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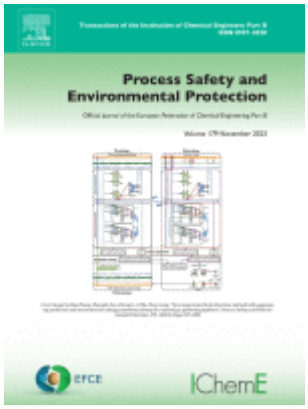

Changwei Niu, Bing Wang, Yaohui Liu, Shengyu Yuan, Zichao Wang. *Effect of hydraulic retention time on the performance of sequencing batch reactor under combined stress of ibuprofen and ciprofloxacin*. Pages 1-9.

The impacts of changes in hydraulic retention time (HRT) on nitrogen elimination, the activity of sludge and the structure of microbial communities in a sequencing batch reactor under the joint stress of ibuprofen (IBP) and ciprofloxacin (CIP) were investigated. Under the combined stress of IBP (belonged to nonsteroidal anti-inflammatory drugs) and CIP (belonged to antibiotics), the elimination level of ammonia nitrogen, chemical oxygen demand, and the rate of specific ammonia oxidation, specific nitrite oxidation, specific nitrate reduction in activated sludge declined with the shortening of HRT. Under the joint stress of IBP and CIP, the content of polysaccharide (PS) and protein (PN) together with the ratio of PN to PS in the extracellular polymeric substances grew with the shortening of HRT, and the content of aromatic proteins increased significantly, which indicated that aromatic proteins were the major protective response substances to the shortening of HRT. Under the joint stress of IBP and CIP, with the reduction of HRT, and the reduction rate of relative abundance of nitrifying bacteria was more evident than that of denitrifying bacteria. This exploration gives novel thoughts for understanding the impacts of HRT on biological nitrogen removal of wastewater under combined stress of IBP and CIP.

- **Keywords:** Ciprofloxacin; Ibuprofen; Extracellular polymeric substances; Hydraulic retention time; Combined toxicity; Bacterial community

Yinquan Hu, Samir I. Badrawi, Jitendra Kumar, Hala Najwan Sabeh, Theyab R. Alsenani, Fahid Riaz, Tamim Alkhalifah, Salem Alkhalaf, Fahad Alturise. *Gas turbine-based system taking advantage of LNG regasification process for multigeneration purposes; Techno-economic-environmental analysis and machine learning optimization*. Pages 10-26.

It is viable for engineers to determine how thermodynamic systems can benefit from heat recovery in order to improve efficiency, reduce costs, and lower carbon dioxide

emissions. The authors of the study propose a new energy system that incorporates various cycles and units, including gas turbines, Rankine and two organic Rankine cycles, an absorption refrigeration unit, a proton exchange membrane (PEM) electrolyzer, and a liquefied natural gas (LNG) unit. The hydrogen produced is stored and transferred for use as fuel. The system was modeled and optimized using MATLAB programming software, with a parametric study and sensitivity analysis conducted before employing a genetic algorithm optimization to find the most suitable performance conditions. Modifying the compressor's pressure ratio within the range of 6–18 caused a shift in the cooling load, ranging from 45 to 36 MW. Nonetheless, these adjustments in pressure ratio yielded a reduction of 0.4 Cent/kWh in levelized cost of electricity (LCOE) and 0.15 $/kg in levelized cost of hydrogen (LCOH). In the base design mode, the total cost rate is 5715.3 $/h, the exergy efficiency is 39.03%, and the normalized CO2 emissions are 335.89 kg/GJ. However, the optimization results showed a reduced total cost rate of 1884.50 $/h, along with an improved exergy efficiency from 39.03% to 40.32% and a decrease in annual CO2 emissions from 211,000 metric tons to 175,000 metric tons. The implementation of artificial neural networks (ANN) has significantly decreased the time required for optimization from 47 h to just 16 min.

- **Keywords:** Machine learning; Hydrogen production; Heat recovery; LNG usage; Absorption chiller

Hongwei Rong, Penghong He, Yuxin Luo, Haizhen Cai, Mahmood Laghari, Dabin Guo, Yan Ren, Baihui Cui. *Research progress of main synthetic catalysts used in biomass pyrolysis.* Pages 27-37.

Biomass catalytic pyrolysis stands as a pivotal solution in the pursuit of alternative fossil energy, with catalysts occupying a crucial role. Diverse characteristics in catalytic pyrolysis necessitate categorization of the primary synthetic catalysts into molecular sieve catalysts, alkali metal catalysts, and transition metal catalysts. Notably, these catalyst types elicit distinct catalytic effects on pyrolysis reactions. Consequently, comprehending the strengths and limitations of diverse synthetic catalysts and surveying the latest advancements in this realm holds paramount importance. This study aims to compare the attributes and catalytic impacts of varying catalyst types while analyzing the factors that influence catalyst performance, encompassing aspects such as structural characteristics, catalytic methods, and reaction temperatures.

- **Keywords:** Biomass; Pyrolysis; Catalyst; Performance regulation; Research progress

Huan Peng, Wenzhe Li, Shiren Zhu, Guangyong Mi, Junliang Peng, Bin Ding, Ling Huang. *Experimental study of influence of CO2 treatment on fracture toughness of tight sandstone*. Pages 38-46.

A large amount of CO2 will be emitted after the burning of fossil fuels, causing global warming and glacier melting which will bring a huge threat to the living environment. Atmospheric clearance through the capture, utilization or storage of CO2 is one of the technologies for dealing with global climate change. In order clarify the mechanization of supercritical CO2 fracturing, the tight sandstone cores in the Jinqiu Gas field, Sichuan Basin were used to carry out the effect research of supercritical CO2 on fracture toughness. The results show that after the treatment of tight sandstone on supercritical CO2, the degradation degree of I-type fracture toughness decreases by 23.6%−33.6% when the soaking days reach 15 days. At the same reaction time, the fracture toughness under 20 MPa and 60 ℃ is lower by 3~11% than that under 10 MPa and 50 ℃. Meanwhile, the geometric fracture trajectories of sandstone samples before and after the treatment of supercritical CO2 treatment are observed. Before the treatment, the Smax was 1.46 mm and the fracture angle was 10.24°, but after the treatment, the parameters were 0.93 mm and 3.41°, respectively. The fracture trajectories after

multiple polishing were observed by SEM imaging, which shows that the fractures can propagate directly through the mineral particles after the supercritical CO2 treatment, which causes the transcrystalline fracture. It is conducive to initiating, propagating, and destroying I-type fractures under smaller external loads. The results further improve the mechanism of CO2 on fracture toughness of tight sandstone, which is useful to explore the feasibility of CO2 fracturing of low-pressure tight sandstone, and provide theoretical support for the safety of CO2 fracturing and CO2 geological sequestration of tight sandstone.

- **Keywords:** Supercritical CO2; Tight sandstone; Fracture toughness; Mineral composition; Microstructure; CO2 sequestration

Benzhou Gong, Kai Duan, Shi Chen, Yingmu Wang. *Enhanced nutrients removal and microbial mechanisms in a pilot-scale anaerobic-oxic-anoxic (A/O/A) system: Synergistic roles of denitrifying polyphosphate accumulating organisms and endogenous denitrifiers*. Pages 47-56.

The realization of low-cost and high-standard nutrients removal are not acquired effectively in conventional pre-denitrification biological nitrogen removal processes (e.g., anaerobic/anoxic/oxic (A/A/O) process) for the treatment of domestic sewage. In this study, a pilot-scale bioreactor system based on the synergism of denitrifying phosphorus removal (DPR) and endogenous denitrification (ED) was proposed for advanced nutrients removal, which was operated under alternating anaerobic/oxic/anoxic (A/O/A) mode with no extracellular carbon source in the anoxic stage. The results showed that A/O/A and A/A/O systems were successfully established and operated in four stages with different mixed liquor suspended solid (MLSS, I: 3.32 ± 0.25 g/L, II: 5.89 ± 0.94 g/L, III: 8.66 ± 0.51 g/L, IV: 9.11 ± 5.72 g/L). Compared with the A/A/O system, the A/O/A system showed significantly higher nitrogen and phosphorus removal effectiveness within hydraulic retention time of 10 h. At MLSS of 8.66 ± 0.51 g/L, the A/O/A system could achieve simultaneously efficient removal of COD (91.47% ± 2.06%, 2.97 ± 0.26 mg COD/(g MLSS·h)), NH4+-N (97.27% ± 1.23%, 0.37 ± 0.06 mg NH4+-N/(g MLSS·h)), TN (89.94% ± 1.47%, 0.45 ± 0.03 mg TN/(g MLSS·h)), and PO43--P (96.67% ± 0.88%, 0.04 ± 0.01 mg PO43--P/(g MLSS·h)), and the effluent concentrations of COD, NH4+-N, TN, and PO43--P were 24.0 ± 3.1, 0.9 ± 0.4, 4.4 ± 0.6, and 0.13 ± 0.03 mg/L, respectively. In addition, microbial community results indicated that denitrifying polyphosphate accumulating organisms and endogenous denitrifiers synergistically enhanced the nutrients removal capacity in the A/O/A system. Overall, this work provides new insight for further scaling and optimization of the A/O/A system.

- **Keywords:** Municipal wastewater; Advanced N and P removal; Denitrifying phosphorous removal; Endogenous denitrification; Microbial community structure

Shohreh Ariaeenejad, Mahmood Barani, Mina Sarani, Azadeh Lohrasbi-Nejad, Ghasem Mohammadi-Nejad, Ghasem Hosseini Salekdeh. *Biocatalytic decolorization of azo dye-containing wastewater by immobilizing metagenome-derived laccase on green synthesized Co-doped NiO NPs*. Pages 57-67.

Efficient removal of toxic dyes from wastewater is crucial for environmental protection. Laccases are enzymes that have been proposed as potential solutions to reduce the devastating effects of toxic dyes with recalcitrant structures present in complex wastewater. However, instability of laccases has been identified as a major issue. This study aimed to develop a carrier matrix based on Co-doped NiO NPs to improve the stability of the metagenome-derived laccase PersiLac1 and achieve high removal efficiency of Azo dye-containing wastewater. The immobilization of laccase led to

improved enzymatic activity over a broader range of pH and temperature. After 15 reuse cycles, the immobilized enzyme retained 57.99 % of its initial activity. The immobilized enzyme demonstrated great potential for the biodecolorization of Congo red over broad pH and temperature ranges, with 66.23 % decolorization achieved after 60 min under optimal conditions. Treatment with real textile wastewater containing an extremely high concentration of Azo dye resulted in more than 92 % dye removal. After 20 cycles of operation, the immobilized enzyme retained 87.66 % of its initial decolorization capability. This study presents Co-doped NiO NPs-PersiLac1 as an efficient, stable, and cost-effective biocatalytic system for Azo dye-containing removal processes in textile effluents.

- **Keywords:** Metagenome-derived laccase; Water remediation; Immobilization; Stability; Green synthesis

Fazil Qureshi, Mohammad Yusuf, Muhammad Tahir, Moinul Haq, Montaha Mohamed Ibrahim Mohamed, Hesam Kamyab, Hong-Ha T. Nguyen, Dai-Viet N. Vo, Hussameldin Ibrahim. *Renewable hydrogen production via biological and thermochemical routes: Nanomaterials, economic analysis and challenges*. Pages 68-88.

The urgent need to address greenhouse gas (GHG) emissions, particularly in relation to climate change, is driving the demand for new sustainable renewable fuels. This demand is promoting the expansion of de-carbonization efforts, which hold tremendous potential as a renewable energy source. One area of focus is the production of hydrogen (H2), which has long been a popular subject of discussion. Currently, large quantities of H2 are generated using conventional fossil fuels. However, the finite nature of these resources has compelled the global community to explore alternative, more environmentally friendly options like biomass. Generating H2 on a large scale from various biomasses presents a complex challenge. Researchers have identified thermochemical (TC) and biological (BL) processes as the primary methods for converting biomass into H2, although other techniques exist as well. Commercializing H2 as a fuel presents significant technological, financial, and environmental hurdles. Nevertheless, nanomaterials (NMs) have shown promise in overcoming some of the obstacles associated with H2 production. This review focuses on the use of NMs in TC and BL processes for H2 generation. Additionally, the paper provides a brief overview of the methods and financial considerations involved in enhancing biomass-based H2 production. Studies indicate that the production of bio-H2 is relatively expensive. Direct bio-photolysis costs range from $2.13 kg−1 to $7.24 kg-1, indirect bio-photolysis costs range from $1.42 kg−1 to $7.54 kg−1, fermentation costs range from $7.54 kg−1 to $7.61 kg−1, biomass pyrolysis costs range from $1.77 kg−1 to $2.05 kg−1, and gasification costs $1.42 kg−1. The paper also explores various challenges related to biomass conversion and utilization for H2 production, aiming to better understand the feasibility of a biomass-based H2 economy.

- **Keywords:** Greenhouse gases; Biological hydrogen; Thermochemical hydrogen; Nano-materials; Economic analysis

Lanmei Zhao, Jing Gao, Long Meng, Jian Liu, Dong Zhao. *The effect of crude oil on hydrolyzed polyacrylamide-containing wastewater treatment using microbial fuel cell biosystem*. Pages 89-98.

One important way to recover valuable energy from the waste streams is to convert organic wastewater into bioelectricity. Microbial fuel cell (MFC) served as the green and sustainable biological treatment can simultaneously treat wastewater and produce moderate amounts of electricity. In the actual hydrolyzed polyacrylamide (HPAM)-containing wastewater of oilfield, crude oil is served as the important active components

that affects HPAM bioconversion in biological treatment system. The effect of different crude oil levels on the bioelectric conversion of HPAM in MFC biosystem has not been explored. This study is the first to explore the bioelectric transformation of HPAM-containing wastewater in MFC biosystem under the stress of different initial crude oil levels. The output voltage, current density, coulombic efficiency and power density showed an upward tendency as crude oil level increased (0–300 mg·L−1), and their maximums reached 22.7 V, 267 mA·m−2, 59.6% and 2.42 W·m−2, respectively. The elevation of crude oil level improved HPAM biodegradation, total nitrogen (TN) removal, metabolite production and extracellular polymeric substance (EPS) intensity, and enhanced carbon/nitrogen bioconversion and electron transfer. Geobacter, Pseudomonas, Flavobacterium, Desulfosalsimonas and Acinetobacter exhibited both substrate degradation and bioelectrochemical activity, dominating the biosystem functions associated with bioelectricity generation, substrate bioconversion, metabolite production and EPS intensity. The elevation of crude oil level stimulated the abundance and function of functional bacteria. This study is of dual practical significance for bioenergy recovery and environmentally friendly bioconversion of HPAM-containing oilfield wastewater, promoting the ecological management of oilfields.

