETN through a mechanism based on the aggregation of gold nanoparticles (AuNPs), even at low concentrations, whereas polynitro-aromatic energetic materials (which can involve donor-acceptor interactions) do not react. The proposed π–hole interaction mechanism is first time used in the colorimetric determination of an energetic material with high selectivity. This approach paves the way for new research avenues in the field-based detection of PETN. Furthermore, the AuNPs@2NT-based colorimetric method is expected to see widespread use in various laboratory applications in the coming years.

Keywords: PETN, gold nanoparticles, π–hole interaction, colorimetric sensor.

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Acknowledgment:

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PP35- Synthesis of Green Carbon Dots from Artichokes as Adsorbent and Fluorometric Sensor for Cu (II) Ions

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Biomass is used as a carbon source in the synthesis of carbon dots (CDots), which are of widespread interest due to their optical properties, strong fluorescence, high photostability and good catalytic activity[1]. Biomass is a heteroatom source for CDots having unique properties and surface functional groups even without the need for further passivation or modification, thereby making it an eco-friendly, biocompatible, and cost-effective raw material for CDots synthesis[2]. In this study we present a facile and effective one-pot hydrothermal method for converting artichoke (Cynara) leaves into two valuable products: a solid biochar adsorbent capable of efficiently removing a heavy metal ion: Cu^{II} from wastewater, and a liquid product of highly water-dispersible CDots with tunable fluorescence. These CDots display a high quantum yield (QY) of 42.44% and show exceptional fluorescence quenching properties towards Cu^{II}, demonstrating their potential as a sensing material for Cu^{II} with a remarkable limit of detection of 0.1 μmol L^{-1} (EPA maximum allowable concentration of Cu^{II} 0.2 μmol L^{-1}). The analytical results showed that the emission intensity varied linearly over a Cu^{II} concentration range from 5 to 50 μmol L^{-1} with a correlation coefficient of 0.9914. The solid form of CDots synthesized from artichoke leaves also exhibit adsorbent properties. In adsorption experiments, sorption capacity for Cu^{II} by these biochars 500 μmol/g from an aqueous medium in approximately 12 h. Thanks to all these features, eco-friendly CDots can adsorb Cu^{II} ions in aqueous environments in its solid form and can accurately determine Cu^{II} ions fluorometrically in liquid form.

Keywords: Cu^{II} detection, carbon dots, biochar adsorbent, eco-friendly.

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PP36- Determination of Copper at Trace Levels in Antartcic Soil Samples by Using Dispersive Solid Phase Extraction Method with Mn3Zn7Fe2O4 Nanoparticles

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Copper (Cu) is a heavy metal which is widely used in different industries including alloy manufacturing, construction, dental, cosmetics, etc. thus its role in human life is not negligible. In addition, it has been demonstrated that Cu is mainly released from Cu-containing ore mining, refinery facilities, fossil fuel processing, soil fertilizers. With taking into account of increasing population of the world and expanding industrial activities, the effects of Cu pollution on human health is getting important day by day1,2. Disrupting of Cu homeostasis of the body leads to liver, neuron and oxidative damage related disorders, thus monitoring copper component of the environment is crucial for public health2. In this presented work, a preconcentration method was applied to the antarctic soil samples to preconcentrate copper(II) ions. For this purpose; nano-sized, magnetic Mn3Zn7Fe2O4 particles were used as adsorbents which were synthesized by microwave-based synthesis. These nanomaterials were characterized by X-ray diffraction spectrometry (XRD), scanning electron microscopy (SEM) and fourier-transform infrared spectroscopy (FT-IR). Different parameters that affect the interaction between Cu(II) ions and nanoparticles were optimized by univariate approach. Determination of Cu(II) content in preconcentrated samples was carried out in the flame atomic absorption spectrophotometry. The results confirmed that under the optimum conditions, synthesized nanomaterial can be used as an adsorbent for copper determination at trace levels to obtain accurate and precise results. Additionally, the feasability of the developed method was examined in soil samples from Antarctica by spiked recovery experiments, which indicated the accuracy of the method even complex environmental matrices.

