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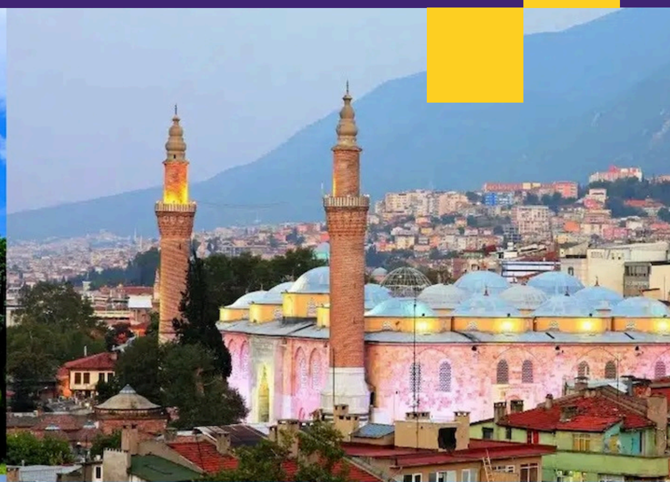
# Engineered Science Annual Conference 2024

## Clean Water and Sustainable Energy 2024



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# Clean Water and Sustainable Energy

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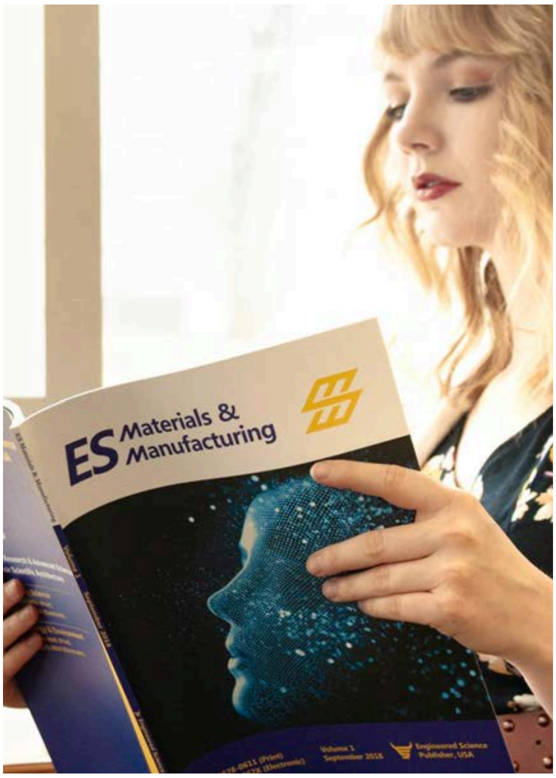


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# Programme

## Day 1: Wednesday, 6th of November

| Time | Event |
| --- | --- |
| From 16:00 | **Registration**<br>Venue: Prof. Dr. Mete Cengiz Conference Center |
| 17:00 - 18:00 | **Welcome Reception** |

## Day 2: Thursday, 7th of November

| Time | Event |
| --- | --- |
| 8:00 - 9:00 | **Registration**<br>Venue: Prof. Dr. Mete Cengiz Conference Center |
| 9:00 - 9:15 | **Opening Ceremony**<br>(National Anthem)<br>Prof. Taner Yonar |
| 9:15 - 10:00 | **Plenary Speech**<br>*Introduction of Engineered Science in Advanced Modern Era*<br>Prof. Zhanhu Guo |
| 10:00 - 10:45 | **Plenary Speech**<br>*Cleaner Production Applications in Turkish Industries*<br>Prof. Mehmet Kitiş |
| 10:45 - 11:15 | **Group photo and break** |
| 11:15 - 11:45 | **Keynote Speech**<br>*Green Ammonia: The Future of Energy through Fuel Cell Technology*<br>Maryam Bayati |
| 11:45 - 12:10 | **A.2.1**<br>*An Examination on Sustainability in the Textile Sector: Ramözlü System*<br>Özlü Mühendislik- Ahmet Akın |
| 12:10 - 12:35 | **B.2.1**<br>Carbon Footprint Analysis of a Phosphate Coating Process in Automotive Production<br>Gülçin Deniz |
| 12:35-13:30 | **Lunch break** |
| 13:30 - 14:15 | **Plenary Speech**<br>*Zero Liquid Discharge Management with Vacuum Evaporation Technology*<br>Prof. Taner Yonar |

| | **Symposium A**<br>Hall: Piyade Kurmay Yarbay İlker Çelikcan Salonu | **Symposium B**<br>Hall: Özel Harekat Polis Memuru İlyas Kaygusuz Salonu |
|---|---|---|
| 14:15 - 14:40 | **A.2.2**<br>Fe3Co nanoparticles embedded carbon nanotube complex as effective bifunctional electrocatalysts for rechargeable zinc-air batteries<br>Denise Bildan | **B.2.2**<br>*Investigation of Electrical Energy Consumption in the Electrochemical Regeneration of Activated Carbon*<br>Leyla Gazigil |
| 14:40 - 14:50 | Break | |
| 14:50 - 15:20 | **Keynote Speech**<br>*Mass Transfer Enhancement for Gas Diffusion Electrode Based Electrochemical Reactors*<br>Asso. Prof. Terence Liu | **Keynote Speech**<br>*Emerging Pollutants: How clean is our clean water?*<br>Prof. Elif Pehlivanoğlu |
| 15:20 - 15:45 | **A.2.3**<br>*Development and Application of Salt-Tolerant Zwitterionic Copolymers for Enhanced Oil Recovery: Synthesis, Characterization, and Performance Evaluation*<br>Zhexenbek Toktarbay | **B.2.3**<br>*Performance of PVDF Membrane for Textile Wastewater*<br>AKKİM- Gülfem Günsür |
| 15:45 - 16:10 | **A.2.4**<br>*Fabrication and application of super hydrophobic polysaccharide membranes*<br>Raushan Soltan | **B.2.4**<br>*A Sustainable Air Purification Technology: Electrostatic Precipitator*<br>Ayça Alkaya- Elif Dicle Turşucular |
| 16:30 - 17:30 | **Engineered Science Society Committee Meeting** | |
| 18:00 - 20:00 | **Banquet Organised by Engineered Science Society** | |