- **Keywords:** Microbial fuel cell; Functional bacteria; Extracellular polymeric substance; Bioelectricity; Hydrolyzed polyacrylamide

Chuanjia Qi, Xu Yang, Junwen Yao, Wenjie Wang, Yong Dong, Xiren Xu, Lin Cui. *Effect of charged spray evaporation of desulfurization wastewater on fine particle removal efficiency of electrostatic precipitator*. Pages 99-107.

The removal of fine particles from coal-fired power plants and the zero-discharge treatment of desulfurization wastewater (DW) from wet desulfurization are critical issues. In this study, we propose a charged droplet evaporation technology of DW for efficient electrostatic dust removal, aiming to achieve zero discharge of DW and effectively remove fine particles. We experimentally studied the effect of charged DW droplet evaporation on the dust removal efficiency of an electrostatic precipitator (ESP) and analyzed the internal mechanism. The results revealed that the removal efficiency of fine particles by ESP was affected by electrode voltage, atomization pressure, DW volume flow, and Cl− concentration. The main internal mechanisms that improved the removal efficiency of fine particles were agglomeration and pre-charging of the particles. Increasing the electrode voltage proved to be the most effective method in enhancing the removal efficiency of fine particles. Specifically, when the electrode voltage was increased from 0 to 12 kV, the removal efficiency of PM2.5 by ESP demonstrated an increase of greater 14 %. The removal efficiency in the penetrating window exhibited an increase of greater than 8 %. Furthermore, augmenting the atomization pressure and DW volume flow also contributed to the improvement in fine particle removal by ESP. In contrast, increasing the Cl− concentration had a detrimental effect on the removal process.

- **Keywords:** Charged droplet evaporation; Desulfurization wastewater; Electrostatic precipitator; Fine particles; Removal efficiency

Aaron N. Adazabra, G. Viruthagiri, Jacob Atingabono. *Developing fired clay bricks by incorporating scrap incinerated waste and river dredged sediment*. Pages 108-123.

The global extraction of several billions of clean clay resources, which destroy millions square meters of land, is triggering environmental problems. Incorporating different dosages of incinerated waste or dredged sediment in bricks production has been studied by many researchers. Research articulating the combined effect of incinerated waste material (IWM) and river dredged sediments (RDS) addition on the performance of bricks

is scarce. This paper aims to present findings on the engineering performance of fired bricks developed with the addition of IWM and RDS. In this regard, bricks were made with 5 wt% IWM and different dosages of RDS (i.e., 0 – 15 wt%). Physical, durability, mechanical, thermal and microstructure of the developed bricks is examined. Bricks' shrinkages were found meeting quality performance criterion in the 1.42 – 4.11% range. The highest bulk density of 1.85 g/cm3 permit to classify bricks obtained as lightweight. Water absorptions were mostly within the acceptable 20% tolerance level postulating the developed bricks high durability standard. Compressive strength reductions, which were confined within 5.28 and 21.57 MPa, showed the developed bricks applicability to structural weight-supporting construction as well as specialized engineering construction works. The 40.5% thermal conductivity reduction in WB15 bricks (at 800 °C) theorized its suitability for thermal insulation construction. Mineralogical and morphological analyses of fired bricks clearly showed kaolinite polymorphic phase transformation, which contributed to the different morphologies in the brick matrices. Consequently, reuse of IWM and RDS offered a chance to advance sustainable use of scarce clay resources in lightweight and thermal insulation brick production.

- **Keywords:** Scrap metals; Incineration waste; Fired clay bricks; Dredged sediments; Built environment

Tzu-Huan Huang, Yu-Sheng Chen, Bor-Yih Yu. *Techno-economic, environmental, and exergetic evaluation of a novel isopropyl n-phenylcarbamate production process through non-reductive conversion of CO2*. Pages 124-136.

The conversion of carbon dioxide (CO2) into valuable chemicals has emerged as a prominent research field. This study attempts to uncover the rigorous design and comprehensive analysis of an innovative process that produces Isopropyl N-phenylcarbamate (IPPhCM) through direct synthesis involving CO2, 2-Propanol (IPA), and phenylamine (PHAM). The reaction system utilizes CeO2 as a catalyst and 2-Cyanopyridine (2-CP) as a chemical dehydrant. In general, this work presents alternative designs in a rigorous manner, with different combinations of conversion and yield. It also evaluates various strategies, such as heat integration, thermal coupling, and the addition of a co-reactant, to enhance the efficiency of the system. Based on the results, the configuration designed with a 92% yield of IPPhCM and incorporating both dividing-wall columns and direct heat integration was determined to be the best scenario. The corresponding minimum required selling price (MRSP) for IPPhCM is 1.996 USD/kg (at a 15% internal rate of return, measured without considering the cost of 2-CP), and the amount of CO2 emission per unit amount of product formed is + 0.075 kg/kg. However, the overall exergy efficiency of this process is only 42.7%. The main reason is the formation of mixtures that are difficult to separate, involving side products such as isopropyl picolinate (IPP), diisopropyl carbonate (DIPC), and others. To enhance the scheme, retrofitting it by adding ammonia to the reaction section enables the conversion of IPP and DIPC into valuable and separable by-products, namely 2-picolinamide (2-PA) and isopropyl carbamate (IPCM). This arrangement significantly enhances the exergy efficiency to 71.8% and reduces the MRSP to 1.759 USD/kg, at the cost of a slight increase in CO2-e to 0.118 kg/kg. With these results, the regeneration of byproducts can make the entire process more appealing and sustainable.

- **Keywords:** IPPhCM; Exergy analysis; CO2 utlization; Techno-economic analysis; Process design; Sustainability

Meng Fei Chia, Pavan Kumar Naraharisetti. *HAZOP using Stateflow software: Methodology and case study*. Pages 137-156.

Safety is paramount to any process plant facilities and its design process. To ensure that safety is considered in design stages, process safety analysis such as hazard and

operability studies are often carried out to address safety concerns throughout the stages of plant design to operation. However, conventional HAZOP studies are labor-intensive and expensive. This paper aims to provide a semi-automated HAZOP study using a computer-aided tool called Stateflow. It describes the rule-based approach and algorithm used to develop the automated HAZOP process. The paper also highlights the limitations and challenges faced and finishes with the potential areas for further works on Stateflow to enhance the HAZOP automation capabilities.

- **Keywords:** Process safety; HAZOP; Automation; Matlab; Stateflow

Gongduan Fan, Yujian Li, Banghao Du, Lei Yao, Chenjian Cai, Hao Li, Shoubin Chen, Jianyong Zou, Zhanglin Hong, Kai-Qin Xu. *Peracetic acid combined with ultraviolet for ibuprofen degradation: Activation mechanism and reactive species contribution*. Pages 157-167.

As an emerging advanced oxidation technology, ultraviolet/peracetic acid (UV/PAA) shows great potential in removing pharmaceuticals and personal care products (PPCPs) in the field of wastewater treatment. In this work, ibuprofen (IBP) was chosen as the contaminant to study the degradation effects and PAA activation mechanisms by UV irradiation. The experimental results showed that UV/PAA had an excellent degradation efficiency (99.22 %) of IBP after 15 min reaction, and the synergistic effect between UV and PAA was also observed. Increasing the dosage of PAA caused the increase in IBP degradation reaction rate. Under acidic conditions, the increase in pH values increased the degradation reaction rate, whereas the opposite was true in alkaline conditions. In addition, the coexisting substrates (e.g., NO3-, CO32-, Ca2+, and HA) could exert inhibition on the degradation. Quenching experiments were carried out using various quenchers to identify reactive oxygen species (ROSs) in the system. The results demonstrated that ·OH and carbon centered radicals (R-C·) played a dominant part in the degradation, and the contribution of CH3C(O)OO·,·O2-, CH3C(O)O·, ·OH, and direct photolysis were estimated to be 29.9 %, 26.9 %, 21.5 %, 14.5 %, and 7.2 %, respectively. The results of IBP intermediates identification indicated that the degradation process was mainly related to its side chain decarboxylation, oxidative dehydrogenation, demethylation, and the oxidation of the aromatic ring. Furthermore, Toxicity Estimation Software Tool (T.E.S.T.) and ECOSAR were applied to evaluate the toxicity of the intermediate products was further evaluated. This study enriched the understanding of the PAA activation mechanism by UV involved, and improved the theory and technology of removing PPCPs by UV/PAA process.

- **Keywords:** UV/PAA; Reactive oxygen species; Pharmaceuticals; Degradation pathways; Toxicity analysis

Wenwen Wei, Shi Liu, Xinyu Li, Linhu Li, Wen Cao. *Thermodynamic and environmental analysis of self-thermal antibiotic residues supercritical water gasification system for hydrogen and power production*. Pages 168-179.

Efficient treatment of antibiotic residue, containing a range of persistent organic compounds, is essential to ensure the protection of both the environment and human health. Supercritical water gasification technology could achieve the clean and efficient energy conversion of antibiotic residues. In this paper, a self-thermal supercritical water gasification system for antibiotic residues is developed to convert antibiotic residues to high-purity H2 and electrical power. The system analysis results demonstrate that increasing the antibiotic residue slurry concentration, elevating the gasification reactor temperature, and optimizing the ratio of water-to-dry antibiotic residues effectively enhance system efficiency and H2 yield within specific ranges. The H2 yield and net electrical power at optimal operating conditions are 634.52 kg/h and 2.3 MW with 10 t/h

dry antibiotic residue feeding. Meanwhile, the energy efficiency, exergy efficiency, and cold gas efficiency of the system are 61.32%, 63.05%, and 53.96%, respectively. The life cycle assessment analysis shows that the global warming potential of the system is 20.77 kg CO2-eq/kg H2 with the above operating conditions. Taking into account the emission reduction impact of the system on thermal power generation, the inclusion of CO2 capture and storage units can potentially lead to a negative global warming potential for the system.

- **Keywords:** Thermodynamic analysis; Supercritical water gasification; Life cycle assessment; Antibiotic residues; Hydrogen and power

Munmun Agrawal, Randhir Singh, Kamalesh K. Singh. *Techno-economic analysis of the sequential recovery of valuable metals from waste tantalum capacitors in Indian context*. Pages 180-188.

The necessity for urban mining of metals has arisen due to the growing demand for metals brought about by technological innovation, the depletion of natural resources, and the exponential growth in e-waste generation. However, to be industrially adaptable, any recycling process must be economically profitable. Therefore, in this article, an economic feasibility study was conducted to determine the profitability of the proposed recycling process for recovering valuable metals from waste tantalum capacitors. Firstly, an integrated process was developed for the recovery of almost all economically and strategically significant metals. A detailed elemental and metallurgical balance followed this to determine the mass flow of metals during various stages of treatment. Lastly, the economic feasibility analysis has been done by estimating various cost components from capital and operating costs (utilizing Indian cost as foundation for calculation) to evaluate the profit that might be made by operating the suggested recycling facility for a month. Sensitivity and scenario analysis further investigated the impact of the most significant cost component on the percentage profit. The findings of this study support the notion that the suggested recycling method has a great deal of potential value and is commercially feasible with an ample profit margin.

- **Keywords:** E-waste; Recycling; Tantalum capacitor; Recovery; Economic analysis

Yan Zhang, Wei Peng, Xiaoyong Liu, Junsheng Ren, Xue Zang, Qi Xie, Jinhu Li. *Experimental study on suppression of thermal runaway in lithium-ion battery by mixed particle size water mist*. Pages 189-198.

With the implementation of the green energy development strategy, new energy vehicles and related industries have been experiencing rapid growth, leading to an expansion in the market scale of the lithium-ion battery (LIB) industry. While the high energy density of LIB is being pursued, the risk of thermal runaway (TR) cannot be underestimated. Water mist (WM) is currently considered an efficient and environmentally friendly fire extinguishing agent, highly favored for its exceptional cooling capabilities. In this study, an alternative WM control strategy is proposed that capitalizes on the distinct advantages of varying particle sizes of WM during different cooling stages and integrates them to enhance overall cooling effectiveness. The experimental results demonstrate that the utilization of WM with mixed particle sizes not only reduces the peak temperature of TR, but also significantly shortens the cooling time. Compared to using WM with a single particle size, this method greatly reduces water consumption and enhances its utilization rate. This finding can offer valuable suggestions for the future implementation of WM in battery fire suppression systems design.

- **Keywords:** Lithium-ion battery; Thermal runaway; Water mist; Cooling mechanism; Particle size

Jin Tang, Xinyuan Wu, Jian Ren, Huihua Min, Xiaomin Liu, Yong Kong, Peipei Che, Wei Zhai, Hui Yang, Xiaodong Shen. *Suppressing thermal runaway propagation of nickel-rich Lithium-ion battery modules using silica aerogel sheets*. Pages 199-207.

Suppressing thermal runaway (TR) propagation within Lithium-ion battery (LIB) modules/packs/systems is one of the key factors to ensure the safety utilization of electric vehicles and energy storage systems. This contribution aims at introducing Silica Aerogel Sheets (SAS) into high energy density modules to suppress the TR propagation. The SAS, synthesized via a sol-gel process followed by supercritical fluid drying, possess almost an ideal thermal insulator characteristic due to the low thermal conductivity of 0.020 W/(m·K) at room temperature. The SAS are inserted between two adjacent pouch cells (LiNi0.86Co0.07Mn0.07O2/graphite, 320 Wh.kg−1) to assemble high energy density modules. A single pouch cell, subjected to the TR test with an Accelerating Rate Calorimetry, releases a huge amount of heat energy (1083 kJ/kg) with the maximum temperature beyond 800 °C. In the open area test site for TR propagation experiments, it can be observed that violent jet and flame burst from the cell, which is designed to undergo TR first and trigger the TR propagation of the modules. The results show that only one single layer of SAS cannot stop the TR propagation or fire spreading. However, more layers of SAS (three in the experiments) can successfully suppress the TR propagation and block fire progression. The temperature of the adjacent cell only reaches 105.4 °C. Therefore, the SAS with acceptable thickness can suppress the TR propagation successfully to improve the safety of the LIB modules.

