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7th INTERNATIONAL ENVIRONMENTAL CHEMISTRY CONGRESS

18 - 20 December, 2025 Istanbul / TÜRKIYE

PROCEEDINGS E-BOOK

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Abacı Kimya Su | Çevre | Proses Kimyasalları & Teknolojileri

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Proceedings Book

Editors

Bülent Keskinler

Ahmet Karagündüz

Çiğdem Balçık

Bahar Özbey Ünal

ISBN: 978-625-94974-5-7

18-20 December 2025

İstanbul- Türkiye

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PREFACE

Environmental chemistry remains essential for understanding how chemical substances affect natural systems, especially as issues like climate change, pollution, emerging contaminants, and ecosystem degradation intensify. The field now extends beyond traditional pollutant analysis to include innovative materials, energy technologies, and sustainable solutions that support future environmental policies and practices.

The EnviroChem Conference series, organized by the **Turkish Chemists Society** and supported by an expanding international scientific community, has become a significant platform for sharing advances in environmental chemistry and related interdisciplinary fields. Bringing together chemists, biologists, ecologists, engineers, geoscientists, and environmental practitioners, the congress aims to foster collaborations that can translate scientific knowledge into effective environmental strategies.

The **7th EnviroChem Conference**, held in İstanbul, Türkiye, continued this mission by providing a dynamic environment for scientific exchange and professional networking. Researchers from numerous countries and diverse institutions contributed oral presentations, posters, and invited lectures that reflected the growing breadth of environmental chemistry research—from analytical techniques and atmospheric processes to water treatment technologies, resource recovery, and next-generation contaminants. The increasing interest from industry R&D teams further highlighted the congress's role as a bridge between academic research and practical applications.

We extend our sincere appreciation to the members of the scientific and organizing committees for their dedication, as well as to our invited speakers for enriching the program with their expertise. We also gratefully acknowledge the support of our sponsors and institutional partners, whose contributions made this event possible. Finally, we thank all participating scientists for their valuable contributions and for helping strengthen the EnviroChem community.

It is our hope that the studies presented in this conference book will inspire new ideas, enhance interdisciplinary collaboration, and contribute to the development of sustainable, science-based solutions for protecting our environment. We look forward to meeting you again at future EnviroChem events.

Sincerely yours,

Prof. Bulent Keskinler	**Prof. Ahmet Karagündüz**
Chair of EnviroCHEM 2025	Chair of EnviroCHEM 2025

PLEANARY SPEAKERS

Soner Olgun

Ministry of Environment, Urbanization and Climate Change, Head of Laboratory, Measurement and Monitoring Department

“Environmental Analysis and Monitoring”

Prof. Eftade Gaga

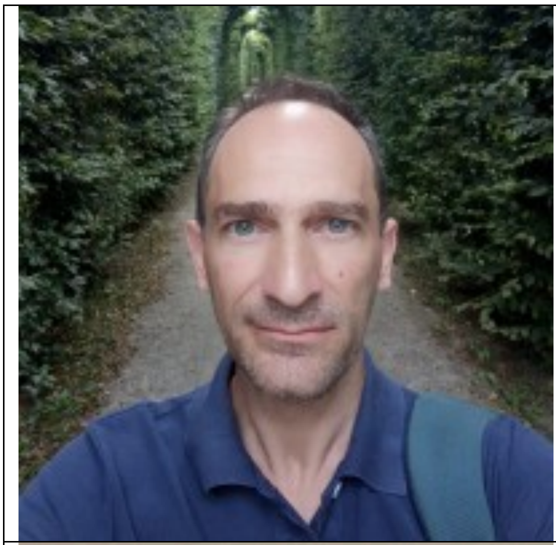
Eskisehir Technical University

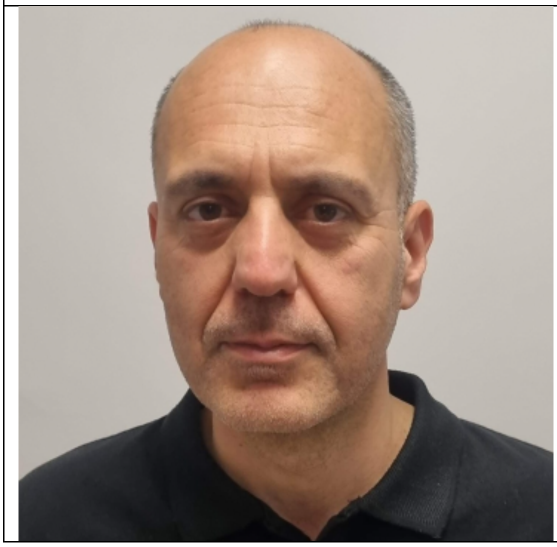
“Air Pollution as a Toxic Cocktail: Emerging Contaminants and Human Health Challenges”

Prof. İpek İmamoğlu

Middle East Technical University

“Complex Interactions of Organic Compounds with Microplastics”

	**Prof. Dimitrios Kalderis** *Hellenic Mediterranean University* *“The impact of war on the environment: managing soil contaminated with explosives”*
	**Assist Prof. H. Enis Karahan** *İstanbul Technical University* *“Innovative Strategies in Thermal Processes and CO2 Utilization Toward Sustainable Fuels and Chemicals”*
	**Prof. Tanju Karanfil** *Clemson University* *“Microwave Regeneration of PFAS laden Granular Activated Carbons”*

	**Prof. Arif Kıvrak** *Eskişehir Osmangazi University* *“Talk Title: Organic Catalysts for Next-Generation Fuel Cells: Towards Green and Efficient Energy Conversion”*
	**Prof. Turgay Pekdemir** *Abant İzzet Baysal University* **“***Carbon Capture and Utilization towards Waste to Resource for Sustainable Future through Circular Economy principles: Chemistry, Challenges, and Opportunities”*
	**Prof. Erkan Şahinkaya** *Marmara University* *“Global and National Perspectives on Chemical Management”*

ORAL PRESANTATIONS

Characterization of Thermoplastic Starch-Based Biopolymer/Acrylonitrile Butadiene Styrene (ABS) Blends Obtained from Bread and Pasta Waste for Edge Banding Applications

Barış Öner

E-Mail : baris.oner@egger.com

In recent years, there has been a significant global increase in the consumption of plastic materials, and in parallel, the production of plastic waste has increased. These wastes remain in nature for many years without decay and cause environmental pollution. In recent years, the use of biodegradable polymers has accelerated to solve this problem. In addition to polymers that can be degraded by 100% in nature, there are also types that can be mixed with conventional petroleum-based polymers. Thus, the use of biopolymers to further reduce the negative environmental impacts caused by plastics and therefore reduce the associated carbon footprints is becoming increasingly important.

This study aims to obtain thermoplastic starch-based biopolymer/acrylonitrile butadiene styrene (ABS) raw materials obtained using bread and pasta waste that can be used as an alternative to edge band materials, especially environmentally friendly raw materials used in edgeband manufacturing processes in the furniture sector. To achieve this, acrylonitrile butadiene styrene (ABS), thermoplastic starch (TPS) from bread waste, and two different compatibilizers were used. The compatibilizers were maleic anhydride grafted ABS (ABS.g.MAH) and glycidyl methacrylate grafted ABS (GMA.g.MAH). All of these compatibilizers contain a high proportion of maleic anhydride (1%). Using a double-screw extruder on a laboratory scale with these selected raw materials, ABS/TPS mixtures were produced with different formulations. The ABS/TPS blends produced were characterized by mechanical, thermal and environmental analyses to assess their properties.

It has been determined that the tensile strength values are increased by the addition of high levels of maleic anhydride grafted polymer-based compatibilizers. Similarly, elongation has been found to increase with the addition of compatibilizers, especially at impact values, which is an important parameter in edge band applications.

Characterization of Atmospheric Microplastics in Deposition Samples Using Micro-FTIR Spectroscopy: Are We Looking From Right Perspective?

Mine SAĞDIÇ ULUSOY[a*], Gönenç OZARLI[a,], Eftade O. GAGA[a]

[a]*Eskişehir Technical University, Faculty of Engineering, Department of Environmental Engineering, 26555, Eskişehir, Türkiye*

E-Mail : hmsagdic@eskisehir.edu.tr

Atmospheric microplastics (AMPs) represent an emerging environmental pollutant, with mounting evidence of their presence in urban, rural and remote areas. Additives and adsorbed pollutants (e.g., POPs, heavy metals) within microplastics (MPs), from production to degradation, further increase their risks to human and environmental health. In this study, deposition samples collected from different areas in Eskişehir Province, Turkey, were filtered from Whatman GF/C glass fiber without any prior treatment. The filters were analyzed using Fourier Transform Infrared Spectroscopy (FTIR, Shimadzu, IR Tracer TM-100) attached to an Automated Infrared Microscope (AIM-8800) with 128 scan numbers and 8 cm^{-1} resolution. The analyses have thus far identified approximately 18% of the particles as polymer, with 5% identified as polymer additives. A common additive in the samples is IRGANOX, which is used as a stabilizer for polyolefins, elastomers, and other polymers, as well as in synthetic motor oil lubricants. Furthermore, the samples were found to contain notable quantities (%22) of additional types of additives and pesticides, which may be present directly in the atmosphere or may act as vectors for contaminants carried by MPs. In light of the potential impact of these pollutants on the spectroscopic analysis of MPs, this study aimed to offer a novel perspective on micro-FTIR analyses of AMPs and MP-related pollutants in atmospheric deposition samples. The process of analyzing the samples and examining the data is ongoing in order to eliminate any remaining uncertainty in the study and to provide a more comprehensive data set.

Keywords: *AMPs, Deposition, Spectroscopic Analysis, Additives*

Assessment of Tire-Derived Microplastics in Eskişehir Urban Road Dust via FTIR-ATR Spectroscopy

Meryem AKSU[1,2], Mine SAĞDIÇ ULUSOY[1], Eftade O. GAGA[1]

1.Eskişehir Technical University, Environmental Engineering Department
2.Sakarya University, Environmental Engineering Department

E-Mail : meryemm@sakarya.edu.tr

Microplastics (MPs) and tire and road wear particles (TRWPs) are among the most widespread and persistent pollutants in the environment, representing a major component of microplastic contamination in terrestrial ecosystems. TRWPs are complex materials generated by friction between vehicle tires and road surfaces, consisting of rubber-based polymers, fillers (e.g., silica, carbon black), and road-derived mineral components.

In this study, road dust samples collected from ten representative locations in the city center of Eskişehir (Türkiye) were analyzed for the presence of macro/microplastics and TRWPs. The samples were sieved into >4 mm, >2.8–4 mm, and >2–2.8 mm fractions and cleaned in an ultrasonic bath for 15 minutes to remove surface contaminants. A total of 100 randomly selected suspected plastic particles were chemically characterized using FTIR-ATR (Shimadzu IR Tracer TM-100, AIM-8800, 30 scans, 4 cm^{-1} resolution).

The highest concentration (0.27 plastic g^{-1}) was observed at TY23, followed by TY15 (0.17 TWRP g^{-1}; 0.20 MP g^{-1}). Both sampling sites are located near industrial areas and showed elevated levels of traffic-related wear particles. The lowest concentrations (0.013–0.033 TWRP g^{-1}) were found at TY5, situated in a densely populated residential area with heavy traffic.

FTIR analyses revealed that the complex chemical composition of TRWPs complicates direct identification. Some particles were identified as styrene–butadiene (SBR) and butadiene rubber (BR), while others exhibited dominant signals of $CaCO_3$, SiO_2, cellulose, PVDF, PVFM, and talc. Additionally, several black suspected TWRPs showed absorption bands of polyoxymethylene (POM), suggesting contributions from vehicle component-derived polymers in urban road dust.

Keywords: *Tire and Road Wear Particles (TRWPs); Microplastics; Road Dust; FTIR-ATR; Additives*

Solar-Driven Photodegradation of Pharmaceutical and Dye Pollutants Using a Chromium-Based MOF Photocatalyst

Elif Özcan

Department of Chemistry, Gebze Technical University, Kocaeli, Turkey

E-Mail : e.ozcan@gtu.edu.tr

The rapid rise in water contamination caused by synthetic dyes and pharmaceutical pollutants has become an urgent environmental concern. Photocatalysis, an environmentally friendly process that uses solar energy to degrade harmful pollutants, is one of the most sustainable methods for water purification, and developing more effective photocatalysts is crucial for advancing this technology.[1] Metal-organic frameworks (MOFs) have gained significant attention due to their large surface area, adjustable porosity, and chemical stability, making them promising materials for photocatalysis. Among them, MIL-100-Cr, a chromium-based MOF, stands out due to its exceptional stability and efficient light-harvesting capabilities, making it ideal for solar-driven photocatalytic applications.[2] This study investigates the solar-assisted photocatalytic degradation of metronidazole, an antibiotic, and Allura Red, a synthetic dye, using MIL-100-Cr as the photocatalyst. MIL-100-Cr was synthesized using a hydrothermal method and characterized through X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy (FTIR) to confirm its crystalline structure and chemical stability. The photocatalytic activity of MIL-100-Cr was tested under simulated solar light using aqueous solutions of metronidazole and Allura Red. The degradation process was monitored by UV-Vis spectrophotometry, revealing that both pollutants were degraded efficiently. Key operational parameters, such as catalyst dosage, pH, and initial pollutant concentration, were also investigated to optimize the photocatalytic performance. After testing the reusability and stability of MIL-100-Cr over several photocatalytic cycles, the material showed almost no loss of efficiency, indicating its potential for long-term use. Further investigation into the photocatalytic mechanism confirmed that hydroxyl radicals ($^{\bullet}OH$) played crucial roles in the degradation process. The results demonstrate that MIL-100-Cr is an excellent photocatalyst for the solar-driven degradation of pharmaceutical and dye pollutants, offering a sustainable solution for water purification and environmental protection.