## Day 3: Friday, 8th of November

| **Time** | **Event** |
|---|---|
| 9:00 | **Arrival**<br>Venue: Prof. Dr. Mete Cengiz Conference Center<br>Hall: Özel Harekat Polis Memuru İlyas Kaygusuz Salonu |
| 9:00 - 9:45 | **Plenary Speech**<br>*Rational Design of HeteroStructured Photocatalyst System to Improve Hydrogen Production*<br>Prof. Nurxat Nuraje |
| 9:45 - 10:10 | **B.2.5**<br>*Functionalized Nanoparticle-Modified Electrochemical Sensor for Simultaneous Determination of Cr(III) & Cr(VI)*<br>Munziya Abutalip |

| | |
|---|---|
| | **Break** |
| 10:10 - 10:35 | **A.2.5**<br>*Biogas Production from Animal Waste and Sustainable Energy Potential within the Scope of Green Economy: A Case Study of Erzurum Province*<br>Leyla Gazigil |
| 10:35 - 11:00 | **A.2.6**<br>*Carbon Emissions Calculation of an Automotive OEM Part: A Study on Compliance with the Carbon Border Adjustment Mechanism*<br>Gülçin Deniz |
| 11:00 - 11:25 | **A.2.7**<br>*Kinetic Modelling of Ammonia-Hydrogen Combustion*<br>Zhichao Zhang |
| 11:25-11:50 | **A 2.8**<br>*Bridging Sustainability with Efficiency: Renewable Energy Solutions in Transportation and Logistics Using Multi-Criteria Decision Analysis*<br>Özay Özaydın |
| 11:50 - 12:30 | **Closing Session and Awards Ceremony** |

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# Plenary Abstracts

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# Cleaner Production Applications in Turkish Industries

Mehmet Kitis[1], Emrah Ozturk[2], Elif Simsek Yesil[1], Pınar Hasanoglu Ozturk[3]

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Cleaner production (CP) is a proactive environmental protection strategy based on the reduction of resource consumptions, prevention of wastes and emissions with a holistic approach at the source. The best available techniques (BATs) include a balance between the required costs and benefits in cleaner production applications. Developing strategies for the sustainable use of water in industries is necessary and compulsory. Integrated approaches such as CP and water control measures can provide effective results in reducing water consumption in industries. In addition to water use, wastewater amount and wastewater pollution loads can also be reduced with water efficiency practices. With such practices, not only water consumption and wastewater generation can be reduced in industrial facilities, but also energy consumption, chemical use, environmental discharge and emissions, and production costs can be diminished. Efficiency studies should be carried out not only for water but also for other inputs such as chemicals, energy, and raw materials in the industrial facilities. Water Efficiency Feasibility Study for a specific industrial facility may basically include following sections: characterization of the facility, current water use and pricing, process-based and other water use points, examination of relevant sectoral BAT reference (BREF) documents and reports of similar facilities related to water use, potential reductions in water use and wastewater production, identification of the current status, determination of the sectoral BATs to improve water efficiency, and cost-benefit analysis. In this invited speech, industrial cleaner production studies and water control measures planned or already implemented in full-scale will be presented. Case studies and success stories from Turkish industries will be discussed.

# Rational Design of HeteroStructured Photocatalyst System to Improve Hydrogen Production

Yerbolat Magazov[a], Vladislav Kudryashov[b], Magzhan Amze[a], Nurxat Nuraje[a,b]

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[b] *Lab of Renewable Energy Systems, National Laboratory Astana, Nazarbayev University, Astana, 010000*

Solar water splitting has become the most promising strategy towards green energy via producing hydrogen fuel. Decades of research resulted in the development of photoactive materials that are capable of splitting water under solar irradiation. Most of them absorb and utilize only UV and visible light. Taking into consideration that the UV accounts for 9.3% ($\lambda < 400$ nm) and visible light is 54.1% ($400 < \lambda < 800$ nm), the rest 36.6% which accounts for IR light ($\lambda > 800$ nm) results in significant losses of solar energy. Therefore, one of the major goals of this work is harnessing and full use of solar energy, especially IR light. The problem of harvesting the lost photons can be solved via implementing photon upconverting materials into water-splitting devices.

Our work is based on the basic approach of using upconversion material for water splitting where the heterostructured system $Cu_2O$/ZnO/TiO2 absorbs the UV-Visible light, and the rest of the light (IR) is absorbed by the upconverter. The upconverter, later, emits high-energy photons which are get absorbed by our photocatalyst. This strategy allows to dramatically improve harnessing the light.

# Zero Liquid Discharge Management with Vacuum Evaporation Technology

Prof. Dr. Taner YONAR[1], Ayça ALKAYA[1], Seminay SALİ[1]

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The increasing focus on sustainability has made conservation of water resources and "Zero Liquid Discharge" (ZLD) an important goal. Zero liquid discharge (ZLD) is the full utilization of liquid (here specifically water) in a lossless manner off-site [1]. ZLD technology is the process of recycling water and reusing valuable nutrients from treated wastewater [1]. ZLD provides significant benefits such as recycled treated water, reduced disposal costs, raw material recovery, reduced environmental footprint and regulatory compliance without exceeding the discharge limit. Achieving ZLD in various industries such as detergents and cosmetics, die casting, chemical-pharmaceuticals, food industry, biogas production and more is associated with Vacuum Evaporation Systems. A system capable of producing high quality treated water for in-process recycling can be achieved through a combination of technologies such as membranes and evaporators. In addition, the waste concentrate can form tangible solid end products.