Keywords: Copper, Adsorption, Magnetic nanoparticles, Flame atomic absorption spectrophotometry

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PP37 Development of an Analytical Method for the Determination of Endocrine Disrupting Pollutants Using Zein@Fe_3O_4 Adsorbent

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Many endocrine-disrupting chemicals are widely used and produced industrially in various fields today. These endocrine disruptors, which are known as exogenous substances, effect the endocrine system[1,2]. Many analytical methods have been developed for the determination of endocrine-disrupting chemical substances. Polycyclic aromatic hydrocarbons, polychlorinated biphenyls, polybrominated diphenyl ethers, and pesticides are generally persistent organic pollutants found in the environment. This study aims to develop a solid-phase microextraction method (SPME) for the determination of trace amounts of organic pollutants using Gas Chromatography-Mass Spectrometry system. Magnetic nanoparticles coated with zein, a plant protein, were synthesized and used as adsorbents in solid-phase extraction methods. Subsequently, trace amounts of organic contaminants were determined using the GC-MS system. To increase extraction efficiency, in the SPME method, the parameters affecting the system (extraction solvent type/amount, stirring type/period) were optimized and the equipment conditions were determined. Under these defined optimum conditions, the analytical performance of the system, limit of detection (LOD), limit of quantitation (LOQ), and the linear dynamic range were examined. The applicability of this analytical method to environmental samples were determined through recovery studies.

Keywords: Gas Chromatography-Mass Spectrometry, Microextraction, Organic pollutant, Zein

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PP38- Turn-on fluorometric method for the determination of nitric oxide radical scavenging activity of antioxidants using functionalized gold nanoparticles

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Since the overproduction of nitric oxide radicals (NO•) leads to oxidative stress, precise determination of the NO• scavenging activities of antioxidants is of great importance for both human physiology and food technology [1,2]. In this study, a "turn-on" fluorometric method for measuring NO• scavenging activity was developed using gold nanoparticles modified with 4-hydroxythiophenol (AuNPs@4-HTP) and the NEDa fluorophore. NO radicals generated from sodium nitroprusside nitrosate the probe, quenching the NEDa fluorescence, whereas the addition of antioxidants scavenges the NO, thereby restoring the fluorescence intensity. Experiments were conducted under optimized laboratory conditions, including a 60 minute interaction time and an excitation wavelength of 330 nm. The developed method was successfully applied to phenolic, amine, and thiol-type antioxidants, with quercetin exhibiting the highest scavenging activity among the phenolics. The IC_{50} value, representing the concentration at which quercetin provides 50% inhibition, was determined to be 3.11 ± 1.26 μmol L^{-1}. This value indicates that quercetin possesses a significantly higher NO scavenging capacity compared to the other tested phenolic antioxidants (e.g., 4.65 ± 1.07 μmol L^{-1} for vanillic acid and 13.81 ± 1.96 μmol L^{-1} for ascorbic acid). In real food samples, the highest inhibition rate was observed in green tea, which is rich in catechin derivatives; meanwhile, the interference effects of Fe^{3+} and Cu^{2+} ions were successfully eliminated via EDTA chelation. The analyses yielded results with high sensitivity at μmol L^{-1} levels and demonstrated statistical consistency with the classical Griess method. Furthermore, the study revealed the presence of synergistic effects in binary antioxidant mixtures, whereas such effects were not observed in ternary mixtures.

This study presents a simple, selective, and sensitive "turn-on" fluorometric analytical alternative for NO monitoring in food samples and biological systems. The developed methodology provides a reliable measurement tool by overcoming the time and interference limitations associated with existing methods such as the Griess assay.

Keywords: Nitric oxide radical, Scavenging activty, Antioxidants, Turn-on fluorescence, Gold nanoparticles.