- **Keywords:** Lithium-ion battery; Thermal runaway propagation; Aerogel sheet; Suppression effect

Zedong Chen, Jiabin Zhou, Xiaohan Zhuge, Zonglan Xie, Ke Du. *Catalytic oxidation of toluene over highly dispersed Mn-Ce solid solutions synthesized with weakly acidic precursors*. Pages 208-227.

In this paper, a series of Mn-Ce composite oxide catalysts were prepared by different preparation methods using different Mn and Ce acidic precursors for the catalytic oxidation of toluene. The activity test results revealed that the Mn-Ce composite catalysts, synthesized through the sol-gel method using weakly acidic Mn acetate and Ce acetate as precursors, exhibited the highest performance for the catalytic oxidation of toluene. The T50 and T90 values for this catalyst were measured at 208 °C and 235 °C, respectively. The relatively weak acidity of manganese acetate and cerium acetate facilitates the presence of acidic -OH groups, which interact with the oxygen-negative charge sites on each other. Furthermore, during the calcination process, there was a strong interaction between hydrated Mn and Ce ions, resulting in the formation of highly dispersed metal oxide species. The formation of Mn-Ce solid solution demonstrated by Raman, XRD. The H2-TPR characterization indicated that the superior redox performance of the MnOx species on the catalyst surface played a pivotal role in achieving high activity. Moreover, the catalytic activity of the CeO2 species was further enhanced by employing the sol-gel method. XPS and O2-TPD results revealed a significantly higher amount of reactive oxygen species on the catalyst surface, which was identified as the primary reason for the increased activity. This study provides a new strategy for the selection of the catalyst precursors, thereby enhancing the catalytic activity of Mn-Ce composite oxides.

- **Keywords:** Precursors; Solid solutions; Dispersion; Sol-gel method; Reactive oxygen species

Jihe Chen, Xunxian Shi, Shuo Liu, Ming Wang, Pei Wang, Zhongan Jiang. *Performance optimization and experimental analysis of angle grinder with dust collection hood*. Pages 228-240.

The grinding process of the angle grinder generates a large amount of dust, which present hazards to the environment and workers' health. In order to capture the grinding dust more efficiently, this paper optimizes the performance of the dust collection hood of the angle grinder by building a grinding experimental platform and using the response surface method (RSM). Using the Box-Behnken design method, the collection quantity Mtotal of all dust particles generated by grinding and the collection quantity MPM10 of PM10 are used as the main performance indicators of the dust collector. Four independent factors such as grinding wheel diameter, suction pipe diameter, mounting angle, and grinding wheel speed of the dust collection hood were optimized to arrive at the best combination of parameters. Through response surface analysis, a quadratic polynomial regression model between each influencing factor and performance indicator is established, and significance test and variance analysis are performed to verify the validity and applicability of the model. Finally, through three-dimensional response surface plots and contour plots, the interactions between each influencing factor are analyzed, and the predicted values of performance indicators under optimal experimental conditions are determined. The experimental results show that the mounting angle has the greatest impact on Mtotal, and the grinding wheel speed has the greatest impact on MPM10. The field engineering application shows that the optimized dust collection hood can effectively prevent dust from escaping. The reduction efficiency of total dust concentration in the grinding place is over 83.6 %, and the reduction efficiency of respirable dust concentration is over 90.0 %. The research results of this paper provide some reference value for the research and application in the field of dust control.

- **Keywords:** Angle grinder; Grinding particles; Dust collection hood; Optimized design; RSM

Yaqin Tan, Rémy Mével, Yu Cheng Liu. *A review on ignition in expanding gaseous media*. Pages 241-256.

Fundamental research on detonation is relevant to industrial safety issues, propulsion and energy production applications, and internal combustion engines. Detonation waves are intrinsically unsteady and may rapidly decelerate under certain circumstances. Fluid elements traveling behind these waves can undergo strong gas dynamical volumetric expansion, which can ultimately lead to quenching. More generally, critical ignition in expanding media results from the competition between expansion and chemical energy release. While the pioneering work by Lundstrom and Oppenheim investigated the role of unsteadiness on detonation dynamics both experimentally and numerically, studies on ignition quenching by the volumetric expansion mechanism has been essentially limited to theoretical and numerical approaches. Studies have converged towards the concept of critical decay rate (CDR), and of critical Damköhler number. The CDR theory incorporates the ignition delay-time and the characteristic time of shock speed decay for identifying the threshold for successful ignition, while the Damköhler number is defined as the ratio of characteristic expansion time over characteristic chemical time. While the majority of early studies only considered globalized reaction models and investigated mixtures with a single step of heat release, more recent studies have employed detailed chemical mechanisms and included mixtures with non-monotonous energy release profiles. Practical consequences of ignition in expanding media under conditions relevant to water hammer, high-pressure hydrogen jet, and deflagration to detonation transition in obstructed channels are also summarized.

- **Keywords:** Critical ignition; Expansion rate; Detonation; Water hammer

Xiaoran Wei, Jia Xu. *Bifurcation and chaos of Li-doped 6,6,12-graphyne impacted by hydrogen atoms: A new way to explore hydrogen storage*. Pages 257-274.

Hydrogen energy, as a green new energy source, has great significance for environmental protection due to its widespread application. This article uses nonlinear dynamics theory to study the problem of hydrogen energy storage firstly, which is different from traditional methods by using simulation and experimental methods. In this paper, the bifurcation and chaos of Li-doped 6,6,12-graphyne impacted by hydrogen atoms are studied. The perturbation of 6,6,12-graphene by Li atoms is treated as the Gauss white noise. The incremental harmonic balance method (IHB) is used for drawing the amplitude-frequency response curve of the system under simple harmonic excitation. Theoretical analysis shows that the inhomogeneity of 6,6,12-graphyne stiffness can affect the system stability, which decides the actual hydrogen storage capacity of graphyne. And then simulation and experiment results confirm the results of theoretical analysis. The maximum increase hydrogen storage efficiency can be more than 10% by selecting appropriate distribution of Li atoms.The research results of this article have a certain promoting effect on the industrial application of hydrogen energy.

- **Keywords:** Li-doped 6; 6; 12-graphene; IHB; Poincaré cross-section; Stability; Nonlocal effect

Hao Zhang, Zhonglin Zuo, Zheng Li, Li Ma, Shan Liang. *An unsupervised leak detection method with aggregating prediction and reconstruction along projection pathway for natural gas gathering pipelines*. Pages 275-289.

Early detection of leaks in natural gas gathering pipelines makes proactive maintenance and corrective measures take place more effective, thus enhancing the safe and reliable operation of pipelines and mitigating serious threats to the environment and human life. The data-driven leak detection methods have become a natural choice owing to the extensive deployment of sensors in the pipeline network. However, the supervised and semi-supervised leak detection methods need to utilize a certain amount of leak data to train reliable classifiers, and labeled data usually difficult to obtain in real-world applications especially for the gas industry. Besides, most of data-driven methods today only consider the long-term or short-term patterns hidden in the multivariate time series rather than both, which may reduce their effectiveness since temporal data generated in the real-world applications often relates to a mixture of these two patterns. To settle this challenge, we propose a novel unsupervised leak detection method by utilizing a one-dimensional convolutional autoencoder (1D-CAE) to learn short-term dependency patterns from local time series and a long short-term memory (LSTM) to discover evolving trends about long-term patterns from entire temporal data. The proposed method not only calculates the difference between actual samples and their predictions but also compares the inputs and their reconstructions, where comparisons of reconstruction are further extended from input space to hidden spaces. The obtained deviations are then integrated through the developed integration strategy and employed to calculate their global leak scores. Specially, considering that the magnitudes of deviations integrated together are diverse or there may exist correlation among these deviations caused by correlated neurons across layers, the minimum covariance determinant (MCD) method is employed to scale deviations and eliminate correlations along the projection pathway. The effectiveness of the proposed method is verified on real datasets of natural gas gathering pipeline. In addition, analysis of experimental results demonstrates that the proposed method has good accuracy, and is conducive to operating in the context of uncontrolled long-term monitoring.

- **Keywords:** Leak detection; Multivariate time series; Long- and short-term temporal patterns; Unsupervised learning; Minimum covariance determinant method

A.E. Kabeel, Mohamed R. Diab, M.A. Elazab, Emad M.S. El-Said. *Solar powered hybrid desalination system using a novel evaporative humidification tower: A numerical investigation*. Pages 290-313.

This research describes a hybrid solar desalination system that includes a humidification-dehumidification unit as well as a solar still unit. The current system is being studied numerically. A one-dimensional model of the important heat and mass exchanges, as well as the flow field, was built using the finite difference method. Freshwater productivity is calculated under various operating and weather conditions. The model has been modified to investigate the steady-state behavior of the system components. Four major parameters that have a significant impact on system water production are investigated: the feed flow rate of cooling water through the dehumidifier unit, the airflow rate, and the number and height of packing columns. According to the results, the proposed hybrid desalination system provides appropriate operational compatibility between HDH technology and solar energy. The system can provide a daily production of up to 35 liters per day. Increasing the number of packing columns results in a higher increase in fresh water productivity than increasing the height of the packing columns. The optimal air flow rate at a constant saline-water flow rate is obtained. For high airflow rates, the packing column height doesn't significantly affect the daily water production. System performance is investigated by four main parameters: gained output ratio (GOR), humidifier efficiency, exergy efficiency, and system efficiency. The system efficiency reached about 65% and the GOR reached 3.1. The humidifier's efficiency varied between 50% and 75%. The maximum exergy efficiency reached about 5.2%.

- **Keywords:** Humidification-dehumidification; Solar still; Hybrid system; Cooling tower

Qing-rui Zeng, Zi-ang Jia, Xu Liu, Jin-ping Cheng. *A novel 1T-2H MoS2/NaBi(MoO4)2 alternating-phase piezoelectric composites for high-efficient ultrasound-drived piezoelectric catalytic removal of Sildenafil*. Pages 314-328.

Ecological risks and environmental contamination from misuse of novel contaminant PDE-5i-like compounds still persisted during the COVID-19 pandemic. In this study, MoS2/NaBi(MoO4)2 piezoelectric composites were utilized to piezocatalytic degradation of the PDE-5i-like novel contaminant Sildenafil by ultrasound-driven piezoelectric process. Among them, 1T-2H MoS2/NaBi(MoO4)2 achieving a piezoelectric catalytic degradation of sildenafil of 99.8% within 60 min by ultrasound-drived, ecotoxicity of Sildenafil also can be effectively reduced. Experimental and DFT calculations proved that the differential enhanced piezoelectric properties were attributed to the loading of different phases (1T, 1T-2H, 2H) of MoS2 on NaBi(MoO4)2. 1T-2H MoS2/NaBi(MoO4)2 material possessed the best piezoelectricity with a piezoelectric response amplitude of 233.3 pm/V, 8.1 times higher than that of NaBi(MoO4)2 (28.89 pm/V). Characterization and calculation reveals alternating changes in the phase state of 1T-2H MoS2 provide an alternating polarization piezoelectric field to optimize the piezoelectric properties of 1T-2H MoS2/NaBi(MoO4)2. This work provides new insights into the application of piezoelectric materials for environmental clean-up.

- **Keywords:** 1 T-2 H MoS2; NaBi(MoO4)2; Piezocatalysis; Sildenafil

Min Qin, Kexi Liao, Yongchun Mou, Xiaodong Hao, Shijian Zhang, Minan Wang, Yuanjie Huang. *Gas liquid-carried flow accelerates MIC by sulfate reducing bacteria biofilm*. Pages 329-347.

The corrosion and perforation leakage of shale gas pipelines can lead to serious environmental damage. By tracking the water and gas components throughout the shale gas production cycle, the main factors that affect corrosion in shale gas pipelines have been identified: carbon dioxide, dissolved oxygen, sulfate-reducing bacteria, and chloride ions. The study focused on understanding the development mechanism of localized corrosion of L360N steel within the upward shale gas gathering pipeline, particularly under the combined influence of sulfate-reducing bacteria and flowing conditions. SRB could form a biofilm on the surface of the steel. Through the Dissimilatory Sulfate Reduction (DSR) process, the metabolites reacted with Fe2+ to produce FeS. The corrosion rate of L360N steel was observed to be higher when exposed to gas-liquid flow compared to static conditions. In the flowing state, the boundary layer within the upward pipeline exhibited backflow tendencies, causing a portion of the corrosion products and biofilm to peel off. This exposure revealed a local surface, acting as an anode. As a result, corrosion pits were further deepened due to microscopic eddy currents, indicating that zero net liquid flow accelerated the corrosion process.

- **Keywords:** Gas liquid-carried; Shale gas; Corrosion; Sulfate-reducing bacteria

Wei Shan, Jie Dai, Ahmad A. Ifseisi, Yong Chen, Xixi Ye. *Enhancing economic viability: Optimal integration of an absorption power cycle for enhanced financial performance in flame-assisted fuel cells*. Pages 348-361.

In the realm of energy economics, where financial considerations are intertwined with policy imperatives, there is a pressing need for advanced power generation technologies, given the escalating CO2 emissions and global warming concerns. Flame-assisted Fuel Cells (FFCs) have surfaced as a promising innovation with several advantages; however, their low electrical efficiency remains a critical concern. A strategic approach is proposed to enhance FFC efficiency by effectively utilizing waste heat through the integration of an Absorption Power Cycle (APC). A comprehensive modeling encompassing exergy, environmental impact, financial factors, and policy alignment was executed, coupled with tri-criteria optimization to identify optimal operational conditions. Through a comparative analysis of the FFC/APC integrated system against the standalone FFC, considering varying operational parameters and optimal configurations, it is shown that despite incurring additional costs, the incorporation of the APC unit falls short of fully compensating for the supplementary power generation expenses. As a result, the combined cycle yields higher electricity costs compared to the standalone FFC. Nonetheless, the integrated system presents a significant increase in exergy efficiency, along with a reduction in CO2 emissions. This integration not only addresses energy efficiency and environmental concerns but also aligns with the broader objectives of transparency and sustainability in capital markets. These compelling advantages may position the integrated plant as a preferable choice among energy economists, policy makers, and environmental advocates, even considering the higher initial capital outlay, due to its alignment with broader economic, environmental, and policy objectives.