Evaporation in wastewater treatment consists of heating wastewater to evaporate the water content, removing contaminants such as salts, heavy metals and organic compounds, and condensing it to obtain a concentrated residue and purified water vapor that can be reused [2]. This method is important for the treatment of highly saline or toxic industrial wastewater. Evaporation can be useful for storage and transportation when used to reduce the volume of anaerobic digestate. The performance of this method is typically vacuum evaporation, which is evaluated on two key metrics: evaporation rate and energy efficiency [3]. Evaporation rate is the amount of solvent removed per unit time, while energy efficiency is the amount of energy consumed based on the amount of solvent evaporated. Several operational factors that seriously affect the performance of the evaporator are temperature, pressure and mass flow rate [4]. High temperatures generally increase the evaporation rate, while optimum pressure control is important to maintain vacuum conditions and reduce energy consumption. The mass flow rate of the feed also directly affects the evaporation rate [5].

**Keywords:** Zero Lquid Discharge, Vacuum Evaporation, Liquid Waste Management, Wastewater Treatment, Evaporation

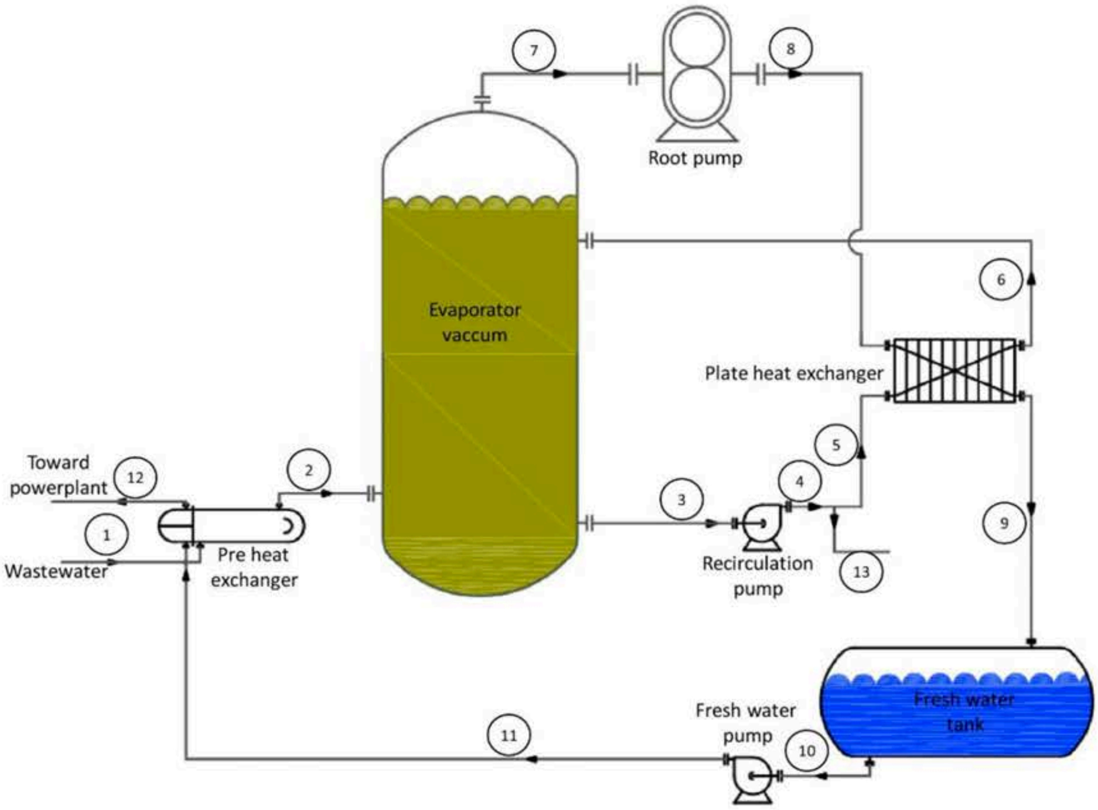


**Figure 1.** Schematic of the ZLD system operation [5]


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# Keynote Abstracts

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# Green Ammonia: The Future of Energy through Fuel Cell Technology

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Ammonia is a promising carbon-free renewable fuel with a high energy density for fuel cells. It can be liquified at room temperature under 10 bar pressure or at −33 °C in atmospheric pressure, making it an attractive hydrogen carrier with an already existing global distribution infrastructure. The integration of ammonia fuel cells and green ammonia synthesis represents a promising pathway towards a more sustainable and secure energy future. By leveraging renewable resources, these technologies can play a crucial role in reducing environmental impact and enhancing energy resilience.

Electrochemistry plays a crucial role in the production of green ammonia and ammonia fuel cells, offering a sustainable alternative to traditional methods. Preparation of an efficient and selective electrocatalyst at ambient temperature and pressure is imperative for both technologies. This presentation focuses on electrocatalysts recently synthesised in my group for ammonia oxidation (AOR) and nitrogen reduction (NRR) reactions and their performance with an emphasis on cost effective low-/non-precious metal catalysts such as Co MOF catalysts MoCxNy for NRR and AOR respectively.