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PP39- Electrochemical Determination of Bisphenol A Utilizing ErGO-Chitosan Nanocomposite Sensing Platform

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Concerns regarding the potential adverse health effects of endocrine-disrupting chemicals (EDCs) are on the rise. Among these, Bisphenol A (BPA)—chemically identified as 2,2-bis(4-hydroxyphenyl) propane—serves as a primary precursor in the synthesis of polycarbonate (PC) and epoxy resins (EP). These materials are extensively utilized in the manufacturing of everyday items such as water bottles, linings for food cans, and plastic containers for food storage[1]. To prepare the ErGO (Electrochemical reduced graphene oxide)-Chitosan composite electrode, the chitosan solution was mixed with a certain volume GO (Graphene oxide) solution at a 1:1 volume ratio (v/v). Subsequently, the resulting mixture was drop-cast onto the electrode surface and allowed to dry at room temperature. For the electrochemical reduction step, the modified electrode was subjected to cyclic voltammetry in 0.1 M H_2SO_4 within the potential range of 0 to-1.3 V. The electrochemical measurements were carried out using Square Wave Voltammetry (SWV) with the modified electrode in a phosphate-buffered saline (PBS) solution at neutral pH. The anodic oxidation response was recorded within the potential range of -0.2 V to 1.0 V. The electrochemical determination of BPA using the GCE/ErGO-Chitosan modified electrode via SWV exhibited a well-defined characteristic oxidation peak at approximately 0.56 V. A linear relationship was established between the anodic peak current and BPA concentration in the range of 0.4-32 µmol L^{-1}, with a correlation coefficient (r) 0.998. Notably, no significant potential shift was recorded in the peak positions despite the concentration increase. Furthermore, the synergistic effect of the GO-Chitosan composite facilitated sharper peak signals, thereby enhancing the detection capabilities and widening the linear working range. In contrast to the poor adsorption observed on the bare GCE, the ErGO-Chitosan modification yielded remarkably stable and sharp oxidation peaks. By combining the high conductivity of reduced graphene oxide with the molecular recognition capacity of chitosan, this platform accelerated electron transfer, significantly enhancing both analytical sensitivity and linear working range.

Keywords: Bisphenol A, Sensor Electrode, Nanocomposite, SWV

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PP40- Development, Validation, and Machine Learning Based Stability Prediction of a novel Apt-MIP Sensor

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In this study, a novel Aptamer-Molecularly Imprinted Polymer (Apt-MIP) hybrid electrochemical sensor was developed for the ultrasensitive and selective determination of the organophosphate pesticide diazinon (DIA) in real environmental and food samples. Followed by the formation of a MIP layer through electropolymerization of *o*-phenylenediamine (*o*PD). This dual-recognition strategy combined the high binding specificity of the aptamer with the mechanical and chemical robustness of the MIP matrix, resulting in a synergistic enhancement in analytical performance. Electrochemical characterization using cyclic voltammetry, differential pulse voltammetry, and electrochemical impedance spectroscopy verified successful sensor fabrication and template removal. The Apt-MIP sensor displayed a wide linear detection range from 0.00328 to 0.164 nM with an exceptionally low limit of detection (LOD) of 0.001 nM, enabling reliable detection of DIA at ultra-trace levels. The fabricated Apt-MIP hybrid sensor exhibited excellent accuracy and precision in real sample analysis. In tap water, recovery values ranged from 98.51% to 99.70%. Similarly, in apple juice samples, recoveries were between 99.76% and 100.81, demonstrating the sensor's capability to operate reliably in complex matrices[1]. To further investigate sensor durability, a series of regression-based and machine learning approaches were applied to model the temporal stability of the sensor. Conventional linear regression proved insufficient due to the inherently nonlinear degradation behavior. Among nonlinear models, logarithmic and power regression provided the most physically meaningful descriptions of gradual signal loss over time. In contrast, higher-order polynomial and spline models exhibited overfitting, while exponential and weighted exponential models failed to adequately capture long-term performance decline. Gaussian Process Regression (GPR) successfully represented early-stage stability trends but overestimated degradation in later stages due to data sparsity. Support Vector Regression (SVR), although theoretically robust, was unable to accurately model long-term nonlinear stability decay, particularly under limited and irregular data conditions[2]. Overall, the results demonstrate that the proposed Apt-MIP hybrid sensor offers superior sensitivity, selectivity, reproducibility, and stability compared to single-recognition systems. The integration of aptamer biorecognition with MIP structural imprinting presents a powerful strategy for next-generation electrochemical sensing of pesticides in environmental and food safety monitoring.