- **Keywords:** CO2 emission reduction; Financial performance; Waste heat recovery; Flame-assisted fuel cell; APC; Economic analysis; Energy policy

Xin Xia, Yu Yan, Junpeng Luo, Tingting Liu, Bingdang Wu, Feiyue Qian. *Effects of peroxide types on the removal performance and mechanism of sulfonamide antibiotics using graphene-based catalytic membranes*. Pages 362-372.

This study reports in situ catalytic oxidation processes using graphene-based catalytic membranes to activate peroxydisulfate (PDS), peroxymonosulfate (PMS), and hydrogen peroxide (H2O2). Sulfonamide antibiotics in water, including sulfamethoxazole (SMX), sulfadiazine (SDZ), sulfamerazine (SMR), and sulfamethazine (SM2), were used as target pollutants. The composites of reduced graphene oxide and nitrogen-doped carbon nanotubes were loaded onto nylon microfiltration membranes at 8 g·m−2 mass dosage. The PDS-based systems exhibited the highest efficiency in removing SDZ (≥ 98%) and SMX (> 93%) during continuous 10 h filtration. In contrast, PMS was more suitable for oxidizing SMR (≥ 99%) and SM2 (≥ 90%) in a single pass. Based on functional group characterization and density functional theory calculations, structural defects and pyridinic/graphitic nitrogen species in carbon mats were identified as the main active centers for peroxide activation. Moreover, PDS, PMS and H2O2 exhibited distinct adsorption behaviors on defective and nitrogen-doped graphitic carbon, influencing the cleavage of peroxide bonds to generate reactive oxygen species. The reaction mechanism was investigated through electron paramagnetic resonance and chemical quenching tests. Surface-active species and singlet oxygen dominated in the PDS- and PMS-based systems, representing non-radical pathways, that selectively oxidize sulfonamides in real water matrices more effectively than the hydroxyl radicals involved in H2O2-based systems. PDS activating exhibited significant performance in organic fouling polishing, lowering the transmembrane pressure during continuous filtration. These findings offer valuable insights into implementing in situ catalytic oxidation processes in actual water purification.

- **Keywords:** Graphene-based catalytic membranes; Peroxide types; Sulfonamide antibiotics; Continuous filtration; Non-radical pathways; Water matrix

Xufeng Yang, Wen Yang, Changlin Liu, Minggao Yu, Shixin Han. *Experimental study on the deformation and oscillation of premixed syngas/air flames in closed ducts*. Pages 373-383.

Experiments were conducted in two closed ducts, 100 × 100 × 1000 mm3 (AR = 10) and 60 × 60 × 2000 mm3 (AR = 33.33), to comparatively study the explosion behavior of premixed syngas-air mixtures. The stoichiometric syngas-air mixtures with the increase in hydrogen volume fraction were tested. The flame structure, flame tip, and overpressure dynamics in two ducts were analyzed, and the propagation behavior was compared according to the two flame types through the flame structure and flame tip dynamics. Results show that the development of the flame's structure is predictable in AR = 10, but the development of the flame's structure is complicated in AR = 33.33. Increasing both the hydrogen volume fraction and the aspect ratio of the duct increases the amplitude of the flame oscillation, and the flame in AR = 33.33 shows a stronger deformation and oscillation. There is a strong correlation between flame tip speed and overpressure profiles. The growth rates of Darrieus-Landau (DL) and Rayleigh-Taylor (RT) instabilities were presented and discussed, and the results show that both DL and RT instabilities significantly affect flame propagation behavior. Finally, the flame exhibits different structural changes, but it is confirmed that the response sources of the flame oscillation in the two ducts are the same, i.e., owing to the pressure wave's excitation.

- **Keywords:** Syngas, Premixed flame, Aspect ratio; Flame oscillation and deformation; Flame instabilities

Zhuang Chen, Yimei Zhang, Ting Cao, Kaiwen Yao. *Electrochemical removal of nitrate using Co/Ni bimetallic electrode: High N2 selectivity and long-term stability*. Pages 384-393.

The effectiveness of the electrochemical reduction of nitrate relies heavily on the N2 selectivity and stability of the cathode. In this study, we present a Co/Ni bimetallic electrode that was fabricated through an electrodeposition process and explored as cathode for the electrochemical reduction of nitrate. Electrochemical test demonstrated that vertical arrays of Co-containing nanosheets significantly improved electrochemical properties of Ni foam, particularly in terms of catalytic activity for nitrate. The removal rate of nitrate by this bimetallic foam electrode was 97.2% within 60 min, which is significantly better than that of Ni foam electrode (15.0%) and Co/Ni plate electrode (70.1%). This is attributed to the comprehensive enhancement of catalytic active sites, electrochemical activity, and nitrate affinity brought by the Co/Ni foam electrodes. The electrode demonstrated high nitrogen selectivity, achieving a total nitrogen removal rate close to 100%. The influence parameters and stability of the electrode were also evaluated, and a possible mechanism of nitrate removal was proposed. Significantly, this study presented novel opportunities for the advancement of effective bimetallic electrode materials intended for the reduction of nitrate.

- **Keywords:** Electrochemical reduction; Nitrate; Co/Ni bimetallic electrode; Total nitrogen

Juan Jiang, Huihui Ma, Yuanrong Zhu, Xiaojie Bing, Kuo Wang, Fan Liu, Jing Ding, Jian Wei, Kang Song. *Characterization of organic phosphorus in soils and sediments of a typical temperate forest reservoir basin: Implications for source and degradation*. Pages 394-404.

Reservoirs can intercept upstream inputs and greatly alter their migration and transformation processes at a basin scale. Taking a typical reservoir basin in the Xiaoxing'an Mountains of Northeast China as an example, the organic phosphorus (Po) and organic matter (OM) compositions in the upstream soil, river and reservoir sediments were characterized by 31P NMR, stable carbon (δ13C) and nitrogen isotopes (δ15N), and the migration and transformation processes of Po from soil to reservoir sediments were explored. The compositional data indicated that both the OM and Po in the reservoir were mainly imported by C3 plants from the upper reaches. Higher monoester phosphorus (P) components in the upstream soils than in the reservoir sediments, which indicated the migration and degradation process of Po from the upstream soils to the river and then to the reservoir sediments. The degradation rate of monoester P was higher, approximately 30.6% and the phosphonate fraction had the lowest degradation rate, about 0.4%. Specifically, the degradation of monoester P including inositol P was higher than that of organic carbon. Thus, at the basin scale, more forest-derived organic carbon was likely intercepted by reservoirs and precipitated to sediments, while Po might degrade to a greater extent. Aggregative results showed that reservoirs may play an important role in the differentiated migration and transformation process of forest-derived OM and Po. And then, the highly degradable Po including inositol P poses a greater risk of eutrophication in the typical temperate forest reservoirs and their downstream, even the ocean, and is accompanied by possible algal blooms in the future. Information derived from this study provides a more scientific basis for the assessment of the ecological and environmental effects of reservoir and dam construction projects.

- **Keywords:** Forest soil; Reservoir sediments; Organic phosphorus; 31P NMR; Carbon/ phosphorus ratio; Migration and transformation

Qiuyue Tan, Zongxue Yu, Qingcan Xiang, Niandan He, Runxuan Long, Juan Wang. *Photo-Fenton properties of MIL-88A(Fe) / Ti3C2 MXene with tunable active crystal facets: Universal for degradation of common pollutants in wastewater*. Pages 405-420.

In this study, the MIL-88A(Fe)/MXene Type-I heterojunction photocatalysts were successfully prepared. The active crystal plane of MIL-88A(Fe) was modulated by changing the solvent ratio used in the solvent-thermal reaction. Taking sulfamethoxazole as the main target pollutant, the effects of different morphologies of MIL-88A(Fe) and different loadings of MXene on the photocatalytic performance of the composite were discussed in detail. The results showed that the degradation rate of sulfamethoxazole by DA-M100 composite photocatalysis combined with Fenton effect could reach about 70% within 10 min of light exposure, and the degradation efficiency reached 92.66% after 60 min of light exposure. The universality test showed that DA-M100 had good photo-Fenton oxidation ability for common dyes and good photo-Fenton reduction ability for heavy metal ions in sewage. After 1 h of irradiation, the removal efficiency of Cr (VI), Cu (II) and Ni (II) reached 95.88%, 79.77% and 66 67%, respectively. The stability experiments showed that DA-M100 had a good adaptability to the environment. The results of electrochemical experiments and photoemission spectroscopy showed that DA-M100 increased the migration rate of photogenerated electron-hole pairs and decreased their recombination rate. The results show that the complex of iron-based MOF and MXene has a good application prospect in the treatment of industrial wastewater, and also provides a new idea for the modification of Type-I heterojunction.

- **Keywords:** Ti3C2 MXene; MIL-88A(Fe); Photo-Fenton; Type-I heterojunction; Oxidative degradation and reduction

Wenjie Lv, Jinchao Zhao, Bin Hu, Yanhong Zhang, Suwen Yang, Jun Ding, Yuan Huang. *Microchannel structure affects fine particulate pollutant interception characteristics*. Pages 421-429.

Deep filtration is an important technology for the separation of fine particle pollutants in industrial wastewater. The theoretical core of microchannel separation is the interaction between channel interface and pollutants. Here, microchannels with different shapes and sizes were designed by microfluidic technology and the particle migration process in microchannels was visualized by high-speed camera. This paper studied the effects of apparent depth, inlet structure and channel angle of the interception channel on fluid flow and particle interception. When apparent depth of the interception channel was equidistantly distributed, the flow rate in each channel was uniform, but interception efficiency gradually decreased with the increase of apparent depth. Interception efficiency of the first layer was 16.7 %, while for the 14th layer was only 0.4 %. Interception performance of the upper wall of the inlet of the interception channel was substantially higher than that of the lower wall. The smoother the angle between the interception channel and the mainstream channel was, the better the interception performance. When the angle between the upper and lower walls of the inlet and the mainstream channel was 30° and 60°, respectively, interception efficiency was the optimal, and cumulative interception efficiency of the three filtrations was 92.4 %. Additionally, flow rate and interception efficiency of the interception channel increased with decreasing channel angle. The total interception performance of the 30°–45° group was the optimal, and the total split ratio and total interception efficiency were 65.5 % and 85.5 %, respectively. This provides reference for the change of microchannel structure and the mechanism of particle migration and deposition.

- **Keywords:** Deep filtering; Microchannel; High-speed camera; Particle migration

Bing Liu, Gaoyuan Geng, Peiliang Xie, Yuying Huang, Feiyong Chen, Jing Wang, Yuxi Chen, Hidenari Yasui, Quanyong Wang, Rajeev Goel, Yifan Li. *The effect of flow rate on the ammonia oxidation rate in the riverway biofilm in-situ remediation and modeling*. Pages 430-438.

The biofilm in-situ remediation is one of the most important and practical techniques for river remediation. The biochemical function of biofilms and the hydraulics of the river are both significant aspects of river remediation study, however, they belong to distinctive research points. To date, little research has combined the biochemical process of biofilm and the hydraulics of the river. In this study, ammonia oxidation rate (AOR) was used to characterize the activity of biofilms and measured at different flow rates. It was increased with the flow rate increasing before the peak (26.13 g-N/m3/h) at 0.3 m/s and then decreased to 0 at 0.414 m/s directly. Meanwhile, the skewness equation of flow rate (Fr)−AOR was established based on previous hydraulics and biology research. The kinetic parameters of the equations were determined by fitting the measured values of AOR (R2 > 0.95), which could be used to simulate the AOR of the river simulators and open channels. Besides, the distribution characteristics of the AOR at various flow rates in different sections were obtained. Overall, this paper provides a novel perspective by studying the internal biochemical model of biofilm and the hydraulic model with multiple influencing factors further to improve the biofilm-hydraulics coupling model.

- **Keywords:** Flow rate; Ammonia oxidation rate (AOR); Fr–AOR Equation; Simulation

Pengju Wang, Feng Yan, Feng Xie, Xuehua Shen, Xuankun Wei, Fan Qu, Yiping Su, Guodong Yang, Rigang Zhong, Zhongzheng Li, Lan Song, Zuotai Zhang. *Field study on variation characteristics of PCDD/Fs and flue gas particles along MSW incinerator*. Pages 439-448.

Wet scrubber systems (WSSs) are commonly used for effective flue gas cleaning by removing acid gases and dust. To determine the influence of a WSS on polychlorinated dibenzo-p-dioxins/dibenzofurans (PCDD/Fs) and flue gas particles, a field study was carried out in a full-scale municipal solid waste (MSW) incinerator (850 t/d). Phase-separated samples at four flue gas sampling points and two scrubbing solution sampling points were collected for PCDD/F analysis. Two particle samples at the WSS inlet and outlet were simultaneously obtained for TEM-EDS analysis. The memory effect inside the WSS apparently elevated the PCDD/F I-TEQ concentration from 0.0056 to 0.0088 ng I-TEQ Nm−3 by increasing the mass concentrations of 17 congeners. A PCDD/F flux chart was established to interpret the adsorption/desorption mechanism of PCDD/Fs inside the WSS that showed apparent desorption from scrubbing solution. The potential interaction relationship between PCDD/F and flue gas particles were also observed, that was, the desorbed PCDD/Fs from scrubbing solution might be adsorbed by flue gas particles again and therefore enhanced the concentration of solid-phase PCDD/Fs from 0.0236 to 0.0411 ng Nm−3. Furthermore, TEM-EDS analysis indicated that the WSS could evidently remove some soluble particles and reduce the particle size. And the variation in morphology, elemental composition, and distribution of flue gas particles were observed during the scrubbing process. This study systematically analyzed the memory effect of PCDD/Fs and firstly investigated the specific impact of WSS on flue gas particles, thereby improving the comprehensive understanding of WSS applications.