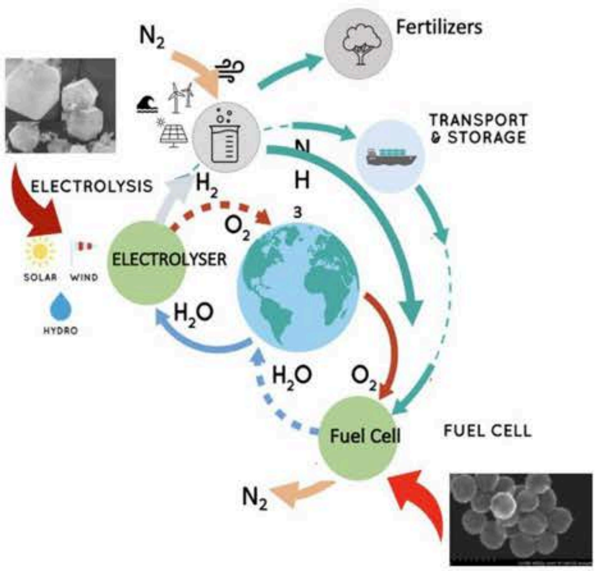


Figure 1. A schematic diagram showing methods and materials demanded for green ammonia synthesis (in an electrolyser), and its utilization by ammonia fuel cells and SEM micrographs of Co MOF catalysts MoCxNy for NRR and AOR respectively.

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# Mass Transfer Enhancement for Gas Diffusion Electrode Based Electrochemical Reactors

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The electrochemical reaction generally occurs at the interface between electrode/electrocatalyst and electrolyte including charge transfer, phase transformation and mass transport. These reactions involve charge transfer, phase changes, and mass transport. A major challenge in these reactions is the limited mass transfer, primarily due to the properties of liquid and gaseous reactants that have low concentrations on the electrode/electrocatalyst surface. This presentation will highlight various strategies designed to enhance mass transfer. These include modifying electrochemical reactors[1], using alternative electrodes[2], and altering the structure of the electrocatalyst layers[3]. These approaches can effectively lower reaction barriers, thereby achieving rates sufficient for the reactants to be present along the gas-liquid-solid interface. This shortens the gas diffusion path and enhances mass transfer. These techniques have been widely adopted in $eCO_2RR$ and fuel cell applications.

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# Emerging Pollutants: How clean is our clean water?

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Water is essential for life and its proper treatment is necessary before its consumption as drinking water. The quality of drinking water is determined through comparison of numeric values of conventional water quality parameters in our samples and in drinking water quality standards. We assume that having compliance with current drinking water quality standards makes our drinking water clean. Unfortunately, ensuring "cleanness" is not easy and one must understand the importance of emerging pollutants- pollutants that are yet to be regulated by drinking water standards.

Emerging pollutants are pollutants that we usually have just started quantifying analytically and/or realized that they pose a threat. Nevertheless, they could have been present in the aqueous environments for a long time without being detected due to limitations of analytical instruments. With advances in analytical measurements, more target compounds can be detected and once we can detect a pollutant, it is relatively easy to find an engineering solution for its treatment.

However, target analysis is not enough to see the full profile of pollutants in waters and using advanced technologies including high resolution mass spectrometry can provide a more holistic picture of our water. Non-target analysis will enable us to detect pollutants in our samples, even if we do not have information about their name or chemical structure or their possible presence in our samples.

Combining target and non-target analysis provide us information about the presence of difference emerging pollutants but to be able to understand their effects such as endocrine disruption, we have to use some bioassays. Knowing the concentrations of different pollutants may not be useful in understanding the effect they will cause at the concentrations they are present, especially all pollutants at once. Therefore, advanced water research should employ a combination of target and non-target chemical analysis along with bioassays.

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# Oral Abstracts

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## A.2.1
## An Examination on Sustainability in the Textile Sector: Ramözlü System

*Ayça ALKAYA[1], İlayda UMUTKAN[2], Ahmet AKIN[2], Selçuk ÖZLÜ[2]*
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The textile sector holds significant economic and social importance both globally and in Türkiye. As Türkiye's second-largest trade center, Bursa possesses substantial potential in the textiles and ready-to-wear industries. In 2021, textile companies in Bursa achieved exports exceeding 1 billion dollars; however, this sector is also notable for its high energy consumption and environmental impacts.[1] Stenter machines are devices widely used in textile production for managing hot air and steam during the processes of hot weaving and dyeing. In this context, stenter heat recovery (HR) systems play a crucial role in recovering waste heat and improving air quality.[2] The smoke and gases emitted from ramöz chimneys can negatively impact air quality, leading to health issues. This study examines the HR and electrostatic filtration system (ESF) of the ramözlü-HHS20 model stenter chimney, focusing on the operational performance of the HR units and the ESP system. The system is designed for stenter machines with a flue gas flow rate of 20.000 $m^3/h$, with the aim of recovering energy from the flue gases and releasing it into the atmosphere in a clean manner. The system consists of air-to-air (AA) and air-to-water (AW) units. The AA-HR unit reduces natural gas consumption by 9% by returning the recovered hot air to the stenter machine. The AW-HR unit, on the other hand, utilizes waste energy from the flue gases to produce hot water. In the AA- HR unit, cold air was heated from 34 °C to 125 °C, resulting in an output power of 114.4 kW. Meanwhile, the AW-HR unit heated water from 20 °C to 46 °C, achieving an output power of 206 kW. Additionally, the ESP system, which operates in conjunction with the heat recovery system, filters out oil vapors, volatile organic carbon (VOC – TOC) compounds, and odor particles from the flue gases. In the examined system, the flue gas temperature before filtration was measured at 175 °C with a TOC value of 155.22 $mg/m^3$, while the temperature after filtration was 57.7 °C with a TOC value of 11.85 $mg/m^3$. These results indicate that the ESP achieves approximately a 92.37% reduction in TOC levels. Thus, greenhouse gas emissions are reduced, contributing to the fight against climate change. The findings underscore the importance of stenter chimney systems and integrated filtration solutions in reducing environmental impacts and enhancing energy efficiency in the textile sector.