Keywords: *Photocatalysis, Metal-organic frameworks (MOF), MIL-100-Cr, Water purification, Solar degradation.*

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Evaluation of pH Neutralization for the Treatment of Acid Mine Lake Waters in the Çan Mining Area

Ali ÜLKER [1], Tanya AKTAŞ ÜLKER [2], Seren KASAP[3], Prof. Dr.Hasan Göksel ÖZDİLEK[4]

[1,2] ENV Enerji, Çevre Yönetimi ve Teknolojileri, Çanakkale, Türkiye

[3] Gemar Çevre Ölçüm ve Analiz Laboratuvarı, Çanakkale, Türkiye

[4] Çanakkale Onsekiz Mart Üniversitesi, Mühendislik Fakültesi, Çevre Mühendisliği

E-mail: ali.ulker@env.com.tr

Acid mine drainage (AMD), which commonly develops in coal mining areas rich in sulfur minerals, represents a significant environmental problem affecting surface and groundwater quality. This study aims to evaluate the treatment performance of pH neutralization applied to acidic mine lake waters within a mining area located in the Çan district of Çanakkale Province, Türkiye. A NaOH-based chemical neutralization method was employed, integrating coagulation, flocculation, and sludge management processes, and the variations in the physicochemical properties of the water were examined.

Post-treatment analyses indicated a notable increase in pH values, an improvement in the Water Quality Index (WQI), and a reduction in dissolved metal concentrations, particularly manganese. Positive changes were also observed in dissolved oxygen, biochemical oxygen demand (BOD), and total Kjeldahl nitrogen (TKN) parameters. The findings demonstrate that chemical neutralization is an effective approach for treating acidic mine waters and provide a scientific basis for sustainable water management and environmental rehabilitation practices in mining areas.

Keywords: *acid mine drainage, pH neutralization, water quality, chemical treatment, sustainable mining, environmental rehabilitation, Çanakkale*

Air Quality Assessment of Çan Urban Area: Monitoring of SO_2 and PM_{10} within the Scope of HAKİP

Tanya AKTAŞ ÜLKER[1*], Ali ÜLKER[2], Seren KASAP[3]

[1,2] ENV Enerji, Çevre Yönetimi ve Teknolojileri, Çanakkale, Türkiye

[3] Gemar Çevre Ölçüm ve Analiz Laboratuvarı, Çanakkale, Türkiye

E-mail: tanya.aktas@gemar-jma.com.tr

Urban development, rising energy consumption, and industrial growth have emerged as major factors influencing air quality in small urban areas. The district of Çan is among the regions most sensitive to air pollution due to its topographic structure, population density, and the types of fuels used for heating. Within this context, the Air Quality Monitoring and Assessment Project (HAKİP) aimed to determine the current air quality in the Çan urban area, evaluate pollutant sources, and develop strategies to mitigate air pollution. SO_2 and NO_2/SO_2 diffusion tubes were installed at selected stations, and PM_{10} measurements were conducted. The locations of these stations were chosen considering the area's topography, residential density, and heating fuel characteristics.

The analysis results revealed that air pollution in Çan is largely (approximately 90%) caused by residential heating. During winter months, SO_2 and PM_{10} concentrations were found to reach or exceed the limit values specified in the Regulation on Air Quality Assessment and Management. The basin-shaped topography of the district, low wind speeds, inefficient combustion systems, and the use of low-quality coal were identified as the main factors contributing to pollutant accumulation in the atmosphere. Based on these findings, it is recommended to improve fuel quality, apply efficient combustion techniques, encourage the use of alternative fuels, and integrate meteorological data into air quality management. This study provides a scientific basis for understanding the current air quality in Çan and supports the development of regional environmental policies.

Keywords: *Air quality, particulate matter (PM_{10}), sulfur dioxide (SO_2), heating-related pollution, environmental impact, Çan urban area.*

Determination of Methiocarb Using an Acetylcholinesterase Biosensor

Ezgi Adak[a, b], Halit Arslan[a]

[a] *Department of Chemistry, Faculty of Science, Gazi University, 06500, Ankara, Turkiye*

[b] *Gazi University Graduate School of Natural and Applied Science, 06500, Ankara, Turkiye*

E-Mail : ezgiadak@gazi.edu.tr

Methiocarb is a carbamate pesticide widely employed in agricultural and environmental applications as an insecticide and acaricide.[1] However, its uncontrolled and intensive utilization in agricultural applications poses considerable risks to human health. It inhibits acetylcholinesterase, disrupting neural transmission and exerting neurotoxic effects on insects, mites, and mollusks.[2] Its LD_{50} value for mammals via oral exposure indicates that it is highly toxic. Therefore, the sensitive and accurate detection of methiocarb residues at trace levels is essential for safeguarding public health and ensuring environmental protection. In this study, methiocarb was electrochemically determined using a biosensor constructed with acetylcholinesterase enzyme. The fabricated biosensor was subsequently utilized for trace-level detection of the pesticide methiocarb via square wave voltammetry. Using this approach, the recovery rates of methiocarb in cucumber samples were determined. The analytical results indicated a relative error of 2.88% and a relative standard deviation (RSD) of 0.46%, demonstrating the method's reliability and precision.

Acknowledgements:

We are grateful to Gazi University Scientific Research Projects Coordination Unit (Project number: FDK-2022-7739) for providing financial support.

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The Rise of Biopesticides in Sustainable Agriculture: Current Status and Future Perspectives

İlknur Çolak, Selver Papakçı, Eylem Funda Göktaş

Agricultural Pesticide Control Laboratory, Istanbul Provincial Directorate of Agriculture and Forestry, İstanbul, Türkiye

E-Mail : ilknur.colak@tarimorman.gov.tr

The use of pesticides in agricultural pest control leads to the depletion of natural resources, the pollution of water sources, and environmental crises, thereby disrupting the natural balance. In recent years, the use of biopesticides has come to the fore to overcome these disadvantages. Biopesticides are products that are becoming increasingly popular due to their high decomposition rates, minimization of health problems, and natural and environmentally friendly origins. In line with the growing interest in biopesticides, the number of research studies focusing on enhancing and reinforcing biopesticide formulations, including the application of nanotechnology, has surged by over 70% in recent years (1). As biopesticides, leaf extracts, emulsions, nanoemulsions, encapsulation, nanoparticles, suspensions, aqueous suspensions, biomass extracts, syringe application, ethanolic extracts, methanolic extracts, oral infection, aqueous extracts, organic solvent extracts, and aqueous extract formulations can be listed. Regulators (International Organization for Biological Control (IOBC), the Organization for Economic Cooperation and Development (OECD), or the Food and Agriculture Organization (FAO)) assess the safety of microbial strains, identify potential risks to non-target organisms, and evaluate environmental impacts as well as the potential for bioaccumulation and long-term environmental contamination (2). Therefore, producers of biopesticides must conduct comprehensive studies to demonstrate the reliability of their products. Highlighting the environmental advantages of microbial biopesticides, such as reduced toxicity, improved biodegradability, and lower risk of ecosystem disruption, can position them as superior alternatives to traditional chemical pesticides. The coordination of biopesticides with integrated pest management (IPM) and organic farming practices is one of the advantages of using them in sustainable agriculture (3). Alongside all these advantages, the degradation of biomass or bioactive metabolites due to factors such as air, light, and temperature is also a disadvantage for biopesticides. To overcome these disadvantages, it is anticipated that the future use of biopesticides, aided by advances in nanotechnology research, could play a key role in protecting green agriculture against pests. Looking ahead, more research should be conducted on the production and use of biopesticides, which are promising for green agriculture, under the guidance of rules established by policies and legal frameworks, to increase environmental compatibility and technological developments. In this study, the current status and future perspectives of biopesticides in agricultural pest control was evaluated.

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Removal of Phenolic Derivatives from Water System Using ZnO Nanoparticles

Yasemin Torlak[1*], Elif Esra Altuner[2]

[1]*Department of Plant and Animal Production, Cal Vocational School of Cal, University of Pamukkale, Denizli, Türkiye

[2]Program of Medical Laboratory Techniques, Department of Medical Services and Techniques, Vocational School of Europe, University of Kocaeli Health and Technology , Kocaeli, Türkiye

E-Mail : yasemin_topal_88@hotmail.com[1*]

Environmental pollution is one of the most challenging problems facing society globally. Human activities and the increasing use of various beneficial chemicals accidentally introduced into the environment are among the most significant contributors to environmental pollution problems[1,2]. For example, among these chemicals, the most common are derivatives of triclosan and related phenolic compounds. Phenol compounds are among the most common organic pollutants, which contribute to water pollution and can cause significant problems if present in domestic water supplies[3,4]. Traditional methods for removing phenol from industrial wastewater include extraction, adsorption onto activated carbon, steam distillation, bacterial, and chemical techniques[5]. Most of these methods suffer from high costs, incomplete treatment, the formation of hazardous byproducts, or low efficiency, particularly when the pollutant is present in dilute concentrations. This study aims to investigate the phenol removal efficiency of ZnO (zinc oxide) nanoparticles (NPs), a model organic pollutant, from water containing trace amounts of phenol and to investigate the effect of phenol dosage on the pollutant removal efficiency. To achieve this goal, ZnO NPs were synthesized using a low-temperature chemical growth method, and a laboratory-based experimental model was designed in which the compound was exposed to phenol for two hours. After the process was completed, phenol concentrations were measured, and the ZnO degradation efficiency was calculated to determine the rate of water pollution removal. The synthesized ZnO NPs were examined using XRD and SEM characterization techniques. They demonstrated high efficiency in photocatalytically degrading phenol and removing it from water systems.

Keywords: *Phenol; zinc Oxide; water contamination; photocatalytica; degradation efficiency.*

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Tailoring Acrylonitrile Fabrics with Ni-MOF-74 for Advanced Carbon Dioxide Adsorption

Yaşar Kemal Recepoğlu, Hande Gürsel and Fehime Çakıcıoğlu-Özkan

Izmir Institute of Technology, Department of Chemical Engineering, Gülbahçe, 35430, Urla, İzmir, TÜRKİYE

E-Mail : yasarrecepoglu@iyte.edu.tr

The increasing concentration of CO_2 in Earth's atmosphere requires the urgent need for effective mitigation strategies, driving joint efforts between industry and the scientific community. Among these, carbon capture, utilization, and storage (CCUS) technologies stand out as vital components in the global response to climate change. As CO_2 adsorption serves as the cornerstone of CCUS, the development of high-performance adsorbent materials and their integration into practical systems have become critical research priorities. In this study, nickel-based metal–organic framework (Ni-MOF-74), recognized as one of the most promising candidates for next-generation CO_2 capture, was synthesized, characterized, and evaluated for its adsorption performance. The synthesized Ni-MOF-74 exhibited a surface area of 180 m^2/g and a CO_2 uptake capacity of 44.31 cm^3/g STP. To enhance its applicability, Ni-MOF-74 was immobilized onto an acrylonitrile fabric via the drip-casting method, yielding a flexible and robust composite structure. Remarkably, the composite retained 92% of the adsorption capacity of the pure Ni-MOF-74 powder, demonstrating only an 8% reduction while gaining substantial structural versatility. This outcome proves the potential of Ni-MOF-74-functionalized fabrics as adaptable and efficient platforms for practical CO_2 capture applications.

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Ultrasonic enhanced treatment of water containing organo-sulfurs in the presence of ternary boron-based MAX phase

Zahra Movaffagh,[a] Alireza Khataee,[b]

[a] *Nano Science and Nano Engineering Department, Istanbul Technical University, 34469 Istanbul, Türkiye*

[b] *Department of Chemical Engineering, Istanbul Technical University, 34469 Istanbul, Türkiye*

E-Mail : Movaffagh25@itu.edu.tr, Khataee@itu.edu.tr

Organo-sulfur compounds, which are extensively used in the rubber industry as vulcanization accelerators and stabilizers, have emerged as a class of persistent and toxic contaminants in aquatic environments and are also employed as corrosion inhibitors, lubricants, fuel additives, and intermediates in pesticide and pharmaceutical production. Their poor biodegradability, strong resistance to conventional biological treatments, and potential carcinogenic and mutagenic effects make them particularly hazardous to ecosystems and human health.[1] Developing effective and sustainable removal strategies for these pollutants has become an urgent environmental priority. Advanced Oxidation Processes (AOPs) are powerful water and wastewater treatment technologies capable of degrading recalcitrant organic pollutants into less harmful compounds through the in-situ generation of highly reactive oxygen species.[2] Among these, ultrasonic enhanced processes, which rely on acoustically induced cavitation to generate highly reactive radicals, have gained attention for their operational simplicity and efficiency.[3] To further enhance the efficiency of sonochemical processes, introducing suitable catalysts provides additional active sites for radical generation and electron transfer, accelerating the degradation rate and improving treatment efficiency.

Here, we introduce a ternary Iron-Aluminium boron-based MAX phase as a highly effective catalyst for ultrasonic-enhanced water treatment containing organo-sulfur contaminants. Various techniques have been used to characterize the ternary FeAlB MAX phase. X-ray diffraction (XRD) confirmed the formation of the catalyst crystal structure without detectable impurities, while scanning electron microscopy (SEM) revealed an aggregated plate-like morphology. Complementary analyses, including Raman, Fourier transform infrared spectroscopy (FTIR), and X-ray photoelectron spectroscopy (XPS), further verified its molecular vibrations, surface functionalities, and chemical states. The layered catalyst exhibited a pronounced synergistic effect in the sonocatalytic degradation of benzoxazol-2-thiol, a model organo-sulfur compound, with the integrated process delivering a remarkably higher efficiency than either ultrasonication or catalysis alone. The layered catalyst particles function as nucleation sites for acoustic cavitation, intensifying bubble collapse and the subsequent generation of hydroxyl radicals. This mechanism yielded a degradation efficiency of

99.33% within 60 min under optimized conditions of the catalyst (0.1 g L^{-1}), benzoxazol-2-thiol (10 mg L^{-1}), ultrasonic power of 150 W, and pH of 6. Radical scavenger tests revealed that Na_2CO_3 strongly inhibited benzoxazol-2-thiol removal, confirming the key role of $^{\bullet}OH$. Furthermore, o-phenylenediamine (OPDA) probing verified $^{\bullet}OH$ formation. When applied to actual water matrices such as tap water, the catalyst maintained high activity, consistently achieving >90% MBT degradation, thus demonstrating its practical applicability.