- **Keywords:** Municipal solid waste (MSW) incineration; Wet scrubber system (WSS); Polychlorinated dibenzo-p-dioxins/dibenzofurans (PCDD/Fs); Memory effect; Flue gas particle; Interaction relationship

Anna Grzegórska, Jakub Karczewski, Anna Zielińska-Jurek. *Modelling and optimisation of MXene-derived TiO2/Ti3C2 synthesis parameters using Response Surface Methodology based on the Box–Behnken factorial design. Enhanced carbamazepine degradation by the Cu-modified TiO2/Ti3C2 photocatalyst*. Pages 449-461.

In the present study, a hydrothermal method in a water/ethanol environment was used for the first time to obtain novel Cu/TiO2/Ti3C2 composites with high photocatalytic activity for the degradation of carbamazepine (CBZ) under simulated solar light. The Box–Behnken factorial design was coupled with Response Surface Methodology (RSM) for synthesis parameter optimisation. The effect of different synthesis parameters, including temperature, time and water/ethanol ratio, was for the first time studied in detail. The analysis of variance (ANOVA) was used to verify the adequacy of the proposed model. The water/ethanol ratio was the most influential parameter for anatase crystallite growth and the efficiency of carbamazepine degradation. The TiO2/Ti3C2 sample prepared under the optimised conditions (synthesis time of 17 h, temperature of 220 °C, and water/ethanol ratio of 58:42 v/v) revealed almost 100% of CBZ degradation within 60 min. Furthermore, the surface modification of this sample with 0.25% - 1 wt% of copper resulted in improved photocatalytic activity. For TiO2/Ti3C2 modified with 0.5% of Cu, almost complete CBZ degradation was observed in 40 min of the photodegradation process. Finally, the combination of the photodegradation process with the activation of peroxymonosulphate (PMS) by Cu-TiO2/Ti3C2 resulted in markedly improved carbamazepine degradation and reached 100% within 20 min under simulated solar light irradiation. The degradation mechanism of CBZ was proposed based on trapping experiments, which revealed that •O2− and •SO4− are the main oxidising species involved in carbamazepine degradation. Moreover, the hybrid system exhibited high recyclability and stability during subsequent photodegradation cycles.

- **Keywords:** Box-Behnken; Carbamazepine; Cu species; MXene; Photocatalysis; Optimisation; RSM; Ti3C2; TiO2

Abdolvahhab Fetanat, Mohsen Tayebi, Hossein Mofid. *Water-energy-carbon nexus and sustainability-oriented prioritization of negative emissions technologies for the oil & gas industry: A decision support system under Fermatean fuzzy environment*. Pages 462-483.

Attaining carbon dioxide (CO2) emissions mitigation has become one of the central goals, and it has received wider attention from policymakers. The CO2 as a negative greenhouse gas (GHG) has been increasing in the atmosphere by anthropogenic activities, including the burning of fossil fuels. In view of this issue, negative emissions technologies can play a very useful role in reducing CO2 emissions concentration and mitigating climate change. Therefore, deploying these technologies is imperative. There are multiple available negative emissions technologies that should be assessed on the basis of different principles (criteria). A decision support system is needed to prioritize these technologies and select the most appropriate option. In this regard, a novel hybrid system including the two multi-criteria decision-making techniques under the Fermatean fuzzy environment is proposed. The Fermatean fuzzy set is applied for evaluating uncertainty in the water-energy-carbon nexus and sustainability principles performance levels of these technologies. The prioritization of negative emissions technologies considering the defined principles is assessed through the utilization of the proposed method. The results indicate that the technology of bioenergy with carbon capture and storage is the most suitable alternative for reaching the carbon management goals in Bidboland Persian Gulf gas refinery in southwestern Iran, Behbahan. This work extracts a roadmaping for piloting the oil & gas industry shift towards a circular carbon economy. Therefore, the industries such as the oil and gas industry should boost environmental awareness, ample funds, and incentives for implementing negative emissions

technologies to encourage sustainable energy systems, develop low-carbon strategies, mitigate climate change, and promote sustainable economic growth. Concerning the government, corresponding policies and measures should be adopted to emphasize increasing the use of these technologies, especially in high-emission areas.

- **Keywords:** Circular carbon economy; Fermatean fuzzy set; Negative emissions technologies; Oil & gas industry; Sustainability; Water-energy-carbon nexus

Ying Sun, Luo Zuo, Xiaolong Li, Xiaoqiang Liu. *Enhancing shale gas recovery by carbon dioxide injection: A method of carbon capture, utilization and storage (CCUS)*. Pages 484-492.

CO2 injection in shale gas reservoir can not only increase the production of shale gas, but also realize carbon dioxide capture, utilization and storage. At present, most experimental studies of CO2 injection in shale are carried out by conventional core experiments. However, it is difficult to analyze the process of CO2 replacing shale gas and adsorption in shale pores on microscopic scale. In this study, nuclear magnetic resonance (NMR) technology is used to analyze the migration and conversion of CH4 in process of CO2 injection and depressurization production. Based on above experiments, microscopic mechanism of competitive adsorption of CH4 and CO2 during CO2 injection is clarified, and the stimulation mechanism of CO2 injection to improve shale gas recovery is further proposed. The results show that CH4 preferentially exists in form of adsorption state in shale. When CH4 adsorption amount reaches a certain degree, CH4 gas in form of free state gradually appears. During depressurization stage, further depressurization failed to promote the desorption of adsorbed gas when pressure reduced to 3 MPa. Therefore, adsorbed CH4 gas still exists after depressurization production. Shale has stronger adsorption capacity for CO2 than CH4. CO2 can replace CH4 adsorbed on the pore surface, and promote the desorption of adsorbed CH4 gas to free state. CO2 has the best displacement effect on adsorbed CH4 in pores with diameter of 15.04–21.62 nm, but it fails to replace CH4 in pores with diameter less than 1.08 nm. The competitive adsorption of CO2 and CH4 can effectively promote the further desorption of residual adsorbed CH4 gas after depressurization, and significantly improve the cumulative shale gas production.

- **Keywords:** Shale gas reservoir , enhance gas recovery; Carbon dioxide; Competitive adsorption; CCUS

Poku Gyasi, Jiandong Wang, Fan Yang, Iman Izadi. *An adaptive method to update alarm deadbands for non-stationary process variables*. Pages 493-502.

False alarms are detrimental to the safety of industrial processes and are often removed by alarm deadbands. However, most of the existing methods design alarm deadbands based on historic data samples under the assumption of stationarity, and may not achieve the desired performance in reducing false alarms for non-stationary process variables. This paper proposes an adaptive method to update alarm deadbands for non-stationary process variables to remove false alarms. Two technical challenges are addressed in this paper. First, time instants of statistically significant changes in process variables are detected based on mean values of maximum amplitude deviations between process variables and alarm trippoints. Second, when to update an alarm deadband width after detecting a mean change is determined based on a confidence interval of the designed width developed from Bayesian estimation rule. Numerical and industrial examples are provided to illustrate the proposed method and compare with alarm deadbands with fixed widths.

- **Keywords:** Alarm systems; Non-stationary process variables; Alarm deadbands; False alarms; Maximum amplitude deviations

Jiaqi Wang, Qing Yu, Bin Tang, Xiaoxia Wang, Fahui Nie, Zheng Shen, Yalei Zhang. *An integrated process of Fe/C micro-electrolysis-anaerobic hydrolyze-microalgae for treatment of high concentration pharmaceutical wastewater*. Pages 503-512.

As a high concentration wastewater of high organic matter content, many toxic substances, large amounts of organic solvents and poor biochemistry, pharmaceutical wastewater is challenging to handle with a single water treatment technology. In this study, a combined process of Fe/C micro-electrolysis (Fe/C-ME)-anaerobic hydrolyze-microalgae was developed to treat high-concentration pharmaceutical wastewater (i.e. 100,000 mg/L chemical oxygen demand (COD), 2800 mg/L ammonia nitrogen (NH3-N) and 130 mg/L total phosphorus (TP)). Firstly, in the Fe/C-ME process, under optimal experimental conditions, the removal rates of COD, NH3-N and TP were 55 %, 36 % and 63 %, and it was worth mentioning that the removal of ammonia nitrogen and total phosphorus may be attributed to the complexation and flocculation of hydrated iron ions. Secondly, the outer circulation anaerobic reactor (OCAR) performed biochemical treatment on pretreated pharmaceutical wastewater, 85 % of COD was removed, and it was found that through anaerobic digestion, and further hydrolyzed and acidified macromolecular pollutants into small molecules to reduce the impact load, which was conducive to the subsequent digestion and absorption of microalgae and improved the treatment efficiency of the aerobic section. The microalgae cultivated by heterotrophy using anaerobic effluent, directly used NH3-N and TP in wastewater to synthesize substances needed for self-growth and reproduction, and removed 88 %, 91 % and 83 % of COD, NH3-N and TP, respectively. The final results indicated that the removal rates of COD, NH3-N and TP in the integrated process of Fe/C-ME-anaerobic hydrolysis-microalgae were 99.8 %, 98.6 % and 98.5 %, respectively, demonstrating that the coupling process is an effective method for treating high-concentration pharmaceutical wastewater.

- **Keywords:** Fe/C micro-electrolysis; Anaerobic hydrolysis; Microalgae; Pharmaceutical wastewater

Haochang Su, Xiaojuan Hu, Wujie Xu, Yu Xu, Guoliang Wen, Yucheng Cao. *Abundances and key driving factors of combined contaminations of antibiotic resistome and metal resistome in tilapia aquaculture*. Pages 513-524.

Microbiota carrying antibiotic and metal resistance genes pose increasing threats to human health. The profiles of the abundance and dissemination of the extracellular and intracellular antibiotic resistome (ARO) and metal resistome (MRO) in aquaculture environments and reared organisms, and their interrelationships, intrinsic connections, and driving factors are poorly understood. The purpose of this study was to investigate the changes in the extracellular and intracellular ARO and MRO abundances and their key driving factors during the rearing process in tilapia aquaculture. The results show that the abundance of the ARO was strongly positively correlated with that of the MRO ($p < 0.01$). The correlation coefficients between the abundances of plasmids and the ARO as well as MRO were 0.93 and 0.97, respectively ($p < 0.05$). Redundancy analysis (RDA) showed that plasmids were significantly positively correlated with the ARO and MRO in tilapia aquaculture water ($p < 0.05$), while multivariable linear regression analysis showed that plasmids were significantly and positively correlated with the MRO ($p < 0.01$). Network analysis and RDA showed that Actinobacteria were significantly positively correlated with ARO and MRO. The results of this study indicate that the extracellular ARO is a preponderant form of and significant contributor to antibiotic resistance. Combined ARO

and MRO contamination could be positively driven and exacerbated by plasmids through propagation. The bacterial flora is an intrinsic bridge between the ARO and MRO. Mobile genetic elements, especially plasmids, are key drivers of their spread. Based on the results of this study, we conclude that extracellular antibiotic resistance genes (ARGs) should receive more attention and focus in the control of the propagation of ARGs. The abundances of ARO and MRO in tilapia pond water increased significantly; thus, the aquaculture water of tilapia farming should be treated effectively before discharge to reduce ARO and MRO contamination in the receiving environment.

- **Keywords:** Antibiotic resistome; Metal resistome; Combined contamination; Extracellular; Driving factor

Mohammed Tahar Habib Kaib, Abdelmalek Kouadri, Mohamed Faouzi Harkat, Abderazak Bensmail, Majdi Mansouri. *Improving kernel PCA-based algorithm for fault detection in nonlinear industrial process through fractal dimension*. Pages 525-536.

Principal Component Analysis (PCA) is a widely used technique for fault detection and diagnosis. PCA works well when the data set has linear characteristics. However, most industrial processes have nonlinear characteristics in their data. Kernel PCA (KPCA) is an alternative solution for such types of data sets. This solution doesn't come without a cost since one of KPCA's disadvantages is a large number of observations which results in more occupied storage space and more execution time than the PCA technique. Furthermore, if the data is too large it may minimize the monitoring performance of the KPCA model. Reduced KPCA (RKPCA) is a solution for the conventional KPCA limitations. Firstly, RKPCA can deal with nonlinear characteristics without crucial problems because it is based on the KPCA algorithm with a data reduction part where it keeps most of the data's information. Thus, by reducing the number of observations RKPCA reduces the occupied storage space and execution time while preserving tolerable monitoring performance. The proposed RKPCA algorithm consists of two parts. First, the large-sized training data set is reduced using the fractal dimension technique (correlation dimension). Afterward, the KPCA model is developed through the obtained reduced training data set. The proposed scheme is applied to the Tennessee Eastman Process and the Cement Plant Rotary Kiln data sets to evaluate its performance in comparison with other algorithms.

- **Keywords:** Principal component analysis (PCA); Kernel PCA; Reduced KPCA; Fractal dimension; Correlation dimension; Chaos theory; Fault detection; Chemical process; Tennessee eastman process; Cement rotary kiln; Process safety

Swellam W. Sharshir, Zhanhui Yuan, Marwan Elsharkawy, Mohamed A. Hamada, Ahmed Swidan, Gamal B. Abdelaziz, A.S. Abdullah, M.O.A. El-Samadony. *Performance investigation of a tubular distiller using parabolic concentrator with various modifications*. Pages 537-545.

In this experimental study, two units are held and studied: the traditional tubular solar still (TTSS) and the developed tubular solar still (DTSS). The influence of a developed solar parabolic concentrator (DSPC) employed with carbon black nanoparticles (CBNs), a V-corrugated Aluminum basin (VCAB), and wick martial on the thermal efficiency and productivity was investigated in four cases: (Case A): DTSS with DSPC, (Case B): DTSS with DSPC and CBNs, (Case C): DTSS with DSPC and V-corrugated Aluminum basin (VCAB), and CBNs, (Case D): DTSS with DSPC and VCAB and CBNs by using factors such as air temperature, cover temperature, water temperature, air speed, and sun radiation. It was found that case four was the best case, where it had the highest hourly efficiency at 18:0 for each of the traditional unit and the modified unit, and that the energy

efficiency, exergy efficiency, and daily productivity increased by 129.8%, 365.44%, and 120.536%, respectively, compared to the traditional unit, its cost, which was 0.026$, was reduced by 23%.