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## A.2.2

# $Fe_3Co$ nanoparticles embedded carbon nanotube complex as effective bifunctional electrocatalysts for rechargeable zinc-air batteries

Jifa Dong[a], Yaming Pang[a,1], Denise Bildan[b,1], Lu Xing[b], Xiaoteng Liu[a,b*], Xiangqun Zhuge[a], Yurong Ren[a], Kun Luo[a*]

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$Fe_3Co$ nanoparticles have been successfully embedded within ZIFs 8-derived carbon nanotube complex using a simple solvent-heated self-assembly-pyrolysis strategy, it acts as an efficient ORR/OER bifunctional electrocatalyst and showed outstanding performance of excellent catalytic activity for ORR ($E_{1/2}$=0.87V at 0.1M KOH) and OER (the overpotential at 10 mA $cm^{-2}$ is 390 mV at 1 M KOH). Density functional theory (DFT) calculations demonstrate that the introduction of iron and cobalt atoms significantly affected the adsorption energies of the reactive intermediates. In particular, the combination of cobalt and iron exhibited significantly enhanced ORR/OER activities, revealing an enhanced effect of synergistic interaction of FeCo site and a high bifunctionalization properties. It is used as $Fe_3Co_1$−NC in aqueous zinc-air battery (ZAB) and exhibited a high open-circuit voltage of 1.52 V, power density of 189.8 mW $cm^{-2}$, and long cycle durability of 290 h. Flexible ZABs assembled exhibit high power density (81.59 mW $cm^{-2}$) and long cycling durability (90 h).

A.2.3

# Development and Application of Salt-Tolerant Zwitterionic Copolymers for Enhanced Oil Recovery: Synthesis, Characterization, and Performance Evaluation

Gulim Imekova,[1,2] and Zhexenbek Toktarbay[1]

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This study presents the synthesis, characterization, and evaluation of zwitterionic copolymers designed for enhanced oil recovery (EOR) applications in saline environments. Zwitterionic copolymers P(SB-2VP)AM, P(SB-1VI)AM, and P(SB-DMAPMA)AM were synthesized with varying comonomer ratios, enabling the fine-tuning of their properties. Comprehensive characterization was performed using FTIR, NMR, TGA/DSC, TEM, and SEM, confirming the polymers' chemical structures, thermal stability, and morphology. Molecular weight analysis via GPC and Static Light Scattering indicated that higher acrylamide content led to increased molecular weights, reaching up to 1 million Da, thereby enhancing mechanical and rheological properties. Reactivity ratios, determined by Fineman-Ross, Kelen-Tudos, and Mayo-Lewis methods, highlighted increased reactivity on the acrylamide side, influencing the copolymers' molecular weights. Zeta potential measurements across varying pH levels demonstrated the copolymers' stability, essential for maintaining performance in diverse salt media. Rheological testing confirmed their superior salt tolerance compared to conventional polymers, making them ideal candidates for EOR operations in high-salinity environments. To simulate EOR processes, a microfluidic device was employed, providing insights into the copolymers' behavior at microscale, while core plug experiments revealed that the zwitterionic copolymer P(SB-DMAPMA) (2:98) achieved a 4.2% higher recovery factor than commercial HPAM, underscoring its economic potential. Overall, the zwitterionic copolymers developed in this study exhibit strong potential to enhance EOR efficiency, offering durability, stability, and salt tolerance essential for practical applications in oil recovery. These findings mark a significant advancement in EOR technology, promising improved operational efficiency and profitability in the oil industry.

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**A.2.4**

# Fabrication and application of super hydrophobic polysaccharide membranes

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The fabrication and application of superhydrophobic polysaccharide-based membranes have gained considerable attention due to their unique properties and environmental compatibility. Superhydrophobic membranes, characterized by their high water repellency, low surface energy, and self-cleaning abilities, are highly desirable in various industrial applications such as oil-water separation, anti-fouling surfaces, and protective coatings. In this study, we developed superhydrophobic cellulose-based membranes specifically designed for efficient oil-water separation. The fabricated membranes exhibit a water contact angle exceeding 150°, demonstrating exceptional water repellency, which is crucial for separating water from oil mixtures. The oil-water separation efficiency of the membranes reached nearly 100%, showcasing their potential for high-performance applications in environmental remediation. To evaluate the repeatability and durability, the membranes underwent over ten separation cycles, maintaining consistent performance without significant degradation. The results highlight the robustness and reliability of these cellulose membranes in demanding separation processes, making them promising candidates for sustainable and efficient oil-water separation solutions. This work contributes to the advancement of eco-friendly, durable, and high-efficiency superhydrophobic membranes for industrial and environmental applications.

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A.2.5

# Biogas Production from Animal Waste and Sustainable Energy Potential within the Scope of Green Economy: A Case Study of Erzurum Province

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Biogas production from animal waste stands out as an important renewable energy source in the face of developing technology and increasing energy demand. The depletion of fossil fuels and the damage they cause to the environment necessitate the use of alternative sources such as biogas. Animal waste is an ideal raw material for biogas production and has great potential, especially in countries with many animal farms, such as Türkiye. This technology both reduces environmental problems and contributes to the country's economy by reducing external dependency. In addition, while obtaining energy from animal waste, waste is eliminated and negative environmental impacts are reduced. Therefore, biogas production is an important tool to achieve sustainable energy goals.