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Revealing the Mechanisms Behind Differently Charged NF Membrane Performance: Explainable AI and Mechanistic Approaches for Sustainable Lithium Recovery

Elif Gungormus Deliismail

Izmir Institute of Technology, Department of Chemical Engineering, Gulbahce, Urla 35430, Izmir, Turkey

E-Mail : elifgungormus@iyte.edu.tr

Abstract

Efficient lithium recovery from high-salinity brines remains a significant challenge due to the similar physicochemical properties of lithium (Li^+) and magnesium (Mg^{2+}) ions. Nanofiltration (NF) membranes offer great potential for selective Li/Mg separation; however, their performance is governed by multiple intertwined mechanisms, steric hindrance, Donnan exclusion, and dielectric exclusion, that vary with membrane characteristics and operating conditions. In this study, Shapley Additive Explanations (SHAP), an explainable artificial intelligence (AI) method, was employed to systematically uncover the relationships between separation mechanisms and membrane types. The findings were directly linked to performance maps, providing clear mechanistic explanations for the variations observed in Li/Mg selectivity. By bridging data-driven modeling with membrane science, this study demonstrates how explainable AI can transform black-box Artificial Neural Network (ANN) models into interpretable design tools, offering actionable guidelines for optimizing membrane structure and process conditions. Ultimately, these insights contribute to the development of next-generation NF membranes capable of overcoming the long-standing permeability-selectivity trade-off and enabling sustainable lithium recovery from natural brines.

Keywords: *Lithium Recovery, Surface-Charged Nanofiltration Membranes, Shapley Additive Explanations, Mechanistic Insights*

Introduction

The rising global demand for lithium, primarily driven by its essential role in energy storage systems, has increased the need for efficient and sustainable recovery methods. While aqueous sources present a promising alternative owing to their abundance and cost-effectiveness, the high magnesium concentration in these sources poses a significant challenge. Given the similar physicochemical properties of magnesium and lithium, achieving selective separation remains a complex task. Therefore, the development of advanced separation strategies that enhance lithium recovery while reducing operational costs and environmental impact is essential. Among various separation technologies, membrane-based processes have gained significant attention due to their energy efficiency, scalability, and environmental sustainability. In particular, NF membranes have shown great potential for lithium recovery due to their tunable pore size distribution and surface charge properties.

The performance of NF membranes in Li/Mg separation is governed by multiple intertwined mechanisms, primarily steric hindrance, Donnan exclusion, and dielectric exclusion[1]. Negatively, neutrally, and positively charged membranes exhibit distinct separation behaviors because these mechanisms act with different magnitudes under varying structural and operational conditions. Understanding which mechanism is dominant under specific conditions is therefore critical for tailoring membrane design and operational strategies. Achieving such mechanistic understanding is challenging because membrane performance depends on a complex interplay of multiple variables, including intrinsic membrane characteristics (e.g., pore size distribution, roughness, surface charge) and operational parameters (e.g., feed concentration, pH, operating pressure).

Traditional experimental approaches are limited in their ability to comprehensively analyze the complex, nonlinear interactions between membrane characteristics and process parameters. On the other hand, conventional data-driven modeling techniques provide highly accurate predictive capabilities; however, they are frequently regarded as “black-box” models because they lack interpretability and fail to offer direct mechanistic insights into the underlying separation processes. To overcome these limitations, explainable AI methods have emerged as powerful tools to bridge the gap between predictive modeling and scientific understanding. Among these, SHAP have proven particularly effective for identifying the relative importance of input variables and revealing how they influence model outputs. By integrating SHAP analysis with ANN-based modeling, it becomes possible to gain mechanistic understanding of the governing separation mechanisms across different NF membrane types.

This study focuses on developing a comprehensive framework that integrates predictive modeling with mechanistic interpretation to enhance the sustainable recovery of lithium from aqueous resources. Specifically, NF membranes with different surface charges are systematically evaluated to reveal which mechanisms dominate under various structural and operational conditions. The SHAP-based explainable AI approach provides a clear and quantitative understanding of how key variables influence membrane performance metrics across differently charged NF membranes, revealing how the dominant mechanisms vary depending on membrane surface charge. Ultimately, the proposed methodology offers a pathway to overcome the long-standing permeability-selectivity trade-off, reduce experimental effort, and guide the development of next-generation NF membranes for efficient and sustainable lithium recovery.

Results and Discussion

The dataset was collected from literature studies through the Web of Science database using the keywords "lithium, magnesium, and nanofiltration membrane." The selected input variables included membrane characteristics (average pore diameter [U1], pore size standard deviation [U2], surface roughness [U3], water contact angle [U4], and surface zeta potential) and operating conditions (total feed concentration [U5], Mg^{2+}/Li^{+} mass ratio in the feed solution [U6], solution pH [U7], transmembrane pressure [U8], and filtration temperature [U9]). The Li/Mg separation factor was designated as the output variable. The previously developed ANN model was integrated with SHAP analysis to calculate SHAP values separately for negatively, neutrally, and positively charged membranes, enabling a detailed interpretation of the governing mechanisms for each membrane type.

The SHAP analysis results revealed that the dominant mechanisms governing Li/Mg separation performance vary depending on the surface charge of the NF membranes (Figure 1.a). In negatively and neutrally charged membranes, parameters representing pore size distribution and surface hydrophilicity exhibited the highest SHAP values, indicating that the steric hindrance mechanism is dominant, while the Donnan effect plays a supporting role. In positively charged membranes, surface hydrophilicity and roughness were identified as the most influential factors, highlighting the Donnan exclusion mechanism as the primary contributor. Furthermore, the results showed that operating conditions, particularly the total feed concentration, Mg^{2+}/Li^{+} mass ratio, and transmembrane pressure, act as secondary but significant factors influencing separation performance. It should be noted that the dielectric exclusion mechanism could not be considered in this study due to the lack of sufficient reported data in the literature.

To provide a mechanistic perspective supporting the SHAP-based findings, the effects of changes in input parameters on the Li/Mg separation factor across different membrane types were examined. As an example focusing on positively charged membranes, Figure 1.b illustrates how variations in pore structure parameters influence the Li/Mg separation factor. In these membranes, the separation process is known to be governed primarily by the Donnan exclusion mechanism, rather than the size exclusion mechanism. A result consistent with this understanding was observed in Figure 1.b, where changes in pore size distribution were found to have only a very limited effect on the separation factor. This finding directly supports the insights obtained from the SHAP analysis.

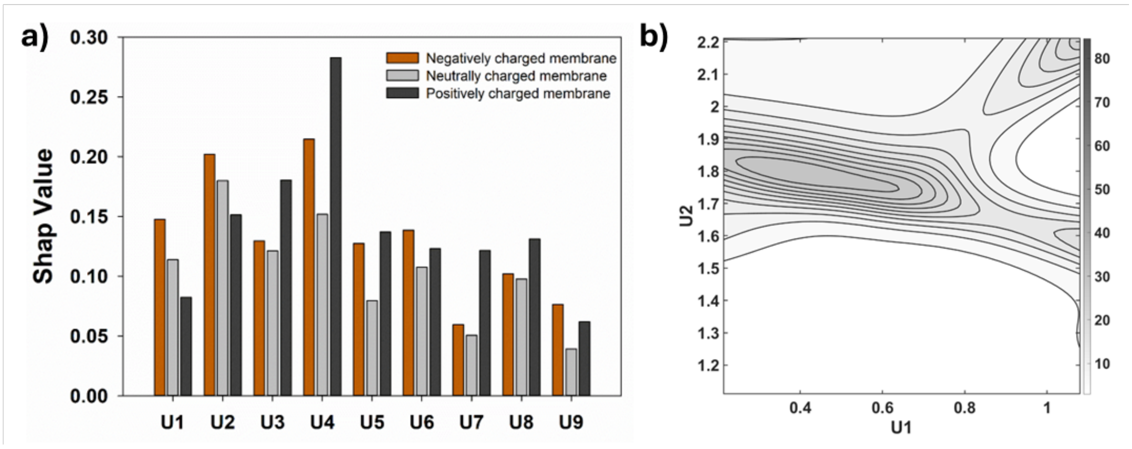

Figure 1. a) SHAP analysis for different NF membranes and b) a mechanistic insight example

This study demonstrated that combining SHAP analysis with ANN modeling effectively explains the mechanisms behind Li/Mg separation. Results emphasize that optimizing membrane surface charge, structural properties, and operating conditions together is essential for developing high-performance NF membranes for sustainable lithium recovery.

Acknowledgement

This study is supported by The Scientific and Technological Research Council of Türkiye (TÜBİTAK) under the Grant Number 125M305.

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A Machine-Learning Assisted Optical Titrimetry Framework for Chloride Determination Using Multi-Space Color Features

Mirkan Emir Sancak

Gebze Technical University, Environmental Engineering Department

E-Mail : m.sancak2018@gtu.edu.tr

This study proposes an integrated image-processing, chemometric and machine-learning framework for the low-cost, automated and sensitive quantification of chloride ions in aqueous media. A Mohr titration was continuously monitored inside a high-illumination Genesis-Chamber (≈15000 lm) using a Raspberry Pi Camera Module v2 equipped with an IMX219 CMOS sensor. Time-resolved chromatic transitions occurring during AgCl precipitation were captured frame-by-frame, enabling the construction of a dynamic optical reaction profile.Raw video frames were subjected to a multi-stage preprocessing pipeline including reflection suppression, background masking, white-balance correction and noise reduction. For each frame, mean intensities across the RGB, HSV, Lab and YCbCr color spaces were extracted. A z-score–based change-point algorithm was then applied to identify the optical breakpoint corresponding to the equivalence zone, followed by segment-based temporal sampling to compute statistically representative color descriptors for each titration step.Machine-learning models, including Linear Regression, Ridge, Random Forest and Gradient Boosting, were trained using the combined multicolor feature set. Among all configurations, RGB-LinearRegression (R^2 = 0.990, MSE = 0.816) and HSV-RandomForest (R^2 = 0.991, MSE = 0.737) yielded the highest predictive accuracy. Conversely, Lab, YCbCr and Grayscale spaces exhibited markedly lower performance, indicating limited sensitivity of their channel mappings to AgCl-induced scattering and absorption dynamics. These findings were further supported by univariate analyses, where RGB and HSV channels consistently showed the strongest correlation with chloride concentration.These performance differences arise from the optical behavior of AgCl precipitates, which induce wavelength-dependent scattering that amplifies contrast especially in the red and value (V) channels. This explains the superior accuracy of RGB and HSV, while Lab, YCbCr and Grayscale compress chromatic information in ways that mask subtle scattering gradients. The segment-based feature extraction was also essential, as it isolates the most informative reaction window and suppresses temporal noise. Overall, the results demonstrate that appropriate color-space selection and adaptive temporal sampling are critical for reliable computational titrimetry. Consequently, the results demonstrate that colorimetric titration, when coupled with low-cost optical hardware and advanced computational analysis, can be transformed into a real-time, automated and portable ion-sensing platform. The proposed color-based computer analysis (CBCA) method provides high precision (typical error ±0.1 mg/L) and strong reproducibility, offering a promising direction for field-deployable water-quality monitoring technologies.

Photocatalytic degradation of atrazine under UV light using Ag-decorated Zr-based MOF: UiO-66-NH_2-Ag/AgCl

Yaşar Kemal Recepoğlu, Merve Korana, Elif Nur Özmekik, Atakan Karaca, Fehime Çakıcıoğlu-Özkan

Izmir Institute of Technology, Faculty of Engineering, Department of Chemical Engineering, 35430, Gulbahce Campus, Urla, Izmir, Türkiye

E-Mail: yasarrecepoglu@iyte.edu.tr

Abstract

Atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine) is a widely used herbicide for controlling broadleaf weeds in crops such as corn, sugarcane, and sorghum. Its persistence in soil and groundwater, resistance to microbial degradation, slow hydrolysis, low vapor pressure, and high leaching potential contribute to its long-term environmental impact. Atrazine contamination can exceed permissible limits (<3 μg/L), leading to significant ecological and human health concerns. Among removal methods from water, such as adsorption, advanced oxidation processes (AOPs), bioremediation, electrochemical methods, and photocatalytic degradation are the most prominent. Metal-organic frameworks (MOFs) stand out due to their significant potential in environmental pollution remediation and developing sustainable technologies as promising photocatalytic materials. In this study, Zr-based Ag-decorated composite MOF (UiO-66-NH_2@Ag/AgCl) was synthesized and characterized by XRD, FTIR, and BET (S_{BET}=364.77 m^2/g), confirming successful material synthesis. The photocatalytic degradation of atrazine under UV light was investigated with various parameters such as catalyst loading, reaction time, and initial atrazine concentration, achieving 71.5% degradation in a 20 μg/L solution using 0.1 g/L catalyst over 120 minutes.