- **Keywords:** Tubular solar still; Parabolic concentrator; Nanoparticles; V-corrugated aluminum; Wick material

Hongying Zhang, Zhou Fu, Dezheng Guan, Jianwei Zhao, Yuxin Wang, Qi Zhang, Jingliang Xie, Yingjie Sun, Liang Guo, Dongbo Wang. *A comprehensive review on food waste anaerobic co-digestion: Current situation and research prospect*. Pages 546-558.

Anaerobic co-digestion (AcoD), which offers advantages such as C/N balance and high product value, has been recognized as a promising technology for treating food waste. Nevertheless, the current status of AcoD involving food waste in combination with other organic solid wastes has rarely been comprehensively discussed. To fill this knowledge gap, this manuscript provides a review of the research status and future developmental trends in food waste AcoD. Firstly, the research hotspots of food waste AcoD were described based on literature reviews. Secondly, the factors affecting food waste AcoD and related mechanisms are analyzed. Thirdly, the enhanced strategies and the characteristics of the microbial communities involved in food waste AcoD were investigated. Fourthly, the treatment strategies of digestate were also outlined, as well as the related advantages and disadvantages. Finally, the research perspectives on food waste AcoD are presented. In future research, more attention should be paid to the advanced treatment and resource utilization of digestate. This work provides an overview of food waste AcoD with the aim of promoting its widespread practical application.

- **Keywords:** Food waste; Anaerobic co-digestion; Influencing factors; Microbial community

Anene Oguaka, Natalia Flores Quiroz, Richard Walls. *Comparative pyrolysis characteristics and kinetics of agricultural food grains by thermogravimetric analysis*. Pages 559-574.

Pyrolysis precedes the development of smouldering or flaming fires in storage and processing facilities. Understanding this process and determining the parameters that characterise it is essential for controlling fires. This study analysed the pyrolysis of African food grains that are important for food security but historically have received limited attention. Cowpeas, lentils, millet, soybeans, unshelled peanuts, flax, sunflowers, shelled peanuts, and sesame were subjected to thermogravimetry in a nitrogen atmosphere at heating rates of 5, 10, 20, and 40 °C/min from ambient to 600 °C. All grains were completely dehydrated at 170 °C and started decomposing at about 180 °C. The decomposition patterns varied with the relative proportion of hemicellulose, cellulose, protein and, particularly, lipids (oil content). Pyrolysis rates peaked at lower temperatures of about 300 °C for non-oil grains but at higher temperatures of 400 °C for oil grains. Friedman and Coats-Redfern methods were used to determine activation energies (130–355 kJ/mol), preexponential factors (8.1 × 107–1.0 × 1031 s−1) and the numerical values of the complex, multistep reaction models. Oil grains (or their powder) generally have lower activation energies, are thus more reactive than non-oil grains, and therefore constitute critical consideration for fire safety in processing facilities. The work is important for developing fire engineering solutions for food facilities based on quantitative fire behaviour data.

- **Keywords:** Fire; Food grains; Kinetics; Pyrolysis; Thermogravimetry

Liang Gong, Tianyu Mo, Xianwen Zheng, Yifei Han, Haoyu Wang, Xufeng Yang, Yuchun Zhang. *Flame behavior and temperature distribution of coupled fire induced by the interaction of hydrogen jet flame and pool flame*. Pages 575-584.

Once fires occur unexpectedly at the oil-hydrogen integrated refueling stations, there is a high likelihood that they will escalate into a coupled fire, resulting in unpredictable casualties and property losses. In this work, experiments on coupled fire induced by hydrogen jet flame and a heptane pool flame were conducted with different nozzle diameters and release pressures. It has been found that there is a critical diameter above which the hydrogen jet can be ignited instantly. This critical diameter is determined by the release pressure and the location of the pool flame. The heat release rate is greater than that of the single pool flame, and it reaches its highest point at 0.2 MPa. Compared to a single fire, the height of the flame decreases while the length of the flame increases, a prediction model is proposed for the dimensionless flame length and width, taking into account the ratio of the heat release rate of the hydrogen jet flame to the heat release rate of the pool flame. The temperature of the coupled fire reaches its highest point at 0.2 MPa and increases as the nozzle diameter. And it decreases with the increase in the distance when Y= 0 m. However, it increases with the increase of the distance when Y= 0.05 m due to the inclination of the flame.

- **Keywords:** Coupled fire; Heat release rate; Flame length/height; Inclination angle; Temperature distribution

Wei-da Wang, Tan Wang, Zhen-bo Sun, Yan-xin Bo, Chang-xiong Zou, Zhe Wang, Chun-li Zheng. *Solidification treatment of rare earth tailings by a renewable biological cementation method*. Pages 585-592.

Rare earth mineral is a kind of polymetallic co-associated mineral, in addition to containing iron, rare earth, niobium, and a certain amount of thorium and uranium. The tailings after wet leaching of rare earth are both a kind of hazardous waste and a kind of potential strategic resource. Therefore, the treatment and disposal of rare earth tailings should not only achieve the purpose of risk control, but also cannot affect the subsequent reuse. Microbially induced calcium carbonate precipitation (MICP) as an environmentally friendly biological cementation technique, it can solidify the tailings and stabilize the polluting elements. The valuable elements in the tailings can be further recovered after the sample solidified by MICP is decomposed by acid. In this study, a strain of urease-producing bacteria (K-1) with excellent performance was screened by dilution culture method from rare earth tailings. Through physiological and biochemical analysis and 16 s rDNA analysis, the strain K-1 belonged to the genus Lysinibacillus. In the mold, strain K-1 was used to induce the formation of calcium carbonate for cementing rare earth tailings, the strength of the cured body after cementation can reach 1.73 MPa after 28 d. There was a significant reduction in the leaching of heavy metals and radionuclides in the cured body. The results obtained from the scanning electron microscopy (SEM) and X-ray diffraction (XRD) indicated that strain K-1 induced a large amount of calcium carbonate, whose crystal forms are vaterite and calcite. The calcium carbonates cemented the rare earth tailings together for tighter texture and reduced porosity. The X-ray fluorescence (XRF) analysis of the rare earth tailings before and after solidification and after acid decomposition showed that the loss of rare earth elements in rare earth tailings after MICP treatment was small. Moreover, the cured body was relatively easy to dissociate, which facilitated the recovery and reuse of potential valuable elements in the tailings. This study provides technical support for the long-term storage of rare earth tailings and the sustainable development of the rare earth industry.

- **Keywords:** Rare earth tailings; Biological cementation; MICP; Urease-producing bacteria; Recycle

Mukesh Kumar Singh, Subrata Hait, Atul Thakur. *Hyperspectral imaging-based classification of post-consumer thermoplastics for plastics recycling using artificial neural network*. Pages 593-602.

The increasing global output of plastic waste has created a critical need for cost-effective and highly accurate methods of plastic recycling. One of the major challenges in recycling plastics is maintaining the purity of plastic streams, which is essential for secondary plastics to compete with virgin plastics in the market. In this context, this paper presents a novel approach for classifying different polymers in a complex plastic waste stream using a hyperspectral imaging system in the near-infrared (NIR) range (900–1700 nm). The study focuses on the applications of entropy and contrast stretching for image segmentation to identify distinct objects in a given hyperspectral image. The classification process is carried out using a two-layer feedforward network with sigmoid hidden neurons and SoftMax output neurons. The performance of the proposed method was evaluated using a dataset comprising hyperspectral images of unknown plastic waste stream samples, and it was able to achieve an accuracy of about 89.5%. The results of this study demonstrate the potential of using hyperspectral imaging in the NIR range as a cost-effective and highly accurate method for classifying different polymers in plastic waste streams. This approach can be further developed for use in real-world recycling facilities, contributing to the advancement of the plastic waste management field.

- **Keywords:** Hyperspectral imaging; Neural network; Post-consumer thermoplastics; Artificial; Neural networks; Classification

Mitil Koli, Rashmi Ranjan, Swatantra P. Singh. *Functionalized graphene-based ultrafiltration and thin-film composite nanofiltration membranes for arsenic, chromium, and fluoride removal from simulated groundwater: Mechanism and effect of pH*. Pages 603-617.

Groundwater contaminant removal using ultrafiltration (UF) and nanofiltration (NF) membranes is complex due to limitations such as low selectivity-permeability and membrane fouling tendency. In this study, we fabricated a thin film composite (TFC) membrane over a highly permeable mixed matrix support UF membrane using sulfonic acid functionalized graphene oxide (SGO) and polyethersulfone (PES) for groundwater remediation application. The pure water permeability of the PES-SGO-TFC membrane was threefold (3.09 LMH bar−1) compared to the pristine PES-TFC membrane. The membrane showed excellent organic fouling resistance with more than 95% flux recovery. The salts and contaminant removal were checked in a cross-flow mode to understand a more practical approach to the applicability of the developed PES-SGO-TFC membrane. The membrane rejected Cr(VI), As(V), and fluoride to the extent of ~89%, ~99%, and ~77%, respectively, at pH ~7. The membrane separation performance varied as a function of pH, with more than 90% removal for monovalent fluoride at higher pH values. In a simulated groundwater matrix, the membrane demonstrated promising results for rejecting these ions. However, the simultaneous rejection of As(V) and fluoride may be impacted by interfering co-ions. This study offers a novel approach for developing highly permeable support UF-modified TFC membranes for better separation for groundwater remediation.

- **Keywords:** Groundwater remediation; TFC membrane; Sulfonated graphene oxide; Ultrafiltration modification; Cross-flow mode

Chien-Ping Wang, Yi-Lin Wu, Shao-Hong Yang. *Effect of channel configuration on the water sterilization efficiency of a photoreactor with ultraviolet C light-emitting diodes*. Pages 618-627.

This study investigated the effect of flow channel configuration on the water disinfection efficiency of a photoreactor with ultraviolet (UV) C light-emitting diodes (LEDs). The synergistic effect of UV radiation and hydrodynamics on microbial inactivation was analyzed to obtain the UV fluence distribution for five channel configurations. Simulations revealed that the serpentine and spiral configurations led to similar microbial residence times. However, the high mixing efficiency in the serpentine configuration resulted in the efficiency of Escherichia coli inactivation being higher in this configuration than in the spiral configuration. Although the pin configuration achieved the highest average UV fluence of the five channel configurations, the E. coli inactivation value in this configuration was low because approximately 25 % of the microbes received UV fluence of less than 5 mJ/cm2. This study modified the pin configuration, and the results revealed that this configuration effectively increased the UV fluence received by microbes and eliminated low-fluence particles. At a flow rate of 120 mL/min, the average UV fluence in the modified pin configuration was 43 %, 52 %, and 72 % higher than those in the serpentine, spiral, and bioinspired configurations, respectively. Experimental findings indicated that at a maximum flow rate of 160 mL/min, the E. coli inactivation value achieved in the modified pin configuration was 3.3 log, which was approximately 0.4, 1.2, 1.5, and 1.8 log higher than those achieved in the serpentine, spiral, pin, and bioinspired configurations, respectively. The results of this study provide insights regarding enhancement of the UV exposure of microorganisms and can be used as a guideline in flow channel design for water disinfection reactors with UV-C LEDs.

- **Keywords:** UV-C LED; Water disinfection; Hydrodynamics; Radiation

Fabio Trippetta, Alberto Maria Gambelli, Giorgio Minelli, Beatrice Castellani, Federico Rossi. *Sustainability of CO2 replacement processes in marine hydrate reservoirs: Factors causing changes on mechanical properties of Gas-Hydrate after CO2/CH4 exchange*. Pages 628-639.

The energy content of Gas Hydrated in form of natural gas is approximately twice with respect to the total energy still producible from all the known conventional energy sources. To reduce the risk induced by exploitation of hydrate reservoirs a good knowledge of the mechanical properties is crucial. Here we simulate CH4 replacement with CO2 and then we analyze the mechanical properties of replaced hydrates through porosity, Vp and Vs measurements. Replacement tests with CO2 have been performed by depressurization and thermal stimulation. Both procedures result in a final CH4/CO2 concentration of ~30/70%. We then measured the petrophysical properties of pure CO2 and CH4/CO2 hydrates hosted in synthetic (Glass beads -GB) and natural sand (Iceland Sand-IS). Porosity and velocity within the same hosting sediments, show a clear inverse relation for the sub-angular and poorly sorted IS being this less evident for the spherical and highly sorted GB sands. CO2 replacement increases Vp and dynamic Young's modulus for GB samples whilst IS are less influenced by the presence of CO2. These results demonstrate that reservoir sediments severely affect the mechanical properties of hydrates and thus their characteristics must be taken in account for safety well and reservoir management.

- **Keywords:** Gas hydrates; CO2 Replacement; Hydrates reservoir safety; Hydrates petrophysical properties; Well and reservoir stability

Zhongmou Liu, Xiangyu Zhao, Jinghui Wu, Yidi Gao, Keqing Li, Xiaohong Wang, Mingxin Huo, Xianze Wang. *Synergistic naproxen adsorption and peroxymonosulfate-driven oxidation on defective magnetic porous graphene dual functional materials*. Pages 640-650.

In this study, recycled and highly active magnetic porous graphene (MPG) was prepared through defect treatment of graphene-based materials and the loading of magnetic nanoparticles. A coupling technology of adsorption and peroxymonosulfate advanced oxidation was established to remove Naproxen (NPX) from water by utilizing the excellent defect structure and abundant active sites of MPG. The removal efficiency of NPX using the MPG/PMS system was 100% within 120 min, in which the adsorption stage took 30 min and contributed 70.3% to the removal of NPX. Subsequently, the reaction rate constant reached the maximum value of 0.782 min−1 in the first minute of the chemical reaction stage after adding PMS. Quenching and EPR analysis confirmed that both free radicals (O2·-, SO4·- and·OH) and nonfree radicals (1O2) generated in the MPG/PMS system participated in the degradation of NPX. The electrochemical test further confirmed that the generation of nonfree radicals promoted by electron transfer played a major role, and the high chemical reaction active center was exposed due to the internal defects of MPG. The excellent anti-interference and widespread applicability of MPG have been verified. The intermediate products, degradation pathways, and toxicity changes of NPX degradation were analyzed and summarized.