In this study, biogas production capacity and energy potential in wastes arising from cattle, sheep and poultry resulting for meat or milk production in Erzurum province were investigated. Animal count were obtained from TÜİK statistics for 2023. Taking into account the rates used in the Agro-Waste project, the amount of usable waste was calculated from species-based animal count. Biogas production capacity and energy potential rates were revealed from the animal waste amounts of Erzurum province in 2023. It is aimed that these data obtained will form a basis for future studies.

**A.2.6**

# Carbon Emissions Calculation of an Automotive OEM Part: A Study on Compliance with the Carbon Border Adjustment Mechanism

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The rapid increase in industrialization and the growth of the global economy has significantly raised energy consumption and, consequently, carbon emissions. Carbon emissions are considered one of the main causes of climate change as they lead to the release of greenhouse gases into the atmosphere. Increasing emissions are causing serious environmental issues, such as global warming, extreme weather events, and degradation of ecosystems. In this context, calculating and reducing the carbon footprint of the industrial sector is critical for a sustainable future. The calculation of carbon emissions allows companies to identify their environmental impact, enhance energy efficiency, and develop sustainable production processes. It is also necessary to comply with international regulations and border carbon adjustment mechanisms. The energy and raw materials used in vehicle production processes lead to significant greenhouse gas emissions. Therefore, calculating carbon emissions in the automotive sector is vital for environmental sustainability. Automotive suppliers, as part of the automotive sector, are required to calculate and report the carbon emissions generated in their production processes as part of the supply chain. Under the Carbon Border Adjustment Mechanism (CBAM), products with high carbon intensity are defined according to their The Combined Nomenclature (CN) codes, which are used in the calculation of carbon emissions and import taxation. Products subject to the CBAM due to their CN codes are required to calculate and report their carbon emissions. These calculations also assist OEM customers in achieving their sustainability goals and complying with their environmental obligations. In this context, a company that imports parts for OEM customers located in Bursa has calculated direct and indirect carbon emissions based on the year 2023 as the baseline, in accordance with the Carbon Border Adjustment Mechanism (CBAM). An OEM part subject to the CBAM due to its CN code was selected, and data was obtained by tracking the process flow of the part through all stages. In addition, direct and indirect carbon calculations were obtained from the part's raw material supplier. As a result of the studies, the carbon emissions from direct emissions in 2023 amounted to 7.43 tons of CO2, while the carbon emissions from indirect emissions totalled 11.476 tons of CO2, making a total of 18.91 tons of CO2. The carbon emissions from the part's production processes are 11.476 tons of CO2, while the carbon emissions from raw material production are 7.43 tons of CO2. This study serves as an example regarding OEM expectations and CBAM calculation methods.

## A.2.7

# Kinetic Modelling of Ammonia-Hydrogen Combustion

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This paper investigated the combustion performance of ammonia-hydrogen mixtures in a combustion chamber using kinetic modelling method. The reaction mechanism proposed by Krishna et al. [1] is used in ANSYS Chemkin Pro for the modelling work. The laminar flame speed, nitrogen oxides (NOx) formation and the amount of unburnt NH3 are recorded and discussed in a range of operating conditions, i.e., temperatures from 350K to 750K, pressures from 1 bar to 5bar, equivalence ratio from 0.8 to 1.1, and H2 concentration of from 20% to 50%. Results show that the laminar flame speed and NOx production increase at increased temperatures and hydrogen concentration but reduced at increased pressures. NOx production can also be increased by increasing equivalence ratio within 0.9, but it will be reduced if the equivalence ratio continues to increase. The rate of production of NO study also revealed HNO + OH = NO + H2O as the most important reaction for NO production under stoichiometric and fuel lean conditions. Equivalence ratio has complex influence on unburnt ammonia. When it is changing from 0.8 to 0.9, the unburnt ammonia remains stable at low level and increases at higher temperature. However, when the equivalence ratio becomes larger than 0.9, the unburnt ammonia increases significantly with increased equivalence ratio but keeps dropping when temperature increases.

**A.2.8**

# Bridging Sustainability with Efficiency: Renewable Energy Solutions in Transportation and Logistics Using Multi-Criteria Decision Analysis

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The demand for sustainable transportation and logistics has become central to global environmental and economic strategies, with renewable energy solutions essential in achieving these efficiency and sustainability goals. This study proposes a Multi-Criteria Decision Analysis (MCDA) framework, combining the Analytical Hierarchy Process (AHP) with the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to assess and prioritize renewable energy options for optimizing performance in transportation and logistics. By integrating economic, environmental, and operational factors, the framework offers a structured approach to evaluating renewable energy technologies suited to specific logistical contexts, incorporating considerations of the water-energy nexus within transportation systems.

The MCDA model evaluates criteria including carbon footprint reduction ($CO_2e$), energy efficiency (kWh/km), water consumption (liters/km), scalability, and cost-effectiveness ($/km) to assess renewable options such as biofuels, hydrogen, and electric power. The analysis draws from 15 case studies (2020-2024) of renewable energy implementation across diverse logistics networks and integrates insights from 25 industry experts to refine criteria weighting. Results demonstrate that renewable energy solutions, selected through the framework, can balance environmental impact with operational efficiency, achieving a 25-30% reduction in operational costs and a 40-45% decrease in carbon emissions.