Keywords: Apt-MIP Sensor, Electrochemistry, Machine Learning, Validation

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PP41- Photocatalytic Applications of Bismuth-Doped g-C_3N_4 in Tubular Form on Methylene Blue Dye

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Graphitic carbon nitride (g-C_3N_4) has been widely studied for dye removal due to its photocatalytic activity under visible light. The limited efficiency of pure g-C_3N_4 has been improved through bismuth doping and tube-shaped structure design, resulting in enhanced performance in methylene blue photocatalytic degradation.[1]

In this study, bismuth-doped tube-shaped g-C_3N_4 was synthesized and used for the photocatalytic degradation of methylene blue (MB) solution. Photocatalytic experiments were carried out using both UV and visible light photocatalytic reactors. The effect of different catalyst dosages on photocatalytic performance was investigated. The catalyst was added to the MB solution, and the reaction was carried out under UV irradiation. The degradation process was monitored at 30-minute intervals using a UV-Vis spectrophotometer, and degradation efficiencies were calculated.

In this study, the effects of different experimental parameters on methylene blue photocatalytic removal were systematically investigated. Based on the results obtained, the optimum catalyst amount that provides the highest degradation efficiency has been determined. Bismuth-doped g-C_3N_4 in tube form has been shown to be an effective catalyst for methylene blue removal.

Photocatalytic experiments were conducted using bismuth-doped tubular g-C_3N_4 for the reduction of methylene blue, and increasing the catalyst dosage significantly enhanced the degradation rate, although complete removal was not achieved. The highest photocatalytic performance was obtained under UV light, demonstrating the effective potential of bismuth-doped tubular g-C_3N_4 for dye removal.[2]

Keywords: Tubular g-C_3N_4; photocatalyst; dye; degradation; UV light.

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PP42- Catalytic Applicatıons of Metallic Graphene Oxide Composites

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Currently, the negative impacts of environmental pollutants, particularly pesticides and antibiotics, on water resources are increasing. The inability to completely remove these pollutants using traditional methods highlights the need for new and sustainable treatment technologies. In this context, graphene-based nanocomposites stand out among photocatalysts due to their environmentally friendly structures and high surface activities.[1] This study will investigate the effectiveness of composites synthesized by binding copper (Cu) ions onto graphene oxide (GO) and reduced graphene oxide (rGO) in the photocatalytic degradation of pesticide or antibiotic-containing pollutants under different light sources. The structural, chemical, and morphological properties of the composites will be characterized using methods such as UV-Vis, FTIR, SEM, and XRD. In photocatalytic experiments, parameters such as degradation efficiency, reaction time, pH, catalyst amount, and light effect will be optimized.[2] The findings are expected to show promising results for Cu-rGO composites in terms of high degradation efficiency, reusability, and environmental stability. This study aims to provide a scientific and applied contribution to the development of an environmentally friendly, low-cost, and effective photocatalytic water treatment technology.

Keywords: Graphene oxide, photocatalysis, pesticides, water treatment, Cu-rGO composite.

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PP43- Investigation of the Synthesis of g-C_3N_4 Based Nanocatalysts and Their Use in the Removal of Organic Pollutants via a Green Chemistry Approach