***Keywords**: Atrazine, composite MOF, photocatalytic degradation, UV light*

Introduction

The persistent contamination of water bodies by organic pollutants, particularly herbicides such as atrazine, poses significant environmental and health challenges due to their resistance to biodegradation and potential endocrine-disrupting and carcinogenic effects.[1] Conventional water treatment methods, including coagulation, filtration, and adsorption, often prove inadequate or economically unfeasible for the complete removal of these compounds.[2]

Photocatalytic degradation, an advanced oxidation process, has gained attention for its capacity to mineralize complex organic pollutants into benign end products like CO_2 and H_2O.[3] However, traditional photocatalysts such as titanium dioxide exhibit limited efficiency under visible or natural light because of their wide bandgap, which restricts activation primarily to ultraviolet radiation. This limitation has spurred the development of novel photocatalytic materials that offer enhanced activity and tunability.[4]

Metal-organic frameworks (MOFs), with their high surface area, tunable porosity, and versatile chemical structures, have emerged as promising photocatalysts. Among these, UiO-66-NH_2, a zirconium-based MOF functionalized with amino groups, combines remarkable thermal and chemical stability with improved light absorption capabilities.[5]

In this context, the present study explores the synthesis of an Ag-decorated UiO-66-NH_2@Ag/AgCl composite designed to enhance photocatalytic performance by facilitating efficient charge separation through localized surface plasmon resonance (LSPR) and improved electron-hole dynamics under UV light. The work aims to evaluate this novel composite's effectiveness in degrading atrazine in aqueous solutions, thereby advancing sustainable strategies for the remediation of hazardous micropollutants in water.

Results and Discussion

The successful synthesis of UiO-66-NH_2@Ag/AgCl was confirmed by XRD, FTIR, and BET analyses. These results verified the structural integrity of the MOF, the incorporation of Ag/AgCl, and the retention of adequate porosity for photocatalytic activity despite a slight reduction in surface area.

Photocatalytic degradation experiments under UV irradiation evaluated the effects of atrazine concentration, catalyst dosage, and reaction time. Figure 1(a) shows that degradation efficiency decreased with increasing atrazine and catalyst concentrations, with the highest removal (71.5%) observed at 20 µg/L atrazine and 0.1 g/L catalyst. Figure 1(b) indicates that longer reaction times enhance degradation, especially at lower atrazine levels, reaching over 70% efficiency after 120 minutes. Figure 1(c) confirms that extended irradiation improves performance across all catalyst dosages; however, increasing the catalyst above 0.1 g/L reduced efficiency slightly, likely due to light scattering, shielding, and particle agglomeration that inhibit photocatalytic activity.

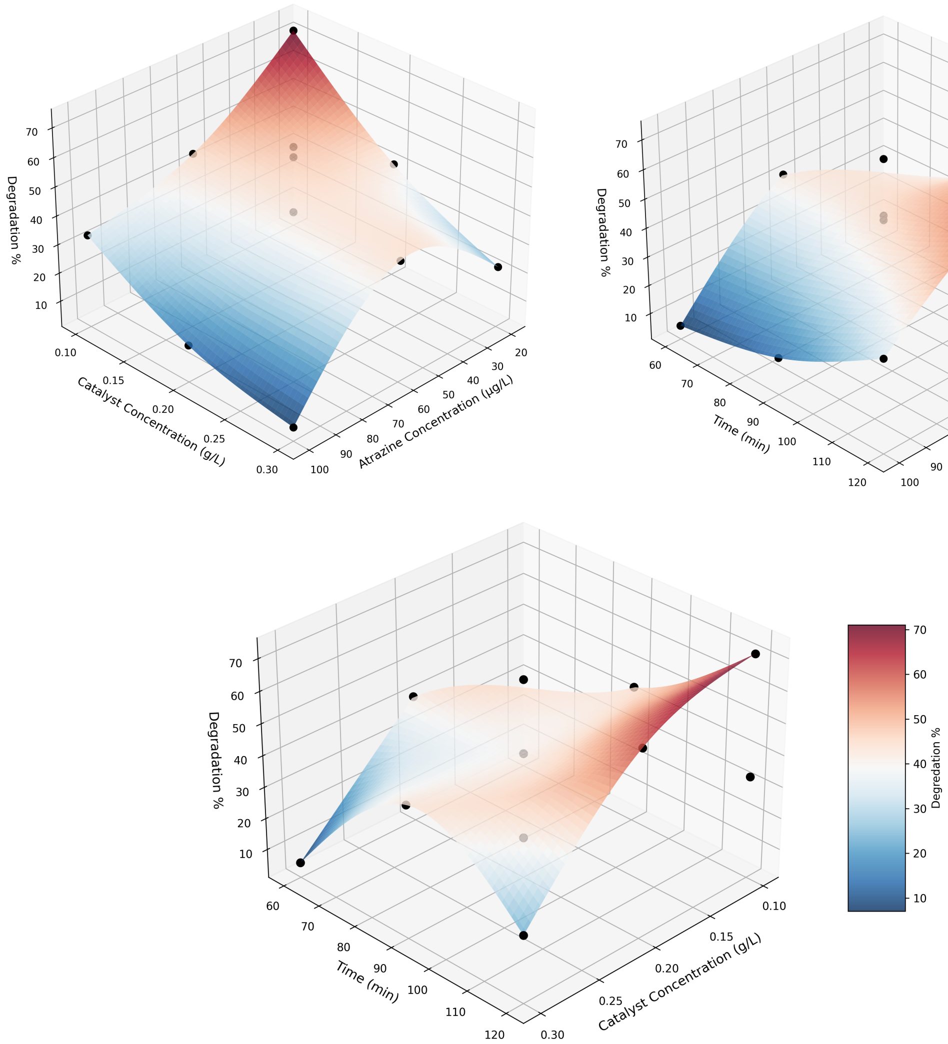

Figure 1. Response surface plots illustrating the interactive effects of key operational parameters on atrazine degradation efficiency (%): Interaction between **(a)** atrazine concentration (µg/L) and catalyst dosage (g/L); **(b)** atrazine concentration (µg/L) and reaction time (min); and **(c)** catalyst dosage (g/L) and reaction time (min).

In conclusion, the UiO-66-NH_2@Ag/AgCl photocatalyst exhibited high efficiency for atrazine degradation under UV light when operated under optimized conditions. The best results were obtained with low atrazine concentration, minimal catalyst dosage, and extended reaction time. These findings highlight the material's potential as a cost-effective and environmentally friendly photocatalyst for the removal of persistent organic micropollutants from water.

Acknowledgement: This study was financially supported through the projects of the Research Universities Support Program by the Higher Education Council of Türkiye (ADEP, Project No: 2023İYTE-2-0023) and the Scientific and Technological Research Council of Türkiye (TUBITAK program code: 2209-A). Elif Nur Özmekik would also like to thank the TUBITAK (program code: 2247-C) for the scholarship.

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Surface Free Energy Prediction for Rough Membranes: An R-Model-Independent Artificial Neural Network Approach

Elif Gungormus Deliismail

Izmir Institute of Technology, Department of Chemical Engineering, Gulbahce, Urla 35430, Izmir, Turkey

E-Mail : elifgungormus@iyte.edu.tr

Abstract

Surface free energy (SFE), derived from contact angle measurements, is a key descriptor for interpreting wetting, antifouling behavior, interfacial adhesion, and selectivity trends in membrane systems. In membrane research, the Owens-Wendt-Rabel-Kaelble (OWRK) method is routinely used to compute dispersive and polar SFE components from liquid contact angles. However, OWRK implicitly assumes an ideally smooth surface. In reality, membranes possess microscale/nanoscale roughness; hence measured (apparent) contact angles are geometrically biased and do not represent the true chemical surface energy. Consequently, reported SFE values are often not intrinsic but distorted by topography, which represents a non-trivial limitation for studies involving surface comparison, modification or digital membrane screening. Analytical corrections such as Wenzel or Cassie-Baxter are typically applied to back-calculate intrinsic SFE before OWRK. These corrections enforce an explicit roughness model (hereafter r-model) to decouple geometrical bias from chemistry. Yet they are deterministic, require explicit roughness-wettability assumptions, and remain sensitive to noise and morphological heterogeneity. Moreover, identical roughness values may not yield identical wetting responses when hierarchical texture or chemical patterning is present, violating the reversibility assumed in analytic correction. Here, we propose a data-driven artificial neural network that predicts the dispersive and polar SFE components (γ^d and γ^p) directly from apparent contact angle and roughness metrics, without enforcing any explicit r-model. The network is trained under stratified balancing, normalization, and Bayesian regularization. The model yields low prediction error (RMSE < 0.5 mN/m) and high R^2 (>0.95) on the test set, with error remaining uniform across SFE bins. This demonstrates that intrinsic SFE can be reconstructed from measurable inputs without analytic correction, with superior robustness to noise and roughness heterogeneity. The framework further enables digital screening and virtual pre-characterization of membrane surfaces without re-measurement. The proposed approach fills a methodological gap in membrane surface characterization and offers a practical, physically consistent alternative to traditional roughness correction for use in surface modification, antifouling design, and data-augmented membrane engineering.

Keywords: *Surface free energy; Membrane Surface; OWRK; Artificial neural network*

Introduction

In membrane science, surface free energy (SFE) is not a secondary diagnostic but a primary governing quantity that manifests itself through virtually every interfacial phenomenon relevant to separation performance. Changes in SFE alter the thermodynamic driving force for wetting, dictate the extent and reversibility of foulant adsorption, determine interfacial adhesion and delamination risk in surface-coated membranes, and correlate with rejection/selectivity trends through hydration structuring. Accordingly, meaningful comparison of membrane surfaces, evaluation of modification routes, and predictive screening for antifouling design all implicitly require physically valid SFE values. Because SFE is not directly measurable, it is classically inferred from contact angle data via the Owens-Wendt-Rabel-Kaelble (OWRK) formulation[1]:

$$\gamma_L(1+\cos\theta) = 2\left(\sqrt{\gamma_S{}^{d}\gamma_L{}^{d}} + \sqrt{\gamma_S{}^{p}\gamma_L{}^{p}}\right)$$

where γ_L is total liquid surface tension, $\gamma_L{}^d$ and $\gamma_L{}^p$ are dispersive and polar components of the liquid, $\gamma_S{}^d$ and $\gamma_S{}^p$ are dispersive and polar components of the solid, and θ is the measured static contact angle. This inversion assumes that the measured contact angle θ reflects only surface chemistry. However, real membrane surfaces are not smooth; they exhibit hierarchical roughness at microscale or nanoscale. As a result, measured angles are apparent rather than intrinsic. Classical correction requires a geometrical model such as the Wenzel equation[2]:

$$\cos\theta = r \times \cos\theta^*$$

where θ^* is the Young's intrinsic contact angle on an ideal smooth surface of the same chemistry, and r is the Wenzel roughness factor. After inversion, Young's intrinsic angle θ^* is substituted into the OWRK equation to compute SFE free of topographic bias. However, this analytical correction is inherently model-bound and fragile. It relies on (i) a single-form r–θ coupling postulate, (ii) deterministic validity under morphological heterogeneity, and (iii) noise-sensitive inversion. In membrane systems, identical AFM-derived R_q values do not necessarily yield identical wetting responses in the presence of phase-segregated chemistry or hierarchical texture, which undermines the core assumption of reversibility embedded in analytical roughness corrections.

To bypass explicit r-modelling, this study introduces a data-driven artificial neural network (ANN) that predicts SFE components (γ^d and γ^p) directly from apparent contact angles and roughness (R_q) inputs. ANN models are particularly advantageous as they (i) do not enforce any predefined r-model, (ii) can learn nonlinear and coupled effects implicitly embedded in data, and (iii) provide rapid forward predictions once trained. Despite the known dependence of SFE on surface morphology, no prior study has systematically reconstructed intrinsic OWRK-SFE from apparent measurements using machine learning without embedding a deterministic roughness model. The present study therefore fills a methodological gap, enabling intrinsic SFE estimation free from analytical assumptions while preserving physical interpretability. The specific objective is to develop and validate an ANN framework capable of reconstructing intrinsic OWRK SFE from routinely measured inputs, thereby providing a generalizable, noise-robust, and model-independent alternative to Wenzel-based analytical correction for membrane surface characterization.

Results and Discussion

The dataset was compiled from peer-reviewed membrane studies indexed in the Web of Science database using the keywords "membrane, surface free energy, OWRK". Apparent water contact angle, diiodomethane contact angle, and AFM-derived R_q roughness were adopted as input variables. Target outputs were the intrinsic SFE components (γ_d and γ_p) computed by first correcting apparent contact angles via the Wenzel relation and then applying the OWRK formulation. Thus, the intrinsic SFE reconstructed from deterministic correction served as the physically informed reference label against which the ANN predictions were trained and evaluated.

The ANN was trained to learn the implicit mapping among input variables and output without embedding any explicit r-model. Prior to training, the dataset was randomly shuffled and optionally screened for IQR-based outliers under a strict removal cap. Contact angles were expressed in cosine space to better align with OWRK linearity. A stratified train–test split was imposed across γ^d and γ^p bins to preserve coverage of the intrinsic SFE spectrum in the hold-out set. To mitigate imbalance in the training distribution, only the training partition was bin-balanced via controlled over/under-sampling. Features and targets were z-score normalized using statistics computed exclusively on the balanced training set to avoid leakage. A single-hidden-layer feed-forward network (5 neurons, hyperbolic tangent activation, Bayesian regularization) was trained with repeated restarts. For each attempt, predictions were denormalized and evaluated in raw units (mN/m). The model achieving the lowest combined test RMSE was retained as the best model.

The parity plots for γ_d and γ_p in both the training and test sets (Figure 1) show a tight clustering along the 1:1 line, evidencing strong agreement between ANN predictions and intrinsic (Wenzel-corrected OWRK) SFE components. The model achieved low test error (RMSE < 0.5 mN/m) and high coefficient of determination ($R^2 > 0.95$) for both outputs. In particular, the bin-wise balanced RMSE across the γ_d range demonstrated that the predictive accuracy was preserved not only within a narrow sub-domain but consistently across the entire intrinsic SFE spectrum, an expected outcome of the stratified splitting and balanced training strategy. Although the polar component (γ_p) is known to be more sensitive to noise and morphological heterogeneity, the ANN maintained high accuracy also in γ_p predictions. This indicates that the combined use of cos θ inputs and R_q enables the network to implicitly compensate for topography-induced distortions without enforcing any explicit analytical roughness model. These findings demonstrate that intrinsic SFE can be recovered solely from measurable apparent inputs without imposing an explicit r-relation. Compared to classical Wenzel-based analytical correction, the proposed approach offers a more noise-robust, model-independent, and computationally instantaneous alternative, providing a notable methodological advantage for membrane surface studies where roughness is intrinsic and analytical reversibility does not hold. The resulting framework enables fast, model-independent and measurement-driven reconstruction of intrinsic interfacial energetics, offering a practical and physically consistent alternative for membrane surface characterization, particularly in studies of surface modification, antifouling coatings and data-augmented membrane design.