Additionally, findings highlight the need for a multi-dimensional approach to renewable adoption, as logistical requirements vary by region, transportation mode, and supply chain structure. It offers stakeholders a practical decision-making tool aligned with Sustainable Development Goals, particularly Goals 12 (responsible consumption and production) and 6 (clean water and sanitation), by addressing water resource management in energy use. Key gains include reduced fuel costs (15-20%), improved fleet efficiency (20-25%), and enhanced regulatory compliance, contributing to a resilient, low-carbon future for global transportation systems through measurable performance metrics.

## B.2.1

# Carbon Footprint Analysis of a Phosphate Coating Process in Automotive Production

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Reducing greenhouse gas emissions has become a priority strategic goal for both developed and developing countries today. In response to the threats of global warming and climate change, steps toward transitioning to a low-carbon economy are being taken rapidly around the world. Various methodologies and international standards have been developed to minimize the effects of greenhouse gases. The effective and sustainable implementation of these standards is closely related to the importance and support that countries attach to this issue. The PAS 2050 standard is widely used in product carbon footprint calculations. The ISO 14064 standard, used in corporate carbon footprint calculations, is among the most preferred in this field. Basing corporate carbon footprint calculations on either the calendar year is a critical factor for the accuracy and sustainability of the calculations. Knowing their carbon footprints is essential for organizations to develop strategies to control and reduce greenhouse gas emissions. In this study, the carbon footprint of a phosphate-coated part from an automotive factory operating in Bursa was calculated for the year 2023. The calculation steps were defined as scope and boundaries, collection of activity data, quality control, emission factors, calculation, analysis, and subsequent processes. As a result of the calculations, the direct CO2 emissions from the activities within the defined scope of the part were determined to be 2.042 tons CO2/ tons. It was found that 1.945 tons CO2/ tons were from upstream sources, while 0.096 tons CO2/ tons were from operational sources. Additionally, the indirect emissions were calculated to be 0.557 tons CO2/ tons. This indirect emission was observed to originate from the natural gas used in the phosphate coating operation. The total embedded carbon emissions were calculated to be 2.598 tons CO2/ tons. As a result, this study provides an exemplary method for calculating the carbon footprint of a workpiece involving a coating process.

**B.2.2**

# Investigation of Electrical Energy Consumption in the Electrochemical Regeneration of Activated Carbon

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One of the most widely used methods for removing pollutants from wastewater both globally and in our country is activated carbon adsorption. It is also necessary to safely dispose of activated carbon that has reached saturation. One of these methods is the regeneration of activated carbon. Although thermal regeneration is commonly used, it brings additional challenges such as transportation costs and the high energy consumption during the process. Electrochemical regeneration, as it avoids the disadvantages of thermal regeneration, presents a good alternative to thermal regeneration.

The aim of this study is to investigate the amount of electricity consumed during the electrochemical regeneration of activated carbon using an in-situ regeneration method, namely the electrochemical method. In the study, the electrical consumption data for the regeneration of activated carbon, obtained from the market in its saturated state, and laboratory-saturated activated carbon were calculated under optimum conditions. In the electrochemical regeneration, Sn/Sb/Ni-Ti electrodes of 2.5x4x4 cm dimensions and Pi/Ti electrodes of 5x5 cm dimensions were used as anode and cathode. The research was conducted under the following optimal conditions, which had been determined in previous studies for both types of activated carbon: 0.1 M, 50 mA/cm², 4 hours, 13 g of activated carbon, and 200 ml of electrolyte volume. The natural pH value was used as the optimum pH. As a result of the research, the electrical energy consumption was found to be 1.12 kWh/kg for activated carbon saturated with methylene blue and 1.16 kWh/kg for activated carbon obtained from the market in a saturated state under optimum conditions.

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## B.2.3

# Performance of PVDF Membrane for Textile Wastewater

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The fashion industry consumes 93 billion cubic meters of water annually. [1] To make a single cotton t-shirt, 2,700 litres of fresh water are required according to estimates, enough to meet one person's drinking needs for 2.5 years. [2]
In general, dyes are difficult to remove because they are stable to light and oxidizing agents, and with low biodegradability. [3] Various technologies and methodologies used for the treatment of textile dye-containing wastewater, such as; adsorption, ion exchange, coagulation- flocculation and ultrafiltration. Environmental problems with used dye baths are related to the wide variety of different components added to the dye bath, often in relatively high concentrations. [4]

Ultrafiltration technology has shown great potential to treat textile wastewater as it can be applied to remove different kind of dyes. PVDF Poly (vinylidene fluoride) hollow fiber ultrafiltration (UF) is one of membrane filtration techniques in which external hydrostatic pressure pushes a liquid through a semipermeable membrane that is capable of removing target compound from the bulk solution. [5] Akkim is the first and only producer in Turkey and neighbouring countries. The following figure shows the Akkim UF module system.

**Figure 1-**UF Modules system.

PVDF has attracted considerable attention as a commercial polymeric membrane material due to its hydrophobic nature and excellent properties, such as great heat and chemical resistances along with high mechanical strength. [7] PVDF can successfully perform between 3 and 11 pH range for a long time which makes it suitable for textile applications [6] We can see the performance of PVDF UF membrane in figure 2. Also there are some water performance analyses such as; suspended solid, turbidity and color. Suspended solid analyses determines the amount of solid particles suspended in the wastewater. Color parameter measured by Spectrophotometer. Turbidity is a measure of water clarity. High turbidity makes water appear cloudy or muddy. Turbidity unit is NTU. NTU stands for Nephelometric Turbidity unit. [8]