- **Keywords:** Magnetic porous graphene; Peroxymonosulfate; Adsorption; Defective treatment; Naproxen

Osman Shamet, Dahiru U. Lawal, Abdul Hafiz AlHariri, Mohamed Antar. *Performance of different HDH desalination units powered by diesel engine generator waste heat*. Pages 651-666.

Diesel generators used for off-grid power generation and other applications waste a significant amount of input power as heat (about 65%), contributing to global warming. To mitigate this, waste heat recovery and utilization systems can be employed. The current study, focuses on utilizing waste heat from a 2.5 MW diesel generator for freshwater production through integrated humidification dehumidification (HDH) systems. Four different HDH system layouts are investigated, considering factors such as dehumidifier and humidifier effectiveness, temperature differentials, mass flowrate ratio, and ambient temperature. The aim is to analyze and optimize the system's pure water productivity, recovery ratio, specific entropy generation, and gained output ratio. The results show that the layout featuring an air heated – air heated cycle (AH-AH) performs the best, with the highest productivity and gained output ratio of 234.48 m3/day and 3.01, respectively. On the other hand, the water heated – water heated cycle (WH-WH) layout exhibits lower performance. The study demonstrates the potential to recover 46–70% of the waste heat, significantly improving the diesel engine's utilization factor from 36% to 68%. The proposed system also proves cost-effective, with freshwater production costing as low as 0.62 $/m3 when utilizing waste heat, compared to 4.11 $/m3 and 13.96 $/m3 when using steam or electric heating elements. Furthermore, the integrated system helps reduce the environmental impact by minimizing waste heat discharge into the environment and thus contributes to mitigating global warming.

- **Keywords:** Humidification-Dehumidification (HDH); Cost Analysis; Entropy Generation; Energy Analysis; Waste heat

Niranjan Sahoo, Anil Kumar, Samsher. *Potential of solar thermal calciner technology for cement production in India and consequent carbon mitigation*. Pages 667-676.

This study describes the potential of solar thermal calciner technology and consequent carbon mitigation for Indian cement industries. Approach used to provide solar energy involves the installation of a solar tower system with a solar reactor atop the solar tower or preheater tower in a conventional cement plant. For potential estimation, locations of the clusters of cement plants with their actual annual cement production have been identified. Based on the annual actual cement production, the yearly process heating demand for the calcination process for each cement plant is estimated. Solar irradiation of each location of the cement plant is identified, and the plants with direct normal irradiation (DNI) > 1700 kWh/m2 /annum are considered. Total thermal energy saved is estimated as 133.36 PJ/annum and CO2 mitigation is estimated as 7413.73 thousand tonnes.

- **Keywords:** Solar energy; Cement industry; Carbon emission reduction; Solar calcination; Solar cement plant

Z.L. Hu, L.L. Ma, H. Wu. *Hazard evaluation framework for large yield explosions in urban environments: A case study of Beirut explosion*. Pages 677-690.

The Beirut explosion is one of the largest yield ammonium nitrate explosions in recent years, causing massive destruction and becoming a valuable case for explosion analysis. Compared with general post-disaster evaluation methods, e.g., on-site investigation and high-resolution satellite imagery, the numerical simulation approach can provide decision-makers and rescue workers with intuitive and visualized assessment results. Additionally, it can also serve as an effective tool to guide the architectural planning and blast-resistant design of building structures. However, due to the large dimension of urban numerical models, simulating explosions in complex urban blocks has low efficiency, often costing days to ensure accuracy. At present, based on the finite element analysis software AUTODYN, a framework to evaluate the post-explosion damage in city blocks is proposed, which is composed of the geospatial data, efficient numerical simulation approach, and damage evaluation principles. Subsequently, the detailed process of the numerical simulation approach is given, and it integrates the multi-stage method, symmetrical modelling, optimized graded mesh size, mapping, and mesh un-refinement technique, to reduce the number of mesh cells and increase the computational efficiency. Furthermore, the applicability of the numerical simulation approach in more complex environments is verified through two typical block explosion tests. Finally, the Beirut explosion is reproduced using the geospatial data obtained from OpenStreetMap, and the evaluation results are compared with field survey reports, satellite image analysis, and related numerical simulations. It is found that the proposed framework can quickly and effectively predict and evaluate the actual explosion accidents in the city environment.

- **Keywords:** Evaluation framework; Beirut explosion; Numerical simulation; Geospatial data; Damage evaluation

Palani Karthik, Siranjeevi Ravichandran, Velusamy Sasikala, Azhagurajan Mukkannan, Jegathalaprathaban Rajesh. *Evaluation of MnO2 incorporated cellulose acetate membranes and their potential photocatalytic studies using Rhodamine-B dye*. Pages 691-699.

In this study, CA/MnO2 nanocomposites were successfully synthesized by using a magnetic stirring method that was not prohibitively expensive. For the purpose of

characterizing nanocomposites, XRD, EDX, Photoluminescence, FTIR, and XPS were used. FESEM was used to observe the shape and dimensions of the formed CA/MnO2 nanocomposites. For the purpose of evaluating CA/MnO2 nanocomposites, photocatalytic degradation of rhodamine-B that was obtained from the dyeing industry was employed. In addition, research was conducted on the photocatalytic process of rhodamine-B degradation in an aqueous solution. This method displayed that the concentration of rhodamine-B decreased by 81 % in only sixty minutes when it was exposed to UV–visible light. These results pave the way towards developing more efficient visible-light-responsive photocatalysts to remove organic pollutants during the water treatment process.

- **Keywords:** Cellulose acetate; MnO2 nanoparticles; Rhodamine-B; Photodegradation

Qiang Guo, Jie Liu, Wenkai Liang, Hewu Wang. *On the explosion characteristics of natural gas with hydrogen and inert gas additions*. Pages 700-713.

In this work, the explosion limits of three different natural gas mixtures (with various proportions of methane (CH4), ethane (C2H6), and propane (C3H8)) have been investigated numerically based on detailed chemical kinetics. Furthermore, a comprehensive investigation of the effects of hydrogen (H2) and inert gas (N2, CO2) addition on the explosive properties of natural gas has been carried out. The results indicate that the C3H8 components have a dominant effect on the explosion limits of natural gas. The addition of high-hydrocarbons in natural gas can significantly reduce the auto-ignition temperature, shorten the ignition delay time, and enhance the explosion risk of the mixture. Furthermore, the negative temperature coefficient (NTC) response of natural gas in the second explosion limit gradually disappears, and changes to the Z-curve response with the addition of H2. However, the explosion tendency of the mixture is reduced with the addition of H2 under normal to high-pressure conditions. In addition, with the increase of inert gas (N2, CO2), the explosion limits of the mixtures shift upwards to a higher-pressure region, which significantly reduces the explosion tendency. Nevertheless, the explosion propensity of the mixture increases significantly under low-pressure conditions when the mixture contains hydrogen. To elucidate the critical control reactions and determine their synergistic effects, sensitivity analyses under different conditions are performed. Finally, the interaction of different fuels in natural gas mixtures is further summarized by analyzing the explosion limits of single-component, binary-component, and multi-component mixtures of hydrogen to propane. This paper provides an important guidance for the development of natural gas with high safety, low risk, and low pollution.

- **Keywords:** Natural gas; Explosion limits; Hydrogen; Methane; Ethane; Propane

Jia Liu, Shaojie Lu, Ping Li, Wenjun Liang. *Effect of starvation on the performance of a biotrickling filter packed with diatomaceous earth composite fillers for xylene removal*. Pages 714-723.

The continuous operation of a biotrickling filter (BTF) is difficult to guarantee in industrial applications. Herein, BTF packed with diatomaceous earth-based composite fillers was investigated to treat xylene under the operating conditions of complete shutdown and nutrient deficiency. The BTF experienced complete shutdown (4 h, 8 h, 12 h, 16 h, 20 h, 2 d, and 7 d), and the removal efficiency recovered completely within 1 d of operation. The performance of the BTF was not significantly affected by 87 d of complete shutdown or 43 d of nutrient deficiency. High-throughput sequencing revealed that the diatomaceous earth-based composite filler could provide a good living environment for microorganisms and maintain microbial activity during starvation stages. The results

show that the diatomaceous earth-based composite filler has great resistance to starvation.

- **Keywords:** Biotrickling filter; Composite filler; Starvation; Recovery; Xylene; Microbial community

Shangbo Han, Yiyan Hua, Yangshu Lin, Longchao Yao, Zhongcheng Wang, ZhengJie Zheng, Jian Yang, Chunhui Zhao, Chenghang Zheng, Xiang Gao. *Fault diagnosis of regenerative thermal oxidizer system via dynamic uncertain causality graph integrated with early anomaly detection*. Pages 724-734.

Regenerative thermal oxidizers (RTO) serve as pivotal equipment for the treatment of volatile organic compounds (VOCs). However, a diversity of faults of the RTO system may threaten personnel safety and lead to unscheduled downtime. In this work, we develop a traceability inference method based on dynamic uncertain causality graph (DUCG) to identify root fault cause of RTO at early anomaly alarm. A general expert knowledge base for the fault diagnosis of RTO system is constructed. And the anomaly alarm thresholds are modified according to historical data with n-sigma rules to improve the diagnostic accuracy. Results on different cases show advantages in both triggering early anomaly alarms and avoiding invalid alarms, which is crucial to improve the fault inference accuracy. By applying our method to 35 fault cases of a real RTO for pharmaceutical VOCs treatment, the fault detection rate reaches 94.29%, and the fault inference accuracy is 82.86%. The two scores are 3% and 21% higher than those with the conventional DUCG (with fixed alarms), respectively. This remarkable improvement underlines the significance of our proposed method for RTO maintenance, and it is expected to assure the system's operational stability and reliability.

- **Keywords:** Regenerative thermal oxidizer; Dynamic uncertain causality graph; Anomaly detection; Fault diagnosis

Guofeng Zhang, Rubar Hassan Dizayee, Vishal Goyal, Yunjing Jiao, Theyab R. Alsenani, Hasan Sh. Majdi, Mahidzal Dahari, Van Giao Nguyen, H. Elhosiny Ali, Huu Cuong Le. *Proposal and exergetic/net present value optimization of a novel integrated process into a two-stage geothermal flash cycle, involving bi-evaporator refrigeration unit: Application of non-dominated sorting genetic algorithm (NSGA-II+LINMAP) method*. Pages 735-753.

Considering the benefits of geothermal energy in low-temperature combined processes, this study intends to present, examine, and optimize a novel thermal integration process incorporated into a two-stage geothermal flash cycle. In order to meet this objective, a modified bi-evaporator refrigeration technology using an ejector has been designed, with the capability of generating coolant for air-conditioning and industrial requirements. Furthermore, the entire system utilizes a low-temperature water electrolysis process for hydrogen production. In addition to designing a new process, this study incorporates advanced methodologies to comprehensively analyze the proposed system's thermodynamic, economic, and exergoenvironmental aspects. In this context, an extensive parametric study is undertaken, followed by the definition of two distinct multi-objective optimization scenarios: the energy-environment and the energy-cost scenarios. Based on the outcomes derived from the first scenario, the corresponding objective functions, namely energy efficiency and exergoenvironmental index, are determined to be 52.89% and 0.5, respectively. This condition is also responsible for generating net output electricity, cooling load, and hydrogen production rate of 3.897 MW, 26.88 MW, and 4.02 kg/h, respectively. Moreover, it exhibits an exergy destruction rate of 5493 kW. In the second scenario, the objective functions, i.e., energetic efficiency and payback

period, are calculated to be 39.37% and 3.94 years, respectively. The aforementioned products demonstrate capacities of 3.697 MW, 17.66 MW, and 5.0 kg/h, respectively. Besides, the exergy destruction rate is determined to be 4667 kW.

- **Keywords:** Bi-evaporator; Two-stage geothermal flash cycle; Low-temperature electrolyzer; Trigeneration application; Parametric study; NSGA-II method

Lifang Tian, Zongguo Zhang, Bashir Salah, Mohammad Marefati. *Multi-variable assessment/optimization of a new two-source multigeneration system integrated with a solid oxide fuel cell*. Pages 754-773.

The integration of renewable energies can improve the thermodynamic performance and increase the popularity and commercialization of the energy production system. Moreover, the exploitation of renewables in the form of cascade energy systems with multigeneration goals has been able to overcome many restrictions and penalties. Meantime, fuel cells are efficient, carbon-free, and promising energy conversion technologies can act as a storage system and improve the sustainability of the energy system. In this article, a new two-source multigeneration system (TS/MGS) based on a biomass fuel and a geothermal source is introduced and evaluated. The upstream process of the considered system is based on a municipal solid waste (MSW)-gasification process-fueled solid oxide fuel cell (SOFC) stack. Besides, the downstream process is comprised of a geothermal source based on a triple-flash cycle, an ejection-based refrigeration process, a water electrolysis cycle, and a domestic water heater unit. The offered TS/MGS is capable of generating electricity, cooling load, heating load, and hydrogen fuel. Converting MSW to energy, in addition to producing efficient energy, can help waste management in urban communities. The operation of the offered TS/MGS was comprehensively investigated from thermodynamic, cost and environmental standpoints. Moreover, the optimal behavior of the TS/MGS is compared under two different decision-making approaches (based on a tri-objective optimization algorithm). Under the considered design parameters, the considered TS/MGS can provide about 3.92 MW of electric power, 2.19 MW of cooling load, ~ 1.55 MW of heating load, and 0.1 g/s of hydrogen fuel to the consumer (at a thermal efficiency of 33.5% and an exergy efficiency of 61%). The values of total unit cost of products and levelized total carbon dioxide emissions were 0.0211 $/kWh and 0.21 kg/kWh. Under the TOPSIS decision-making approach, relatively more optimal exergoeconomic and environmental outcomes can be achieved compared to the LINMAP decision-making approach. However, the thermodynamic behavior under the LINMAP decision-making approach is more optimal than the TOPSIS decision-making approach.

- **Keywords:** Two-Source Multigeneration System; Municipal Solid Waste; Geothermal Source; Solid Oxide Fuel Cell; Environmental; Optimization

Ying Chen, Caiwu Lu, Shuicheng Tian, Qinghua Gu, Song Jiang, Xinhong Li, Yuan Zou. *Monitoring and detecting coal miners' fatigue status using MPA-LSSVM in the vision of smart mine*. Pages 774-783.