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Nanocatalysts have attracted attention due to their high surface-to-volume ratio and enhanced catalytic activity compared to conventional catalysts[1]. Recently, green chemistry approaches have been explored to synthesize g-C_3N_4-based nanocatalysts for environmental remediation[2].
In this study, g-C_3N_4 nanocatalysts were synthesized using plant extracts as natural reducing and stabilizing agents. Opuntia ficus-indica, rich in polyphenols and flavonoids, was selected as a bio-inducer for nanoparticle formation. The synthesis process aimed to replace toxic chemicals with renewable, eco-friendly precursors.
The green-synthesized g-C_3N_4 nanocatalysts exhibited improved surface properties and high reactivity in degrading persistent organic pollutants. Enhanced catalytic activity was observed in the removal of dyes, pharmaceuticals, and pesticides from aqueous media. The bio-assisted synthesis provided stable nanostructures with superior selectivity and energy efficiency. These findings highlight the potential of plant-derived nanocatalysts in sustainable water purification technologies[1,2].
Green synthesis of g-C_3N_4 nanocatalysts using Opuntia ficus-indica extracts offers an effective and eco-friendly approach for water treatment. This strategy contributes to the development of sustainable nanomaterials for environmental remediation.

Keywords: Nanocatalysts; g-C_3N_4; Green chemistry; Opuntia ficus-indica; Water purification

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PP44- Determination of TNT and Antioxidant Stabilizers in Military Explosives by Copper(II)-Neocuproin Based Spectrophotometric Method

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The ability to accurately and selectively analyze stabilizers/antioxidants such as diphenylamine and resorcinol in determining and maintaining the stability of active ingredients in military munitions plays a crucial role in extending the shelf life of munitions and improving their performance in the field. These antioxidant additives, used in conjunction with energetic materials, improve the processability and transportability of energetic materials, as well as increasing their long-term storage stability [1]. Trinitrotoluene (TNT), a nitroaromatic energetic material, is widely used in military ordnance due to its low sensitivity and high chemical stability. Despite these characteristics, it is important to investigate the quantitative changes of stabilizers such as diphenylamine (DFA) and resorcinol under long-term storage conditions. In this context, a selective spectrophotometric method based on copper(II)–neocuproin has been developed for the determination of TNT [2]. In addition, the presence and potential interactions of diphenylamine and resorcinol, used as preservatives to extend the shelf life of explosives, in TNT-containing systems were evaluated, and the roles of these compounds on the stability and long-term storage performance of ammunition were investigated. Under optimal conditions, linear calibration curves were obtained for TNT, DFA, and resorcinol in final concentration ranges of 0.5–15 mg L^{-1}, 1–6 mg L^{-1}, and 1–15 mg L^{-1}, respectively. The molar absorption coefficient for TNT was determined to be 1.74×10^4 L mol^{-1} cm^{-1}, and the limit of detection (LOD) was 2.3×10^{-2} mg L^{-1}. The additivity of absorbances of DFA and resorcinol, which may be present as protective agents along with TNT in ammunition compositions, was investigated at mixing ratios of 1:1, 1:2, and 1:5. Furthermore, in binary mixture analyses performed with household detergent, aspartame, and glucose at ratios of 1:1, 1:10, and 1:50 (mass/mass), which could be used to camouflage the presence of TNT, it was shown that these substances did not constitute a significant interference with the developed method, and TNT could be successfully determined with high recoveries ranging from 92% to 111%.

Keywords: Antioxidant stabilizers, TNT, Diphenylamine and resorcinol, CUPRAC spectrophotometric determination,

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PP45- Development of a Novel Molecularly Imprinted Poly(melamine)/Chitosan Graft Copolymer Sensor for the Determination of 2,4,6-Trinitrotoluene (TNT)