**Figure 2**- Perfomance of textile waste water filtration by PVDF hollow membrane.

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**B.2.4**

# A Sustainable Air Purification Technology: Electrostatic Precipitator

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The acceleration in industrialization has become a serious concern for clean air quality and healthy living. Generally, electrostatic precipitators (ESP), wet scrubbers and fabric filters are suitable technologies for the collection of small particulate matter [1]. According to the Regulation on the Control of Industrial Air Pollution in Turkey, industrial and energy production facilities must reduce their emissions to the atmosphere below the limit value [2]. According to the decisions and reports taken by the Provincial Directorates of Environmental Urbanization and Provincial Directorates, the use of electrostatic precipitators, especially in the textile sector, has been made compulsory as a result of the suitability of their removal efficiency [3], [4], [5].
The principle of operation of electrostatic precipitators is based on the deposition of dust particles in the waste gas stream by the use of electric forces to attract them onto collector plates by imparting a charge in an electrostatic field[6]. Once particles are deposited on the collector plates, they can usually be removed by dropping them from the plates. There are different types of ESPs, some of which remove particles intermittently or by washing with water [7], [8].
This text reviews several studies on the aerodynamic properties and efficiency of electrostatic filters (ESPs) in industrial air purification. One study focuses on an electro-aerodynamic filter with a corona cage using 0.005-inch tungsten wires, achieving up to 99.98% particle capture efficiency [9]. Another study develops a Computational Fluid Dynamics (CFD) model for wire-plate ESPs, using the Reynolds-averaged Navier-Stokes equations and the k-ε turbulence model to simulate turbulent gas flow and electrostatic forces [10]. Results indicate higher particle density near collection walls, aligning with existing data [10]. Additional CFD research simulates flow in thermal power plant ESPs, showing that perforated plates improve flow and energy efficiency [12]. Other simulations identify that cross-flow vortices and ionic winds impact collection efficiency, particularly for small particles [13]. Together, these findings highlight the significant role of aerodynamic design and CFD in enhancing ESP performance across different industrial applications [9-14].

**Keywords:** ESP, Electrostatic Precipitator, Air Purification, CFD.

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**B.2.5**

# Functionalized Nanoparticle-Modified Electrochemical Sensor for Simultaneous Determination of Cr(III) & Cr(VI)

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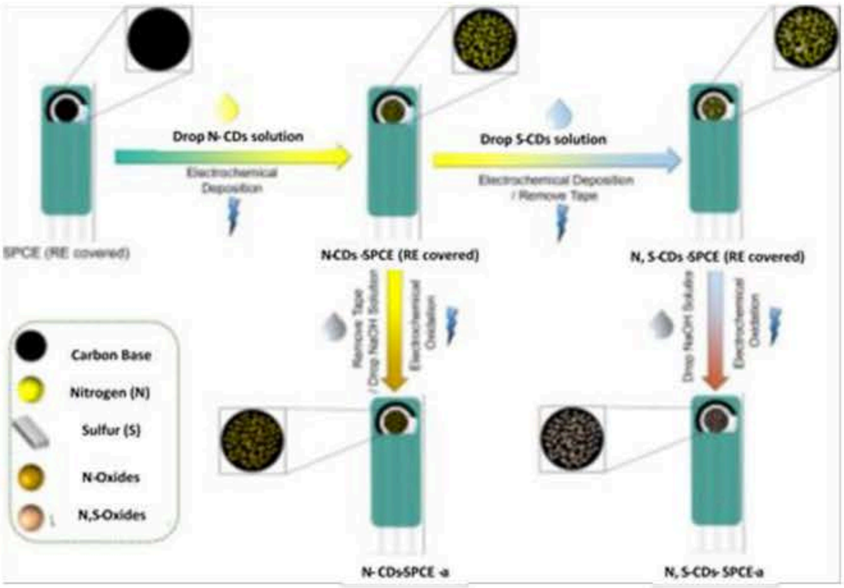
Airborne particulate matter (PM) has become a major global environmental concern due to its critical role in atmospheric processes, adverse health effects, and global climate change [1-4]. Airborne particles serve as vectors for trace metals that are emitted into the atmosphere from anthropogenic and natural sources. Some of these metals, including Cr, are toxic and are linked to adverse health outcomes [5]. Chromium exists primarily in the trivalent, Cr(III), and hexavalent, Cr(VI), forms in ambient particulate matter [6,7]. Cr(III), an essential element and required for the proper functioning of living organisms, is less toxic [8] while Cr(VI) has been identified as a human carcinogen [9]. Exposure to industrial and environmental Cr(VI) may lead to cancer, nasal damage, asthma, bronchitis, and pneumonitis [10].

The proposed work, focused on the development of a functionalized carbon dot-modified electrochemical sensor for the simultaneous determination of Cr(III) and Cr(VI) in ambient particulate matter (PM), holds immense scientific novelty and significance for Kazakhstan. This endeavor not only addresses critical environmental and public health concerns but also contributes to advancing knowledge and technology in several ways. Kazakhstan, with its expanding industrial activities and urbanization, faces growing challenges related to air quality and environmental pollution. Chromium contamination in ambient PM is a significant concern, with potential health risks for the population. By developing a unique sensor array capable of simultaneously detecting both Cr(III) and Cr(VI), this project directly addresses a pressing environmental issue specific to Kazakhstan.

Results from our previous research [11] on sensor development (Figure 1) for Cr detection have garnered significant interest in environmental pollutant monitoring. Nitrogen and zinc-doped fluorescent carbon dots (N,Zn-CDs) were synthesized and utilized as "off" fluorescence detectors, enabling rapid and sensitive detection of only Cr(VI). The fluorescence experiments achieved an impressive low detection limit of 0.47 nmol/L for Cr(VI). Real water samples validated the practical utility of this CDs for Cr(VI) quantification, demonstrating favorable recoveries. The robust recoveries underscore the suitability of the fluorescence probe for precise environmental measurements.




Conceptual illustration of research design of this research work

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