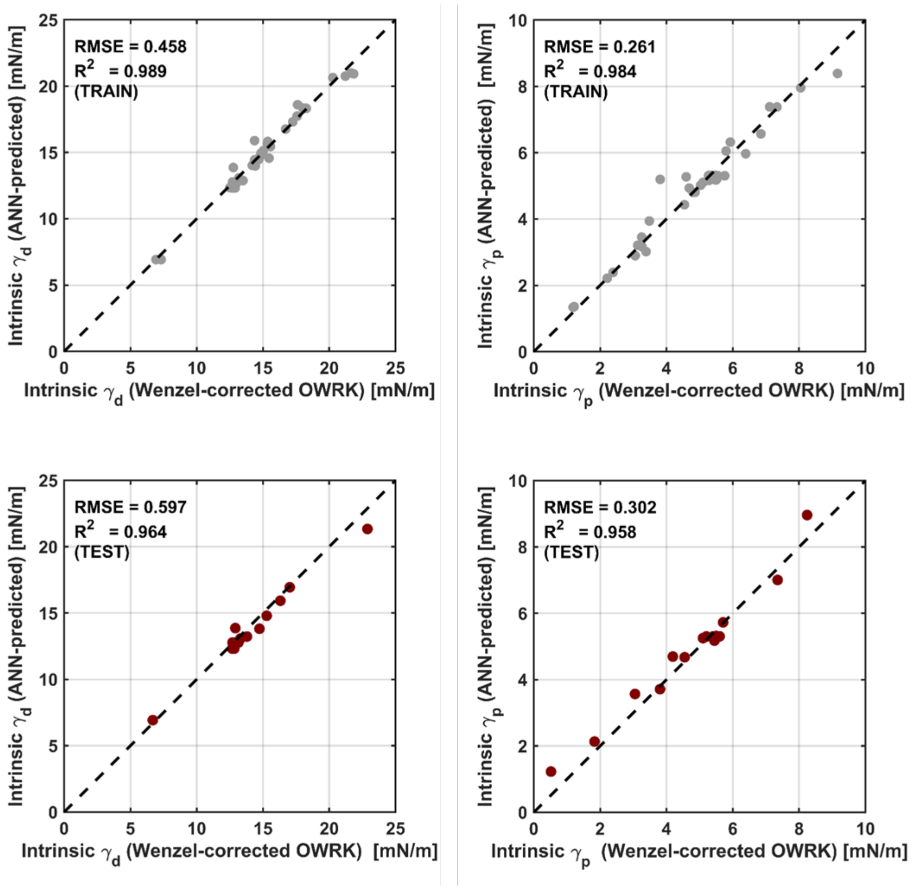

Figure 1. Comparison of ANN-predicted intrinsic SFE components (γ^d and γ^p) with Wenzel-corrected OWRK references for train and test sets.

Acknowledgement

This study was conducted using licensed MATLAB software provided by İzmir Institute of Technology (IzTech). The author thanks IzTech for the computational infrastructure and software support.

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Sustainable and cost-effective antimicrobial cellulose filters functionalized with tannic acid-mediated silver and zinc oxide nanoparticles

Kadir Çakıral[1,2,*], Mümtaz Güran[2], Mustafa Gazi[1]

[1]*Polymeric Materials Research Laboratory, Chemistry Department, Faculty of Arts and Science, Eastern Mediterranean University, Famagusta, Northern Cyprus Via Mersin 10, Türkiye*

[2]*Department of Medical Microbiology, Faculty of Medicine, Eastern Mediterranean University, Famagusta, Northern Cyprus Via Mersin 10, Türkiye*

**Corresponding author and speaker. E-Mail: kadircakiral@gmail.com*

This study presents a sustainable approach to water purification by developing antimicrobial cellulose filters functionalized with silver and zinc oxide nanoparticles through a green synthesis method. Leveraging tannic acid, a natural plant polyphenol, as both a reducing and capping agent, silver and zinc oxide nanoparticles were immobilized onto cellulose filter paper modified with citric acid and chitosan. The resulting composites were characterized using Fourier Transform Infrared Spectroscopy (FT-IR), X-ray Diffraction (XRD), and Scanning Electron Microscopy with Energy-Dispersive X-ray Spectroscopy (SEM-EDX), confirming successful tannic acid grafting and uniform nanoparticle distribution while maintaining the cellulose structure. Filtration assays against *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans* demonstrated robust efficacy. The silver nanoparticles-loaded filter achieved near-complete inactivation of *E. coli* (~99.84%) and strongly reduced *S. aureus* and *C. albicans*. The zinc oxide loaded filter excelled against *S. aureus* (~99.78%) and *C. albicans* (~96.79%). The dual-metal filter showed balanced efficacy across all three microbes (90.28–95.13% reductions). Release assays revealed minimal leaching of active compounds, with the silver nanoparticles-loaded filter showing negligible release and the zinc oxide loaded filters releasing only trace amounts of tannic acid, ensuring environmental safety. This eco-friendly filtration material offers a promising solution for effective water disinfection, particularly in low-resource settings, aligning with green chemistry principles.

Keywords: *Antimicrobial filters, Tannic acid, Silver nanoparticles, Zinc oxide nanoparticles*

Influence of the divalent ions composition in the RED system compartments on uphill transport and energy harvesting performance

Aydın Cihanoğlu[1,2]

[1]*Ege University, Faculty of Engineering, Department of Chemical Engineering, İzmir, Türkiye,*
[2]*Ege University, Aliağa Vocational School, Department of Refinery and Petrochemical, İzmir, Türkiye*
E-Mail: aydin.cihanoglu@ege.edu.tr

Meeting rising global energy demand with fossil fuels is increasingly unsustainable, highlighting the need for clean and reliable alternatives. While conventional renewables contribute significantly, many are limited by geographic or climatic constraints. Salinity gradient energy (SGE) offers a complementary, condition-independent option that produces no waste. With a theoretical global potential of 1.4–2.6 TW, nearly 20% of today's energy demand, SGE could notably reduce greenhouse gas emissions.[1] Reverse electrodialysis (RED) stands out among SGE technologies for its simplicity and high power potential, converting natural salinity gradients directly into electricity. Despite extensive research, a gap remains between RED studies using pure NaCl and its operation with real feedwaters. Natural waters contain divalent ions that, even at low levels, increase resistance, reduce permselectivity, and undergo uphill transport, ultimately lowering OCV and power output. Three uphill ion transport phenomena negatively affect power density: (i) transport of divalent ions against the concentration gradient, (ii) binding of divalent ions to single fixed charge sites, and (iii) binding to multiple fixed charge sites.[2]

This study examined how varying molar ratios of divalent ions in the dilute and concentrated compartments affect RED performance. Fujifilm Type II AEMs, tailor-made AEMs, and polyelectrolyte-coated versions were tested under different sulfate (SO_4^{2-}) fractions, and stack and membrane analyses were used to quantify their influence on open circuit voltage (OCV) and power output.

Acknowledgments

This study was supported by the Scientific and Technological Research Council of Türkiye (TÜBİTAK) through the National Postdoctoral Project (Grant No. 118C549). We also thank FUJIFILM Manufacturing Europe BV for providing the Fujifilm Type II AEMs and CEMs; Mitsubishi Chemical, Japan, particularly Ando Kiyoto, for supplying the PAN sample; and Osaka Soda Co., Japan, for providing the PECH polymer. I extend our sincere gratitude to Prof. Dr. Nalan Kabay for providing access to all the facilities necessary for this work.

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Metal-Organic Framework Based Polymer for Controlled Drug Delivery and Antibacterial Activity

Junior Kabanza-Kalala*, Akeem Adeyemi-Oladipo*, Mümtaz-Güran, Mustafa-Gazi*

**Polymeric Materials Research Laborator, Chemistry Departement, Faculty of Arts and Science, TR North Cyprus, Eastern Mediterranean University, Famagusta via Mersin 10, Türkiye.*

Department of Medical Microbiology, Faculty of Medicine, Eastern Mediterranean University, Famagusta, Northern Cyprus Via Mersin 10, Turkey

E-Mail : 22600284@emu.edu.tr

Bacterial infection coupled with uncontrollable drug delivery represent an enormous challenge in healthcare and environmental management. The excessive use of antibiotics has led to drug resistance and pharmaceutical pollution, created by waste drug release. Metal-organic frameworks (MOFs), are a class of hybrids and porous materials, synthesized by bonding together metal clusters with organic ligands. MOFs represent a promising candidate for strategically fighting drug resistance and loading high amounts of drugs. In this study, a solvothermal method was employed, to synthesize bimetallic Cu-Zn@MOF followed by its encapsulation in Copper-alginate crosslink polymer for antibacterial activity and doxycycline drug delivery. By processing time kill assay method, bimetallic Cu-Zn@MOF showed substantial antibacterial activity against S. aureus and E-coli bacteria, by killing 100% of microorganisms at the concentration of 3mg/mL after 60 min and 120 min respectively. In drug delivery application, bimetallic Cu-Zn@MOF loaded in Cu-alginate crosslink beads achieved 66.8% of doxycycline loading, and a cumulative release of 78.7%, 18.6% after 24 hours, at pH of 7.4 and 5.2 respectively, while no release was observed at pH 2. These results demonstrated that bimetallic Cu-Zn@MOF encapsulated in Copper-alginate beads is promising material for controlled drug release, and antibacterial activity.

CO_2 Capture from Indoor Air by Hydrophobic Membrane Contactors: Mechanism and Experimental Assessment

Handenur YAŞAR[1], Zehra KÖLE[1], Bülent KESKİNLER[1], Ahmet KARAGÜNDÜZ[1]

Gebze Technical University, Department of Environmental Engineering, Kocaeli, Türkiye

hnuryasar@gtu.edu.tr, zkole@gtu.edu.tr, bkeskinler@gtu.edu.tr, akaragunduz@gtu.edu.tr,

The need for low-energy, practical carbon capture technologies has grown as CO_2 emissions from burning fossil fuels have increased. Because of its large surface area, modularity, and operational flexibility in gas-liquid mass transfer processes, membrane contactor (MC) technologies are becoming more and more popular for carbon capture applications. This technique, in contrast to conventional absorption systems, is based on the use of microporous membranes, which are typically hydrophobic and form a regulated interface that keeps the gas and liquid phases from directly mixing. As a result, CO_2 diffuses from the liquid adsorbent through the membrane pores, and the system can be tuned for energy efficiency, variable operating conditions, and mass transfer coefficients. PP, PVDF, or hollow fiber membrane configurations, in particular, are prominent for industrial-scale carbon capture because they offer a high specific surface area-to-volume ratio (SAR) and low pressure drop. The fundamental advantage of membrane contactors is that mass transfer occurs exclusively in a diffusion-controlled environment, employing a membrane interface that precludes direct mixing of the gas and liquid phases. This makes modular design, varied working conditions, and a lower footprint possible.

The transfer of CO_2 from the gas phase into the hydrophobic micropores of the membrane, diffusion inside the pores, and dissolution at the membrane-liquid interface, where it comes into contact with the liquid absorbent, form the basis of the operating principle of MCs[1]. Important factors influencing the mass transfer rate include gas-side pressure, membrane wetting control, and absorbent characteristics (such as carbonate buffer systems and amine-based solutions)[2]. The hollow-fiber module architecture greatly improves CO_2 absorption efficiency because of its high surface area-to-volume ratio. In this investigation, CO_2 from indoor air was retained in a Na_2CO_3 solution after passing through a membrane contactor. By altering the liquid pressure and gas flow rate, variations in the CO_2 content in the discharged gas were noted. Figure 1 depicts the experimental setup.

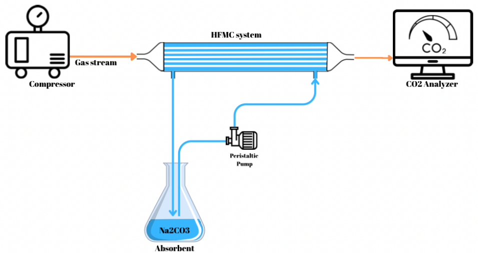

Figure 1. Diagrammatic illustration of the experimental configuration

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A Novel Technology for Resource Valorization from Waste Streams

Zehra KOLE[1], Gülfem SOYDEMIR[1], Bengisu CIFTCIOGLU GOZUACIK[1], Handenur YASAR[1], Mirkan Emir SANCAK[1], Bülent KESKINLER[1], Ahmet KARAGUNDUZ[1]

[1]*Gebze Technical University, Department of Environmental Engineering, 41400, Kocaeli, Turkiye*

zkole@gtu.edu.tr, g.soydemir@gtu.edu.tr, bciftcioglu@gtu.edu.tr, hnuryasar@gtu.edu.tr, m.sancak2018@gtu.edu.tr, bkeskinler@gtu.edu.tr, akaragunduz@gtu.edu.tr

The increasing raw material crisis and production activities day by day highlight the importance of resource recovery over end-of-pipe treatment. In this context, the challenges associated with managing streams containing complex compounds are increasing the need for sustainable and energy-efficient treatment technologies. Conventional treatment methods are often insufficient due to their high energy demand, chemical consumption, and low recovery rates. This situation highlights new approaches that focus on recovering valuable substances rather than simply removing pollutants. Among the innovative technologies that have gained prominence in recent literature, Mechanical Vapor Recompression (MVR) systems stand out, particularly due to their high energy efficiency and operational flexibility (sea water desalination, food industry (milk power and whey production), high-value-added compounds recovery). Although evaporation systems are widely used in product recovery processes, MVR systems, which can increase energy efficiency by reusing the energy of the vapor, are gaining importance. In MVR processes, the secondary vapor generated during evaporation is mechanically compressed to increase its temperature and enthalpy, thereby reusing the latent heat carried by the vapor. This enables energy savings exceeding 65% compared to traditional evaporation methods. Our findings from the study conducted with landfill leachate indicate that MVR technology offers significant potential, especially for recovering high-value-added compounds such as ammonia and volatile fatty acids (VFA). In the continuous pilot-scale MVR system study, it was observed that ammonia recovery rates from the leachate ranged between 70-97% at %40-%90 evaporation rates. In the conducted MVR study, it was also found that the COD (Chemical Oxygen Demand) in the distillate of the landfill leachate can reduced under 400 mg/L. In another study, we achieved an 89% recovery of VFAs (acetic, propionic, i-butyric, butyric, i-valeric, and valeric acid) from raw leachate (initial concentration: 4.7 g/L) at pH 4.0 by implementing an MVR system supported by controlled evaporation, pH optimization, and integrated crystallization/condensation steps. These results demonstrate that MVR is a strong alternative both in terms of environmental sustainability and economic recovery. Overall, the results shows that MVR, with its low energy consumption, high thermodynamic efficiency, and capacity for separating valuable products, is a next-generation, scalable, and promising technology for recovering valuable substances from waste.