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Over the past century, millions of tons of nitroaromatic explosive compounds have been produced for military applications, and their use or accidental release has led to contamination of soils and groundwater. Among these materials, 2,4,6-trinitrotoluene (TNT), the most widely used explosive in military operations, can be employed either alone or as a component of mixtures such as Composite B (39% TNT, 60% RDX) and Octol (30% TNT, 70% HMX). In this study, a novel molecularly imprinted polymer (MIP)-based electrode incorporating melamine and chitosan (CS) materials was developed to enable the rapid, sensitive, and selective detection of TNT for public safety and environmental monitoring purposes. The sensor was fabricated on a glassy carbon electrode (GCE) via electropolymerization of a melamine–chitosan mixture in the presence of TNT as the template molecule, using cyclic voltammetry (CV). The removal of TNT from the polymer matrix generated specific recognition cavities, providing high selectivity toward the target analyte. The surface morphology and electrochemical properties of the prepared sensor electrode were characterized by FTIR, XPS, EIS, and CV techniques. TNT measurements were performed in pH 10 phosphate buffer using differential pulse voltammetry (DPV). The developed MIP sensor exhibited a linear response toward TNT in the concentration range of 40–500 μg L^{-1}, with a limit of detection (LOD) of 25 μg L^{-1}. The sensor demonstrated excellent anti-interference performance in the presence of structurally similar energetic compounds (RDX, HMX, tetryl, TNP, and TNB) as well as common soil ions. This high selectivity was attributed to CH_3–π interactions and hydrogen bonding between TNT and poly(melamine). In the analysis of real explosive samples, namely Composite B and Octol, recovery values of 97.8% and 100.8% were obtained, respectively. Moreover, TNT was successfully determined in the presence of various energetic substances, electroactive camouflage agents, phenolic compounds, and soil ions, yielding recovery values ranging from 91.9% to 102.5%. Finally, the proposed DPV method was statistically validated against the standard LC–MS/MS method reported in the literature using t- and F-tests, and no significant difference was observed between the results. Owing to its stability, reliability, and low cost, this MIP sensor offers considerable potential for the determination of TNT in complex environmental matrices and military explosive mixtures [1].

Keywords: 2,4,6-Trinitrotoluene; Molecularly Imprinted Electrode; Sensor Electrode; Chitosan; Melamine

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PP46- Determination of Aroma Compounds in Sunflower and Olive Oils by HS-GC-MS

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Aroma compounds consist of different chemical classes such as aldehydes, alcohols, ketones and acids and play an important role in determining the odour and taste profile of food. Aldehydes, in particular, are formed as a result of fat and lipid oxidation and are associated with characteristic flavours such as oily, green, fresh and citrus-like (1-2).

In the study, Agilent model 8890 GC with 7697A headspace unit and 5977C MSD ion source and 7693A autosampler were used. In the headspace programme used for the determination of aromatic compounds, the temperature settings were set as oven temperature 80 °C, loop temperature 90 °C and transfer line temperature 100 °C. The oven programme was initially kept at 40 °C for 8 minutes, then increased to 230 °C at 8 °C/min and kept at this temperature for 5 minutes. The total chromatogram time was 51 min.

The DB-WAX Ultra Inert column is a capillary GC column that provides high inertness and reproducibility, especially developed for the analysis of polar compounds, and is widely preferred in food, flavour, oil and volatile compound analyses. For these reasons, DB-WAX Ultra Inert column (60 m × 250 µm × 0.25 µm) was used as a column for the analysis of sunflower oil and olive oil samples by HS-GC-MS. In the direct analysis study, 3-5 flavour compounds were identified in sunflower oil from different locations, while more than 20 flavour compounds were identified in olive oil. In sunflower oil, 1,4,7,10,10,13,13,16-Hexaoxacyclooctadecane compound (13.7-97.3%) was predominant.

As a result of this study, it was revealed that the flavour profiles of sunflower oil and olive oil samples differed significantly by HS-GC-MS method, richer and more diverse flavour compounds were detected in olive oil, while 1,4,7,7,10,10,10,10,13,13,13,16-Hexaoxacyclooctadecane was dominant as the main compound in sunflower oil.

Keywords: HS-GC-MS, Sunflower oil, olive oil, aroma compouns.

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PP47- CUPRAC-Functionalized Nafion Membrane Biosensors for Sensitive Colorimetric Detection of Glucose and Cholesterol

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Abstract: A colorimetric optical biosensor detects specific analytes through a visual color change. The CUPRAC (Cupric Ion Reducing Antioxidant Capacity) reagent is a well-established chromogenic agent that induces a measurable color change in the presence of reducing agents or antioxidants [1,2]. Nafion (Nf), a sulfonated tetrafluoroethylene-based fluoropolymer-copolymer, is frequently employed as a membrane material in biosensors due to its high ionic conductivity and chemical stability [3]. In this study, colorimetric optical biosensors were developed using CUPRAC reagent-modified Nf membranes. These membranes were combined with two oxidase enzymes, glucose oxidase (GOx) and cholesterol oxidase (COx). Both enzymes catalyze reactions between molecular oxygen (O_2) and their respective substrates, producing hydrogen peroxide (H_2O_2). Consequently, non-reducing substrates such as glucose were detected indirectly *via* the CUPRAC-reactive product (H_2O_2) generated during the enzymatic reaction. The absorbance of the yellow–orange $[Cu(Nc)_2]^{2+}$ complex formed during the colorimetric reaction on the Nf membrane surface was measured at 450 nm. In this system, the enzymes were immobilized onto silanized magnetic nanoparticles (SiO_2@Fe_3O_4), where the enzymatic reaction occurred in the presence of the target substrates. The resulting H_2O_2 participated in the CUPRAC reaction on the Nf membrane, and the colorimetric response correlated with analyte concentration. Analytical performance was evaluated by optimizing experimental parameters to determine the optimal working conditions for both enzymes. The optical biosensors incorporating GOx and COx demonstrated a linear detection range of 5–200 µM, with limits of detection (LOD) of 1.57 µM for GOx and 1.35 µM for COx. The selectivity of the proposed optical biosensor was assessed in the presence of potential interfering species, including several monosaccharides, ascorbic acid, uric acid, and dopamine. Finally, the developed optical sensor was successfully applied to the analysis of real samples.

Keywords: *CUPRAC reagent, colorimetric biosensor, magnetic nanoparticle, nafion membrane*

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PP48- Electrochemical Determination of Hydroxychloroquine Using a Modified Pencil Graphite Electrode (Alizarin Red-S)

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Hydroxychloroquine, a drug commonly used in the treatment of COVID-19, malaria, and various chronic diseases, is produced by introducing a hydroxyl group to the chloroquine molecule [1-2]. Compared to chloroquine, hydroxychloroquine is more polar, less lipophilic, more soluble in water, and diffuses more slowly through cell membranes [2]. Because improper dosing can lead to serious toxic effects, the precise detection and monitoring of hydroxychloroquine during treatment is essential. Therefore, developing sensitive and reliable electrochemical detection methods is of great importance. In this study, we aimed to achieve selective and highly sensitive determination of hydroxychloroquine using a pencil graphite electrode (PGE), which is inexpensive, readily available, disposable, and demonstrates high electrochemical activity. The PGE surface was modified by electropolymerization with Alizarin Red-S solution, resulting in a polyALR/PGE electrode. The electrochemical behaviors of both bare PGE and polyALR/PGE were examined in the absence and presence of hydroxychloroquine (100 µM) within Britton–Robinson buffer solutions containing 0.1 M KCl at pH values ranging from 2 to 11. The optimal electrochemical response was observed at pH 10. Method optimization was performed using linear sweep voltammetry (LSV), with measurements conducted in the potential range of 0–1200 mV and a scan rate of 100 mV s^{-1}. Calibration curves revealed two linear ranges: 1–10 µM and 30–450 µM. The limit of detection (LOD) and limit of quantification (LOQ) were calculated to be 0.32 µM and 1.06 µM, respectively. Selectivity studies indicated that potential interfering species, including dopamine, uric acid, glucose, ascorbic acid, KCl, NaCl, $NiCl_2$, $CaCl_2$, $MgCl_2$, $CuCl_2$, $ZnCl_2$, and $Pb(NO_3)_2$, did not significantly affect the determination of hydroxychloroquine. Finally, analysis of pharmaceutical tablet samples yielded a relative standard deviation (RSD) of 2.9%, demonstrating the reliability and practical applicability of the developed method.

Keywords: Hydroxychloroquine, pencil graphite electrode, linear sweep voltammetry, electrochemical sensor

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