Acknowledgements: This study was supported by TUBITAK project numbers 121Y481 and 124R001.

POSTER PRESANTATIONS

Multidimensional Assessment of the Potable Water Supply System in Constantine, Algeria: Quality, Infrastructure, and Consumer Perception

Oumnya CHERITI, Leila SAHLI
Laboratory of Biology and Environment, Campus Chaab-Erssas, Biopôle, University Brothers Mentouri-Constantine1, Constantine, Algeria
E-Mail : oumnya.cheriti@umc.edu.dz

The city of Constantine, a major urban center in northeastern Algeria, has been facing increasing pressure on its water resources in recent years. This study presents a multidimensional analysis of the potable water supply system in Constantine and its surrounding localities. To better understand the issues at stake, the study began with the collection of consumer concerns and complaints recorded through the customer service call center (short number 3025). This was followed by the administration of a structured questionnaire designed to assess water usage habits, supply frequency and pressure, perceptions of water quality, and household consumption practices, particularly with regard to drinking and cooking.

Our investigation focused on the water supply chain from its sources—primarily dams and groundwater wells—through to its conveyance to drinking water treatment plants (STEP), and finally to end-users. The study examined the physical (e.g., sedimentation, filtration) and chemical (e.g., chlorination, coagulation-flocculation) treatment processes employed at these facilities to ensure compliance with potable water standards. Special attention was given to the quality of water at the household level, with samples collected from various storage systems, including rooftop tanks (metal or plastic), ground-level reservoirs, and bottled water. This emphasis was motivated by questionnaire results that revealed a predominant reliance on bottled water for direct consumption, along with widespread use of domestic filtration devices. The measured water quality parameters were evaluated against national and international drinking water standards, thereby revealing the gap between consumer perception and the actual quality of available water sources. Notably, in neighborhoods where distribution infrastructure has been recently upgraded and storage conditions are adequate, tap water consistently met potability standards—and in some cases, exceeded the quality of bottled water. Bottled water, typically packaged in PET containers, is prone to physical and chemical degradation, particularly when exposed to sunlight or elevated temperatures during transportation and storage. Such exposure may compromise the safety of bottled water, raising questions about its presumed superiority over municipal tap water. Furthermore, the study identified several critical challenges, including aging and deteriorating infrastructure, insufficient maintenance of treatment facilities, significant technical losses in the distribution network (exceeding 30%), and inconsistent water quality due to varying domestic storage practices. In peri-urban areas, physico-chemical and microbiological deviations were detected, indicating potential public health risks. The findings underscore the urgent need for infrastructure modernization, enhancement of treatment plant performance, and improved distribution network management. In parallel, public awareness campaigns promoting safe water storage practices are essential for maintaining water quality post-distribution. An integrated and inter-municipal water governance framework is deemed necessary to ensure equitable and sustainable access to potable water in the Constantine region.

Water-Based Polyurethane Dispersion Synthesis

Kevser Harmandar, Muhammet Ekenel, Yücel Aktay, Murat Baranak

Poleks Kimya Sanayi ve Ticaret AŞ. Akçaburgaz, Osmangazi Cd No:5, 34522 Esenyurt/İstanbul

kharmandar@polexchem.com

Water-based polyurethane is widely used in textile coating due to its excellent film-forming ability and durability. It provides textiles with properties such as flexibility, abrasion resistance, and waterproofing. Unlike solvent-based alternatives, it significantly reduces volatile organic compound (VOC) emissions. This makes it safer for employees and minimizes harm to the environment. Its application supports the production of eco-friendly and sustainable textiles. Water-based systems also contribute to energy savings since they often require lower curing temperatures. They align with global regulations that encourage greener production processes. In addition, they improve the recyclability and biodegradability of coated fabrics. Consumers increasingly prefer textiles treated with environmentally responsible technologies. Overall, water-based polyurethane in textile coating represents a balance between high performance and environmental protection. However, with growing environmental concerns, efforts to reduce volatile organic compounds (VOCs) and other pollutants have become a global priority. VOCs are often toxic and, in many cases, carcinogenic. In particular, benzene-related compounds can damage the central nervous system and cause neurological disorders in humans. For example, halogenated hydrocarbons have been reported to induce platelet loss. Acetone, one of the most widely used solvents in industry and laboratories, can impair the kidneys, liver, and pancreas by depressing the human central nervous system. Recent studies suggest that VOC pollution may contribute to more than 5 million premature deaths worldwide each year. Moreover, the human olfactory system is generally not sensitive enough to detect these volatile hazards.

In the present study, waterborne polyurethane dispersions with varying solid contents were synthesized using polyether polyol as the diol source, dimethylol propionic acid (DMPA) as the internal emulsifier, and isophorone diisocyanate (IPDI) as the isocyanate source, employing both the conventional acetone process and an acetone-free method.

Acknowledgement: TÜBİTAK/ 1501-Sanayi Ar-Ge Destek Programı, 3240621.

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Synthesis of Polyurethane Dispersions Using Different Polyol Types and IPDI Isocyanate and Their Application in Textile

Ezgi Topcu Gürbüz[1,3], Nesrin Köken[2]

[1]*Istanbul Technical University, Graduate School of Science Engineering and Technology, Department of Polymer Science and Technology 34469, Istanbul, Turkey*

[2]*Istanbul Technical University, Faculty of Science, Department of Chemistry 34469, Istanbul, Turkey*

[3]*Textile Chemicals R&D Department, Akkim Kimya San. ve Tic. A.Ş., 77602 Yalova, Türkiye*

gurbuz24@itu.edu.tr, nesrin@itu.edu.tr

Polyurethane technology has become a highly versatile field of polymer science, serving a wide range of industries today. Through modifications in monomer structures, polyurethanes can be specifically tailored to exhibit desired properties, enabling the production of numerous different types. Within this diversity, the use of waterborne polyurethane dispersions (PUDs) in the textile industry has gained particular importance. Due to their environmentally friendly nature and low volatile organic compound (VOC) emissions, the applications of PUDs in textiles have been steadily expanding.

In this study, polyurethanes were synthesized via the dispersion method using IPDI as the fixed isocyanate component, while five different polyols with varying properties were employed to prepare five distinct formulations. The resulting polyurethane dispersions were comparatively evaluated in terms of their chemical structures and performance characteristics. To assess their potential application in the textile field, padding, exhaust, and coating processes were applied to different fabric types, followed by comprehensive testing of adhesion behavior on fabric surfaces, film formation ability, elasticity, mechanical strength, and overall performance. These evaluations enabled the identification of performance differences among the formulations in coating and finishing processes and the determination of the suitability of each dispersion for specific textile applications. In addition, the treated fabrics exhibited notably improved tensile strength, tear strength, bursting strength, and wrinkle resistance, demonstrating the effectiveness of the synthesized polyurethane dispersions in enhancing the mechanical and functional performance of textiles.

A Study on Toxic Dye Biosorption by Biomass of Indigenous Bacterial Strains

Rana Nur ALVER, Seda ŞEN, Nur Koçberber KILIÇ

Department of Biology, Faculty of Science, Ankara University, Ankara, 06100, Türkiye E-Mail : nrkilic@ankara.edu.tr

Biosorption represents an eco-friendly, low-cost, and efficient biological remediation technique that utilizes dead or inactive biological materials, including bacteria, fungi, and microalgae. In this study, the biomass of indigenous bacterial strains isolated from various environments in Turkey was employed to investigate their biosorption potential for the removal of textile dyes from aqueous solutions. The research specifically aimed to assess the efficiency of dead bacterial biomass in eliminating textile dyes present in industrial wastewater. In the experimental procedure, mixed bacterial cultures were obtained from water samples collected from different regions of Turkey, namely Kıbrıs Village Canyon (Ankara), Eğirdir Lake (Isparta), and Küçükçekmece Lake (Istanbul). Pure bacterial isolates were subsequently obtained from these mixed cultures, and the strains exhibiting the highest growth performance were selected for further experiments. These isolates were employed in the biosorption of Reactive Blue 21 [(RB21) Remazol Turquoise Blue G-133]. The effects of parameters such as pH (2 - 9), initial pollutant concentration (25 mg/L - 300 mg/L), and biosorbent dosage (0.25 g/L - 4 g/L) on the biosorption process were investigated. As a result of the study, highly effective and sustainable biosorbent candidates with potential applicability in the treatment of textile wastewater were identified. The findings are expected to provide valuable insights and guidance for future advanced applications in the field of environmental biotechnology.

Nanoremediation of Methylene Blue with Biologically Synthesized AgMgO Nanoparticles from *Parmelia tiliaceae*

Ayşe Selin SAYGI, Zekiye KOCAKAYA , Esra ERKOÇ, Nur Koçberber KILIÇ

Department of Biology, Faculty of Science, Ankara University, Ankara, 06100, Türkiye E-Mail nrkilic@ankara.edu.tr

Department of Plant and Animal Production, Safiye Çıkrıkçıoglu Vocational School, Kayseri University

Green synthesis of nanoparticles has garnered significant attention due to their status as an eco-friendly and sustainable alternative to conventional chemical and physical synthesis methods. This method utilizes a variety of biological sources, including plants, lichens, bacteria, algae, and fungi, to produce nanoparticles. In the biological synthesis of nanoparticles using living cells, the selection of microorganisms that produce high amounts of biomass is very important. Lichens are among the most abundant organisms in terms of biomass. Recently, the bimetallic nanoparticles have emerged as a promising approach to generate novel materials that benefit from the combined effects of their individual metallic components. The enhanced morphology of silver-based MgO nanomaterials has been reported to have exceptional photocatalytic properties.

In the current study, the lichen-based AgMgO nanoparticles (AgMgO NPs) was synthesized from *Parmelia tiliaceae* (Department of Plant and Animal Production, Safiye Çıkrıkçıoglu Vocational School, Kayseri University). The characterization of AgMgO NPs was performed with using UV-Vis spectroscopy, Dynamic Light Scattering (DLS), Scanning Transmission Electron Microscopy (STEM), Scanning Electron Microscope (SEM), Fourier Transform Infrared Spectroscopy (FTIR) analysis. It was observed that AgMgO NPs had photocatalytic activity in removing Methylene Blue (MB) dye. Nanoremediation trials were carried out with various concentrations (2-10 mg/L) of MB dye. The findings highlighted that lichen-mediated, green-synthesized AgMgO nanoparticles are a cost-effective and biocompatible nanomaterial, indicating that they may have a wide application capacity in environmental and industrial fields.

Removal of Methylene Blue Dye Using Biogenically Synthesized Silver Nanoparticles

Batıkan FERAH[1], Filiz KORKMAZ[2], Nur Koçberber KILIÇ[1]

[1]*Department of Biology, Faculty of Science, Ankara University, Ankara, 06100, Türkiye*

[2]*Department of Engineering, Faculty of Science, Atılım University, Ankara, Türkiye*

E-Mail : nrkilic@ankara.edu.tr

Silver (Ag) nanoparticles have attracted considerable attention due to their distinct properties and versatile applications in various fields such as medicine, agriculture, and environmental science. These nanoparticles exhibit unique characteristics, such as high surface area to volume ratios, enhanced reactivity, and the ability to interact with biological systems at the molecular level, which make them particularly useful in a wide range of applications. The biogenic synthesis of these nanoparticles, a process involving the use of microorganisms offers a sustainable and environmentally friendly alternative to traditional chemical synthesis methods. Unlike traditional chemical routes, which often involve toxic reagents and high energy consumption, biogenic synthesis relies on natural processes to reduce metal ions to their nanoparticle form, leading to the production of nanoparticles with distinct size, shape, and functional properties.

In this study, biogenic silver nanoparticles (AgNPs) were synthesized using shipyard wastewater effluent from Muğla/Turkiye as a sample. Wastewater sample was inoculated in Nutrient Broth medium which contains heavy metal and a mixed bacterial culture was obtained. From this mixed culture, a 100 µL sample was transferred onto agar plates containing heavy metal salts to facilitate the isolation of a pure bacterial culture capable of reducing metal ions. The isolated bacterial strain was then utilized for the biogenic synthesis of silver nanoparticles. Production and characterization of the nanoparticles was confirmed with UV-Vis spectroscopy, Transmission Electron Microscopy (TEM), FTIR and zeta potential analysis. Biogenically synthesized AgNPs were applied for the nanoremoval of Methylene Blue (MB) dye. Bacterial-mediated AgNPs were added to a 75 mL study solution containing 10 mg/L of dye, at a concentration of 25 mg. As a result of the experiments, methylene blue was efficiently removed from the solution.

Silver Nanoparticles (AgNPs) by *Stenotrophomonas maltophilia*: An Investigation About Different Application Areas of These Biogenic AgNPs

Esra ERKOÇ, Nur KOÇBERBER KILIÇ

Department of Biology, Faculty of Science, Ankara University, Ankara, 06100, Türkiye E-Mail : eerkoc@ankara.edu.tr

The synthesis of nanoparticles by means of green synthesis has become an environmentally friendly alternative to classical methods and toxic chemical synthesis. Green synthesis is an environmentally friendly method that involves the use of biological materials, including bacteria, plants, fungi and algae. This method involves the synthesis of nanoparticles of varying sizes and morphologies through diverse synthetic pathways. Synthesized nanoparticles have a variety of applications. Among these are antibacterial properties in food packaging, catalytic properties leading to environmental improvements, use in electronic devices, medical equipment, bioimaging, water treatment, biosensors, cancer therapies, and the textile and dye industry. Silver nanoparticles are utilized due to their distinctive properties, including their large surface area to volume ratios and the ease with which they can be modified.

In this study, *Stenotrophomonas maltophilia* bacterium from the Bioremediation Research Laboratory (Ankara University, Faculty of Science, Department of Biology) was used in producing silver nanoparticles. The production of silver nanoparticle (AgNP) by *S. maltophilia* was investigated under 37°C. During the AgNP production process, UV-vis spectrophotometry and Transmission Electron Microscope (TEM) analysis were employed to find the conditions conducive to the formation of the smallest AgNP. To determine the structure that facilitate AgNP production, attenuated total reflection Fourier Transform Infrared Spectroscopy (ATR-FTIR) analysis was performed. Photocatalytic activity of AgNPs were carried out in a working solution of 75 mL distilled water containing 20 mg/L Methylene Blue (MB) and 25 mg AgNP was added. The photocatalytic efficiency of AgNPs obtained by green synthesis were investigated with samples taken at different time intervals (10–320 minutes). The data obtained from trials showed that the tested particle demonstrated effective dye removal capability.

Lichen-Mediated Synthesis of Ag–ZnO Nanoparticles and Their Application in Methylene Blue Removal

Esra ERKOÇ[*], Zekiye KOCAKAYA[**], Fatma KILIÇ DOKAN[***] Nur KOÇBERBER KILIÇ[*]

[*]*Department of Biology, Faculty of Science, Ankara University, Ankara, 06100, Türkiye*

[**] *Department of Plant and Animal Production, Safiye Çıkrıkçıoglu Vocational School, Kayseri University, Kayseri, 38400, Türkiye*

[***] *Department of Chemistry and Chemical Processing Technologies, Mustafa Çıkrıkcıoglu Vocational School, Kayseri University, Kayseri, 38400, Türkiye,*

E-Mail : *eerkoc@ankara.edu.tr*

In recent years, nanoparticles (NPs) have emerged as a significant class of nanomaterials (NMs) and are widely applied in various fields, including catalysis, photonics, optoelectronics, biology, pharmacology, environmental monitoring, and drug delivery systems. The integration of green synthesis methods into scientific research and industrial production processes has been proposed as a potential solution to the limitations of conventional synthesis techniques. Lichens can serve as natural reagents and stabilizers in nanoparticle production. The biological components found in lichens can regulate the size and morphology of nanoparticles while preventing aggregation. Furthermore, biomolecules present in lichens facilitate the formation of metal nanoparticles through the reduction of metal ions. Bimetallic nanoparticles (BNPs) consist of two different metal atoms that are bonded to form a single nanoparticle. Besides the combination of properties associated with the two metals, BNPs are suggested to exhibit new characteristics due to the synergistic effects of the constituent metals.

This study aimed to achieve the biogenic synthesis of Ag-ZnO nanoparticles using *Ramalina farinacea*. The primary goal was to characterize these nanoparticles, and their properties were analyzed using techniques such as Ultraviolet–Visible (UV-Vis), Dynamic Light Scattering (DLS), Field Emission Scanning Electron Microscopy (FE-SEM), Scanning Transmission Electron Microscopy (STEM), Fourier Transform İnfrared (FTIR), Energy Dispersive X-Ray Spectroscopy (EDX), and X-Ray Diffraction (XRD). The photocatalytic activity of the biogenic Ag-ZnO NPs was evaluated through the catalytic degradation of Methylene Blue (MB) under UV irradiation. Ag-ZnO NPs were employed as catalysts at a concentration of 50 mg in 50 mL of 10 mg/L MB solution. The degradation process was monitored by recording absorption spectra using a UV-Vis spectrophotometer at 664 nm. According to the results obtained, the tested nanoparticles were found to be effective in methylene blue removal.

Silver Nanoparticles Produced by *Psuedomonas aeruginosa* and Investigation of Their Potential in Nanoremediation

Esra ERKOÇ[*], Filiz KORKMAZ ÖZKAN[**] Nur KOÇBERBER KILIÇ[*]

[*] *Department of Biology, Faculty of Science, Ankara University, Ankara, 06100, Türkiye*

[**] *Department of Engineering, Faculty of Science, Atılım University, Ankara, Türkiye*

E-Mail : eerkoc@ankara.edu.tr

Biogenic nanoparticles have become an important research topic in recent years due to their advantages such as cost-effectiveness, environmental friendliness, ease of production, and the ability to use different organisms. Among nanomaterials, metal-based nanoparticles are one of the most studied types due to their wide range of applications and various biological properties. Metal-based nanoparticles possess numerous beneficial physicochemical and biological properties, including a high surface area-to-volume ratio, ease of modification, the ability to interact with different ligands, antimicrobial activity, and cytotoxic effects against cancer cells.

In this study, silver nanoparticles (AgNPs) were biologically synthesized using the cell-free supernatant of *Pseudomonas aeruginosa* bacterium. The synthesized AgNPs were characterized using analytical techniques such as UV-Vis spectroscopy and Transmission Electron Microscopy (TEM) and Attenuated Total Reflection Fourier transform Infrared Spectroscopy (ATR-FTIR). Additionally, the photocatalytic performance of AgNPs was evaluated using an experiment that examined the degradation capacity of organic compounds such as Methylene Blue (MB). The aqueous solution was prepared in dye concentration of 20 mg/L and 25 mg AgNPs.These findings suggest that silver nanoparticles could offer a potential solution in combating environmental pollution and that biological synthesis methods provide an environmentally friendly and effective alternative.

Cellular Immune Response of *Periplaneta americana* to Bio-based Silver Nanoparticles (AgNPs) Synthesized by *Bacillus cereus*

Berfin DİLEKÇİ*, Ayşe Selin SAYGI*, Hakan ESKİZENGİN*, Ebru Gökalp ÖZKORKMAZ**, Nursel GÜL*

**Department of Biology, Faculty of Science, Ankara University, Ankara, 06100, Türkiye*

*** Faculty of Health Sciences, Ankara Yıldırım Beyazıt University, Ankara, 06760,Türkiye*

E-Mail : ebru.gokalpozkorkmaz@aybu.edu.tr

Silver nanoparticles (AgNPs) have garnered significant interest because of their remarkable properties and broad applicability in diverse sectors, including medicine, agriculture, and environmental sciences. Their exceptional features—such as a large surface area-to-volume ratio, increased chemical reactivity, and strong interactions with biological molecules—make them highly valuable for various technological and scientific purposes. The production of these nanoparticles through biogenic synthesis, which utilizes microorganisms, provides an eco-friendly and sustainable alternative to conventional chemical methods. In contrast to traditional synthesis techniques that often involve hazardous chemicals and substantial energy requirements, the bio-based approach leverages natural biological mechanisms to transform metal ions into nanoparticles, resulting in materials with unique sizes, morphologies, and functional traits. Several researches revealed that AgNPs cause oxidative stress and immunotoxic effects on different insect species that has significance in terms of biological control.

In this context, a bacterium namely *Bacillus cereus* was used to synthesize AgNPs. It was aimed to evaluate the efficacy of bio-based AgNPs in biological control through immune modulation in *Periplaneta americana*. In the present study, 0.02, 0.04, and 0.06 mg/ml AgNP doses were applied to 5th stage *P.americana* nymphs. Hemolymph samples were taken from the nymphs at 1, 4,72 hours, and 1 week after the application. Samples were stained with Giemsa and observed under the light microscope. Hemocytes of the control group insects had a normal cell structure and no cellular immune reactions were observed in the hemolymph. In the samples of 1, 4, 72 hours, and 1 week after 0.02 mg/ml AgNP dose exposure, the hemocytes came into contact with each other, formed nodules and capsules compared to the control group. Following the application of the 0.04 mg/ml dose, it was determined that hemocytes, especially plasmatocytes, were in contact with each other with their cytoplasmic extensions and formed nodules and capsules. Moreover, AgNP seemed to cause morphological changes and loss of chromatin material in the nuclei of some hemocytes and vacuoles in their cytoplasm. Additionally, following highest dose 0.06 mg/ml AgNP exposure, nodule and capsule formations were observed in this group as in the application of the 0.04 mg/ml dose. Although resistance to the doses was observed, further studies are required to clarify the knockdown effect.

Development of Environmentally Friendly Spray Insulatıon Foam System

Safa Kağan Şakar, Kevser Harmandar, Yücel Aktay, Murat Baranak

Poleks Kimya Sanayi ve Ticaret AŞ. Akçaburgaz, Osmangazi Cd No:5, 34522 Esenyurt/İstanbul

ksakar@polexchem.com.tr

Spray foam insulation is widely used to improve energy efficiency in buildings by reducing heat loss. However, many traditional spray foams contain chemicals that can harm the environment. An environmentally friendly spray foam insulation system uses natural and sustainable materials to lower environmental impact while providing effective insulation. Each year, millions of tons of PET (polyethylene terephthalate) waste accumulate worldwide underscoring the urgent need for effective recycling strategies. This project aims to address both issues by developing a sustainable spray foam insulation system that utilizes recycled PET-based polyester polyols and excludes the use of hydrocarbon-based blowing agents.

The proposed material will be applied in liquid form using a spray gun and will rapidly expand upon application to form a rigid foam structure, providing efficient insulation. The innovative formulation will rely solely on water as a blowing agent, significantly reducing environmental impact while maintaining high performance standards. By enabling the reuse of PET waste and eliminating harmful chemical propellants, the project will contribute to the green transition in the insulation materials sector and support broader goals for a sustainable and low-carbon future.

In this study, an environmentally friendly spray insulation foam system was developed to reduce volatile organic compound (VOC) emissions and minimize environmental impact. The formulation was based on waterborne polyols and bio-based raw materials, replacing conventional petroleum-derived components. Experimental results demonstrated that the foams exhibited excellent thermal insulation, dimensional stability, and mechanical strength. Moreover, the system showed reduced flammability and lower toxicity compared to traditional spray foams. These findings suggest that the developed foam system is a promising alternative for sustainable building insulation applications.

Acknowledgement: TÜBİTAK / 1832 - Sanayide Yeşil Dönüşüm Çağrısı, 3248307.

A Project on the Circular Economy Pathways for the Energy Transition

Cigdem Balcik*, Krzysztof Pikoń, Selcuk Toprak, Banu Cetin, Marta M. Alves, Andreas Saniter, Kylene De Angelis, Agnieszka Sznyk, Oguz Dal, Myrthe Reinsberg

** Gebze Technical University, Department of Environmental Engineering, 41400, Gebze, Kocaeli, Türkiye*

e-mail:cigdembalcik@gtu.edu.tr

The Circular Economy Pathways for the Energy Transition (CESynergy) project, funded by the Erasmus+ Programme (KA220-HED), aims to embed circular economy principles into higher education curricula to support Europe's transition toward a sustainable and resource-efficient energy future. Although renewable energy systems significantly reduce greenhouse gas emissions, they depend heavily on critical and finite raw materials. This interdependence creates a fundamental challenge between achieving climate neutrality and ensuring material circularity. CESynergy responds to this challenge by developing innovative educational tools that link energy transition, sustainability, and resource management within a circular framework. The project brings together six European partners from Poland, Germany, Portugal, Türkiye, Italy, and Poland to co-design and implement an **interactive e-learning course**, a **digital compendium of knowledge**, and a collection of **modular educational "nuggets."** These learning resources integrate real-world case studies, challenge-based activities, and flexible teaching methodologies that can be adapted across disciplines and institutions. Expected project results include:

- An open-access e-course and e-compendium on circular economy pathways for the energy transition.
- Transferable teaching modules and assessment tools promoting active, interdisciplinary learning.
- Enhanced educator competencies in sustainability-oriented pedagogy.
- Increased awareness among students, teachers, and professionals about material efficiency, circular design, and sustainable energy systems.

By fostering collaboration between academia, industry, and civil society, CESynergy contributes to the development of future professionals equipped with the knowledge and skills necessary to balance climate protection with responsible resource use. Ultimately, the project supports the **European Green Deal** objectives by integrating circular economy thinking into engineering and environmental education, bridging the gap between technological innovation and sustainable development.

Acknowledgement

This project is funded by the Erasmus+ Programme of the European Union (2023-2-PL01-KA220-HED-000176449). Views and opinions expressed are however those of the author or authors only and do not necessarily reflect those of the European Union or the Foundation for the Development of the Education System. Neither the European Union nor the entity providing the grant can be held responsible for them.

Reduction of Carbon and Water Footprints in Environmental Analysis Laboratories: A Sustainable Management Approach

Seren KASAP*, Ali ÜLKER[2], Tanya AKTAŞ ÜLKER[3]

[1] *Gemar Çevre Ölçüm ve Analiz Laboratuvarı, Çanakkale, Türkiye*

[2,3] *ENV Enerji, Çevre Yönetimi ve Teknolojileri, Çanakkale, Türkiye*

E-mail: seren.keklik@gemar-jma.com.tr

Environmental analysis laboratories play a pivotal role in pollution monitoring, ensuring regulatory compliance, and supporting the development of environmental management strategies. However, their operations can themselves generate environmental impacts due to high energy and water consumption and chemical waste generation. This study evaluates sustainability strategies implemented to reduce the carbon and water footprint of an active environmental laboratory operated by Gemar Çevre Ölçüm ve Analiz İş Sağlığı ve Güvenliği Jeo. Mad. İnş. San. Tic. Ltd. Şti. The study prioritized the optimization of analytical workflows, the adoption of high energy-efficiency instruments, the utilization of solvent recovery systems, and the improvement of waste management practices. Furthermore, the transition to micro-scale sample preparation techniques and the integration of closed-loop cooling systems significantly reduced water consumption. Preliminary assessments for 2023 indicate an approximately 32% reduction in annual water use, with 112,500 L of 351,795 L total consumption recovered, and a complete (100%) offset of electricity demand through photovoltaic (PV) energy generation, resulting in surplus energy supplied to the grid. All these improvements were achieved while maintaining analytical performance and data integrity. The findings demonstrate that environmental laboratories can evolve from mere pollutant detection centers into active contributors to sustainable solutions. The widespread adoption of such practices will support climate change mitigation efforts and facilitate progress toward green laboratory accreditation processes.

Keywords: Environmental laboratory, sustainability, carbon footprint, water footprint, energy efficiency, solvent recovery, green laboratory

Reducing Carbon Footprint in Polymer-Based Materials: Recycled and Bio-Based ABS Applications in the Context of Carbon Border Regulations

Yasemen Gökkurt

R&D Product Technology Manager, EGGER GROUP, R&D Department,

EGGER Dekor A.Ş. GEPOSB, 12. Cad, No: 12 Gebze, 41400 Kocaelil/Türkiye

yasemen.gokkurt@egger.com

Sustainable material development has become a strategic focus in polymer chemistry, aiming to mitigate environmental impacts through innovative approaches. This presentation explores the use of recycled (rABS) and bio-based acrylonitrile butadiene styrene (ABS) resins to reduce the carbon footprint in polymer production. These materials will be evaluated in comparison to conventional fossil-based ABS in terms of life cycle assessment (LCA), energy consumption, greenhouse gas emissions, and processability.

The second part of the presentation addresses the implications of emerging regulatory frameworks, particularly the EU Carbon Border Adjustment Mechanism (CBAM), on the polymer industry. Although polymers are not yet directly covered by CBAM, future inclusion is anticipated, especially for high-emission materials such as ABS. CBAM aims to level the playing field between EU producers and international suppliers by pricing embedded carbon emissions in imported goods. This creates a strategic incentive for manufacturers to adopt low-carbon alternatives, such as recycled and bio-based polymers.

By aligning with circular economy principles, this study highlights how sustainable polymer solutions can meet both technical performance requirements and regulatory compliance, offering a competitive advantage in carbon-conscious markets.

Valorization of Poultry Cartilage By-Products for the Sustainable Production of Chondroitin Sulfate

Ahmet Tekin[1,2], Beyza Çay[2], Saeid Chobdar Rahim[2], Zehra Betül Ahi[2], Mahmut Durmuş[1]

[1]Gebze Technical University, Department of Chemistry, Gebze 41400, Kocaeli, Türkiye

[2] Kazlıçeşme Leather Products R&D Industry and Trade Ltd. Co., İstanbul, Türkiye

E-Mail : ahmettekin.ahmettekin@gmail.com

Chondroitin Sulfate (CS) is a sulfated glycosaminoglycan that serves as a fundamental building block of articular cartilage and is widely used in the treatment of osteoarthritis. With the increasing global market size, the search for sustainable raw material alternatives to traditional bovine and porcine sources has gained importance. The poultry processing industry has a large production volume worldwide, and significant amounts of breast cartilage (sternal cartilage) are generated as by-products during this process. In Türkiye, these cartilage wastes, estimated to exceed 6,000 tons annually, are generally converted into low value-added products or disposed of. The aim of this study is to develop a sustainable process for the production of high value-added CS from sternal cartilage, a waste of the chicken processing industry, in line with "Zero Waste" and "Circular Economy" principles, and to realize its production on a pilot scale.

In the study, cartilages cleaned by mechanical pre-treatment were subjected to hydrolysis using different proteolytic enzymes (Papain, Alcalase, and Flavourzyme) and ultrasound-assisted extraction (UAE) methods. In optimization studies performed at laboratory scale, parameters achieving the highest yield and purity values were determined using Response Surface Methodology (RSM). The obtained hydrolysates were passed through coarse filtration, linter filtration, and microfiltration processes; subsequently, they were purified using membrane technologies (diafiltration) and ion-exchange resins. Optimum conditions were transferred to 20 L volume bioreactors to carry out pilot production, and the product was converted into powder form using a spray dryer.

Findings showed that the Papain enzyme provided the highest bioactivity and yield by preserving the molecular integrity (~35-37 kDa) of CS. Conversely, it was determined that the Alcalase enzyme excessively degraded the CS structure, reducing the molecular weight to undesirable levels (<10 kDa). FTIR spectra of samples produced at pilot scale confirmed the preservation of characteristic bands belonging to sulfate and carboxylate groups and structural compatibility with commercial standards. As a result of chemical analyses, it was determined that the obtained product had a purity of over 90%, and its protein and ash content met USP standards. In conclusion, this study proved that contribution to the national economy can be provided by creating import substitution through the valorization of industrial wastes and that sustainable CS production is possible with green chemistry principles.

Design, Synthesis and Electrochemical Properties of Pyrazole-Based Organic Fuel Cell Anode Catalysts

Omruye Ozok-Arici [1], Arif Kivrak [2*], Sefika Kaya[3], Aykut Caglar [4] , , Hilal Kivrak [3]

1- Faculty of Engineering and Architecture ,Eskisehir Osmangazi University, Eski ¸sehir 26040, Turkey

2- Faculty of Sciences and Arts Department of Chemistry, Eski ¸sehir Osmangazi University, Eskisehir 26040, Turkey

3- Department of Chemical Engineering Faculty of Engineering and Architecture Eskisehir Osmangazi University, Eski ¸sehir 26040, Turkey

4- Department of Basic Sciences, Faculty of Engineering, Architecture and Design, Bartin University, 74100, Bartin, Turkey

E-Mail : arif.kivrak@ogu.edu.tr

Abstract

Energy is considered the most important indicator of social and economic life. However, obtaining energy from fossil fuels causes serious problems such as global warming and environmental pollution. New solutions have emerged to minimize these problems. The use of renewable energy sources has become an alternative solution to address these issues. Nitrogen- and sulfur-based organic compounds, including indoles, benzothiophenes, oxadiazoles, thiophenes, pyrazoles, and carbazoles, play a significant role in the development of new materials[1]. Pyrazoles with heteroaromatic ring systems are highly important for both biological and materials applications. The high thermal and redox stability of pyrazoles and their derivatives makes these structures a sought-after heteroaromatic in material applications[2]. Hydrazine, glucose, formic acid, ethanol, and methanol are frequently used in fuel cells. Among these, hydrazine is of great importance due to its advantages such as easy storability, high energy density, and low cost. However, hydrazine does not produce CO2 through electrooxidation and therefore does not cause greenhouse gas emissions. In this study, pyrazole derivatives were synthesized and characterized and it was found that pyrazole-based compounds containing -CN have significant potential as anode catalyst materials for clean energy utilization.

Keywords: Hydrazine fuel cell, organic material, pyrazole.

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Acknowledgements: This work was supported by TÜBİTAK with project number 223Z243.

Toxic and essential elements in Thymus serpyllum L. and Sambucus nigra L. from the region of North East Bulgaria

Angelika Georgieva, Katya Peycheva*, Veselina Panayotova, Stanislava Georgieva, Albena Merdzhanova

Department of Chemistry, Medical University of Varna, 9002 Varna, Bulgaria

**Corresponding author's email address: peycheva@mu-varna.bg*

Medicinal plants have long been recognized for their therapeutic properties, but recent research has also highlighted their potential as bioindicators of environmental pollution. Due to their wide distribution, capacity to accumulate toxic elements and sensitivity to environmental changes, herbs can serve as effective tools for monitoring ecological contamination. The assessment of the levels of toxic elements in medicinal plants not only provides insight into the safety of their use in traditional and modern medicine but can also be used to objective analysis of environmental quality.

The aim of the study was to assess the concentrations of some toxic and essential elements (Cd, Ni, Cr, Pb, Zn, Cu, Fe, Mn and Al) in two commonly used medicinal plants: wild thyme (Thymus serpyllum L.) and elder (Sambucus nigra L.).

Materials and Methods: Samples were collected from two different locations: industrial areas and rural regions near Varna, Bulgaria. The concentrations of toxic and essential elements were determined by inductively coupled plasma optical emission spectrometer (ICP-OES) after sample mineralization.

The values of toxic elements Pb, Cr and Cd in wild thyme were found respectively from 0.400 to 0.816 mg/kg, from 0.060 to 0.859 mg/kg and from none detected (nd) to 0.028 mg/kg. The measured concentrations of these elements in elder collected from rural regions are below the limit of detection, while the values of elements in this medicinal plant for the industrial zone are: Pb (0.563 mg/kg), Cr (0.949 mg/kg) and Cd (0.102 mg/kg). Concentrations are calculated based on the dry weight of the medicinal plants. The levels of the elements in both herbs from the industrial area were measured higher than in these from the rural region. The differences in the concentrations of the toxic elements (especially of cadmium), for both medicinal plants, collected from the two different regions are larger for the elder.

The levels of toxic elements Pb, Cr and Cd were found below the permissible limit recommended by WHO for herbs. Further systematic study of the content of toxic metals in different medicinal plants from Northeastern Bulgaria is needed as an environmental bioindicators.

Acknowledgment: This study is financed by the European Union-NextGenerationEU through the National Recovery and Resilience Plan of the Republic of Bulgaria, project No. BG-RRP-2.004-0009-C02.

Macro- and Trace-Element Profile in Black Sea Red Mullet (*Mullus barbatus*). Human Health Risk Assesment

Katya Peycheva*, Veselina Panayotova, Diana Dobreva, Rositsa Stancheva, Tatyana Hristova, Albena Merdzhanova

Department of Chemistry, Medical University of Varna, 9002 Varna, Bulgaria

**Corresponding author's email address: peycheva@mu-varna.bg*

Heavy metals are commonly categorized based on their physiological roles and toxicity in organisms as potentially toxic (arsenic, cadmium, lead, mercury, nickel, etc.), probably essential (vanadium, cobalt) and essential (copper, zinc, iron, manganese, selenium). This classification underscores the dualistic nature of trace metals in environmental and food safety evaluations: while some are indispensable at low levels, both deficiency and excess pose health risks, necessitating careful monitoring, particularly in seafood and other bio accumulative dietary sources. Further microelements (Ca, K, Na, Mg) are chemical elements required by living organisms in relatively large amounts to maintain physiological and biochemical functions.

The aims of this study were to measure the concentrations of selected toxic, essential and major elements in the muscle tissue of a common marine fish species *Mullus barbatus* from Black Sea (Bulgaria). In the analysed samples the levels of Cd, Cu, Mn, Ni, Pb, Fe and Zn were under the maximum allowed concentrations for safe human consumption in Bulgaria. The concentration of Cr was under detection limit. The red mullet species is a good source of macronutrients such as potassium and sodium.

An assessment of the human risk by calculation of the target hazard quotients (THQ), hazard index (HI) and target risk (TR) was performed. The target hazard quotient (THQ) for individual elements and HI for combined metals were lower than 1, indicating no health risk for consumers due to the intake of either individual or combined metals. The target risk for Pb and Ni was below 10^{-6}, indicating no carcinogenic risk. According to these results, the consumption of this marine fish species is safe for human health.

Acknowledgment: This study is financed by the European Union-NextGenerationEU through the National Recovery and Resilience Plan of the Republic of Bulgaria, project No. BG-RRP-2.004-0009-C02

Graphene Oxide Functionalized Membranes for Enhanced Antimicrobial and Antibiofilm Performance in Osmotic MBR Systems

Zelal Isik, Zeynep Bilici, Sadin Ozdemir, Nadir Dizge

Department of Environmental Engineering, Mersin University, Mersin, 33343, Türkiye

E-Mail:1zelalisik@gmail.com

Graphene oxide (GO) has emerged as a promising nanomaterial for mitigating biofouling in membrane-based water and wastewater treatment systems due to its unique two-dimensional structure and surface chemistry. In this study, the biological performance of GO-modified membranes was systematically evaluated with respect to antioxidant, antimicrobial, antibiofilm, and microbial cell viability properties. GO exhibited concentration-dependent antioxidant activity, reaching 69.97% DPPH radical scavenging at 100 mg/L. Antimicrobial assessments revealed notable activity against a broad spectrum of microorganisms, with higher effectiveness observed against Gram-positive bacteria. GO also demonstrated significant antibiofilm inhibition against *Staphylococcus aureus* and *Pseudomonas aeruginosa*, particularly at elevated concentrations. Microbial cell viability tests using *Escherichia coli (E. coli)* confirmed a strong dose-dependent inhibitory effect, achieving up to 75.61% inhibition at 20 mg/L. Furthermore, incorporation of GO into membrane surfaces significantly enhanced antimicrobial efficiency, increasing *E. coli* removal from 6.22% for pristine membranes to 82.64% at 2.5% GO loading. These findings highlight the multifunctional role of graphene oxide as an effective surface modifier for improving antimicrobial and antifouling performance in advanced membrane systems, particularly for osmotic membrane bioreactor applications.