With booming computer technology and diverse computer-based smart applications, intelligent monitoring and detection of the fatigue state of coal miners (miners) has attracted extensive attention from enterprises. In order to accurately and fast knowledge the fatigue status of Miners and reduce production accidents. The article proposes a Fatigue Monitoring and Detection (FMD) model based on a fusion Machine Learning (ML) approach: Marine Predators Algorithm (MPA)-optimized Least Squares Support Vector Machine (LSSVM). Firstly, the physiological information of electroencephalogram (ECG) of coal miners before and after manual handling operations was collected using the MP160 recorder (multiconductance physiological 160) produced by BIOPAC, USA. Using the paired-samples t-test method, the characteristic indicators reflecting miners' fatigue were extracted from the ECG. Secondly, Principal Component Analysis (PCA) was used to

optimize the selected feature indicators and establish the depth fatigue feature parameter set to characterize the fatigue level of miners. Finally, the proposed MPA-LSSVM-based FMD model is applied to recognize Miners' fatigue levels. The results show that the selected indexes can effectively reflect the fatigue status of Miners. The proposed MPA-LSSVM-based FMD model has higher recognition accuracy than SVM and LSSVM models (13.99% and 18.68% higher, respectively) and better robustness. Therefore, the proposed MPA-LSSVM-based FMD model can accurately and effectively identify the fatigue status of Miners.

- **Keywords:** Coal miner; Fatigue monitoring and detection; Smart mine; ECG signal; MPA-LSSVM

Indhu Suresh, Noel Nesakumar, Gautham B. Jegadeesan, B.G. Jeyaprakash, John Bosco Balaguru Rayappan, Arockia Jayalatha Kulandaiswamy. *An enzyme-less energy driven electrochemical approach for carbendazim detection using f-MWCNT/NTAA Na3.H2O composite in water to improve environmental sustainability*. Pages 784-795.

Carbendazim, a systemic fungicide, is being largely used in different sectors like, agriculture, aquaculture, forestry, and food industries. However, due to the presence of stable benzimidazole ring in it leads to the persistence of its toxic residues in the environment. Thus, the detection and quantification of carbendazim residues becomes highly imperative for early risk-assessment and decision-making. Herein, we developed a functionalized multiwalled carbon nanotube with nitrilotriacetic acid trisodium salt monohydrate (f-MWCNT/NTAA Na3·H2O) composite-based electrochemical sensor for the detection of carbendazim. From UV spectroscopy and electrochemical measurements, it has been confirmed that the interface aids in the electrocatalytic reaction towards carbendazim due to the inherent thermodynamic feasibility between the analyte and interface, and the same has been tested with density functional theory (DFT). In addition, the developed sensor showed an excellent sensing performance towards carbendazim by eliminating the effect of matrix and by recognizing the active ingredient. The sensor exhibited two distinct wide linear concentration windows in the range of 0.5–25 nM, and 0.1–500 μM with a low detection and quantification limit of 5.54, and 16.80 pM; 10.94, and 33.14 pM, respectively. The f-MWCNT/NTAA Na3·H2O modified electrode can be taken for the real-time analysis in water owing to its specificity.

- **Keywords:** Electrochemical sensor; Carbendazim; MWCNT; HOMO-LUMO; DFT

Tongyu Xu, Xiaoyang Wang, Yafei Wang, You Li, Huayue Xie, Haolin Yang, Xindong Wei, Weijun Gao, Yingzi Lin, Chunyan Shi. *Integration of sewage source heat pump and micro-cogeneration system based on domestic hot water demand characteristics: A feasibility study and economic analysis*. Pages 796-811.

The reduction of carbon emissions from building space heating and cooling technology has become a crucial approach in achieving global carbon neutrality. Among these technologies, heat pumps and cogeneration systems are effective methods for carbon reduction in buildings. However, in numerous studies of coupled system operation, few scholars have considered the energy use of domestic hot water. This research investigates the operational feasibility of a sewage source heat pump coupled with a micro-cogeneration system, using a large-scale hotel building as the basis for the study. An economic operation strategy, based on the load characteristics of domestic hot water, is proposed and validated through simulation using TRNSYS software. The results showed that the proposed system can reduce peak power usage by 37 % annually, leading to lower operating costs. The calculations indicate that the proposed system can decrease

the annual operating cost by 402,300 CNY compared to a single sewage source heat pump system. The payback period for the proposed system is estimated to be 6 years at the current time-of-use electricity price. Under various energy policy conditions, 71 % of the proposed system's payback period is less than 20 years. Moreover, the emissions of SO2, NOx, and CO2 are reduced by 73.5 %, 73 %, and 64.8 % respectively. The system offers substantial economic and environmental benefits, and this study can serve as a reference for energy supply systems in cold regions.

- **Keywords:** Sewage source heat pump; Micro cogeneration; Hotel; Domestic hot water load; Techno-economic and environment analysis

Chenhao Li, Zuohua Liu, Erfeng Hu, Jianglong Yu, Chongyang Dai, Yishui Tian, Yang Yang, Yongfu Zeng. *Infrared heating and synergistic effects during fast co-pyrolysis of corn stover and high alkali coal*. Pages 812-821.

Infrared heating method aids in the investigation of the primary volatiles-volatile interactions during co-pyrolysis by minimizing the secondary reactions. In this study, characteristics and synergistic effects during the rapid co-pyrolysis of high alkali coal (HAC) and corn stover (CS) using infrared heating were systematically investigated. The co-pyrolysis liquid yield initially increased and then decreased with increasing the pyrolysis temperature. The synergistic effects clearly promoted the tar yield and quality. The co-pyrolysis tar yields increased with rising temperature, from 23.29 wt% at 500 °C to 28.87 wt% at 700 °C, before decreasing to 23.57 wt% at 800 °C. At 700 °C, the largest deviation was 63%. Moreover, the co-pyrolysis interaction had a maximal negative deviation of − 35% for CO2 mass at 700 °C, indicating that the co-pyrolysis of CS and HAC reduced carbon emissions. The tetracyclic and tricyclic aromatic hydrocarbons in PAHs were substantially reduced due to CS hydrogen radicals, and the quantities of the binary aromatic rings decreased by 50% with the increase in temperature. The presence of AAEMs in coal affected the bond breaking and reformation of molecular bonds within the tar components. Raman analysis and BET analyses suggested that AAEMs in HAC enhanced the reactivity of char. The interaction between the volatile of CS and HAC increased the amount of ammonia carbon and the number of active sites.

- **Keywords:** Infrared heating; Co-pyrolysis; Synergistic effects; Carbon emission; Tar yield

Chongchong Zhang, Boqiang Lin. *Assessing and interpreting carbon market efficiency based on an interpretable machine learning*. Pages 822-834.

The urgency of addressing climate change and reducing carbon emissions necessitates the establishment of effective carbon markets. Our paper focuses on assessing and interpreting the efficiency of carbon markets, which is a crucial aspect of their successful implementation. We selected Hubei, Shenzhen, and Guangdong carbon pilots as examples to measure their dynamic information efficiency by combining the rolling time window and wild-bootstrap variance ratio test. Furthermore, we combined SHapley Additive exPlanations (SHAP) and Extra Trees (ET) regressor to reveal the nonlinear relationship between market performance and efficiency. Our findings highlight the time-varying nature of carbon market efficiency and reveal that China's carbon market has not yet achieved stable weak-form efficiency. Additionally, we identified excessive trading volume volatility as a significant constraint on market efficiency, while the trading volume itself exhibits weak explanatory power. Our proposed hybrid model demonstrates superior predictive and explanatory capabilities, offering regulators a valuable tool for continuously monitoring and interpreting carbon market efficiency. Finally, we suggested

that reducing trading volume volatility should be a major concern for regulators to optimize market operations at present.

- **Keywords:** Emission trading system (ETS); Market performance; Market efficiency; Efficient Market Hypothesis (EMH); Wild-bootstrap variance ratio test; Interpretable machine learning model

Jingru Cui, Yue Feng, Bingwen Xu, Weidong Zhang, Liang Tan. Reactor performance of static magnetic field membrane bioreactor for treating actual high-salt textile dyeing wastewater and possible mechanism on magnetically enhanced membrane fouling control. Pages 835-846.

Performance of the static magnetic field membrane bioreactor (SMFMBR) for treating actual high-salt textile dyeing wastewater was evaluated. Membrane fouling behavior and possible mechanisms were investigated using multiple methods including chemical composition analysis, microbial community analysis, and four-dimensional label-free quantification metaproteomic analysis. The results showed that three SMFMBRs equipped with the SMFs of 97.2 mT (1#), 202.3 mT (2#) and 303.4 mT (3#) possessed higher removal efficiency of color, chemical oxygen demand (COD) and acute toxicity, as well as higher activity of key enzymes than the conventional MBR (0#). Treatment efficiency of 3# SMFMBR was the highest among all the four groups. Potentially effective bacterial and fungal species were selectively enriched in the suspended sludge of three SMFMBRs according to the results of both high-throughput sequencing and quantitative real-time polymerase chain reaction (QRT-PCR). Membrane fouling rate of 3# SMFMBR was the lowest among all the groups, followed by that of 2#, 0# and 1# reactors. SMF of higher intensity (in 2# and 3# SMFMBRs) mitigated membrane fouling by inhibiting the production of microbial products (mainly consisting of proteins) and the growth of potential fouling-causing microbes on the membrane surface. By contrast, SMF of lower intensity (in 1# SMFMBR) aggravated membrane fouling by improving the yield of fouling-causing microbial products and the growth of biofilm on the membrane surface. Furthermore, the down-regulated porin and the up-regulated Ca2+-binding protein in biocake EPS were also responsible for the mitigation of membrane fouling in 3# SMFMBR.

- **Keywords:** Actual high-salt textile dyeing wastewater; Static magnetic field membrane bioreactor (SMFMBR); Membrane fouling; Microbial community analysis; Metaproteome analysis

Xia Wu, Lei Mou, Wenlong Jia, Yibin Sun, Haifeng Liu, Changjun Li. *A machine-learning method to accurately recognize the leakage pressure-drop signals in trunk natural gas pipelines*. Pages 847-863.

A block valve installed along a trunk natural gas pipeline can automatically shut down when it detects a pressure-drop rate that is over a threshold value for a specified duration, indicating that leakage accidents have occurred. However, current methods have difficulties on identifying the differences among the pressure-drop rate signals caused by small-hole leakage, compressor startup, and block valve emergency shut-down conditions. This usually leads to improperly shutting down the block valve. Based on an optimized support vector machine, a machine-learning method is proposed to recognize the pressure-drop rate signals through the eigenvalue of the pressure-drop curve instead of only using the pressure-drop signal and its duration. Firstly, the singular decomposition method and the support vector machine method are applied to initially classify the pressure-drop rate signals of three operating conditions: the gas leakage, compressor startup, and block valve emergency shut-down conditions. Secondly, a teaching-learning-based optimization method is applied to optimize the penalty factor and kernel function parameter in the support vector machine model. Particularly, the tent chaotic maps and adaptive inertia weight methods are applied to improve the teaching-

learning-based optimization method to balance its local and global search performance. Thirdly, an improved teaching-learning-based support vector machine method is established. Finally, 960 sets of simulated pressure-drop signals taken from three trunk natural gas pipelines and pressure-drop rate signals collected from an actual pipeline are applied to verify the accuracy of the proposed model. The results show that the improved teaching-learning-based support vector machine model achieved high classification and recognition accuracy. Specifically, it achieved accuracy rates of 99.4%, 100%, 98.3%, and 100% for the pressure-drop rate signals generated by pipelines A, B, C, and Cangzhou branch in the presence of pipeline leakage (the leak hole diameter is from 25 to 125 mm). Additionally, it demonstrated an average recognition accuracy of 97.42% for the pressure-drop rate signals generated by pipelines under other operating conditions. Through cooperating with Supervisory Control And Data Acquisition system, this method provides a more relevant approach to determine the shutdown conditions of a block valve while preventing mistaken actions.

- **Keywords:** Natural gas pipeline; Block valve; Pressure-drop rate; Support vector machine (SVM); Teaching-learning-based optimization (TLBO)

Summaiya Javed, Arun Kumar Tiwari. *Performance analysis of zeotropic mixture as a working fluid for medium temperature in regenerative Organic Rankine cycle*. Pages 864-872.

Energy consumption is a never-ending need so, for levelizing the energy demands the efficient recovery of waste heat is a crucial mechanism to address energy and environmental problems. Organic Rankine cycle is the most technically feasible and promising approaches for recovering waste heat. To augment the system performance and technology economic viability, the opted fluid plays a vital role. So, zeotropic fluid acts as a best candidate by showing a proper match with the temperature of heat source as a result enhances the thermodynamic performance of Organic Rankine cycle system. In this study a detailed thermo-economic analysis of regenerative Organic Rankine cycle to recover medium temperature waste heat from glass industry employing zeotropic mixtures of cyclohexane + benzene, toluene + benzene, toluene + nonane and cyclohexane + nonane as a viable working fluid at 0.5 mass fraction. Result reveals that, at 375 °C hot gas inlet temperature the maximum power, energy and exergy at respective parameters are 1132.96 kW, 50.15 % and 75.53 % by using cyclohexane + benzene. Economic analysis shows the maximum operating cost of 118.8 $/h. Likewise, the impact of hot gas input temperatures are investigated for the best mixture at a mass fraction of 0.1–0.9.

- **Keywords:** Regenerative Organic Rankine cycle; Energy economic analysis; Exergy analysis; Zeotropic mixture

Yangfan Chen, Jiangling Li, Wenxin Teng, Jiangfeng Song, Weizao Liu, Shan Ren, Jian Yang, Qingcai Liu. *Ecofriendly extraction of zinc from hazardous electric arc furnace dust via sulphating roasting: Non-isothermal and isothermal kinetics analyses*. Pages 873-886.

Electric arc furnace dust (EAFD) formed during steelmaking in electric arc furnace is a hazardous solid waste that is rich in zinc and iron. In our previous study, we realized the efficient extraction and separation of Zn and Fe from EAFD by co-roasting with FeSO4·7H2O followed by water leaching processes, which achieved a high extraction rate of Zn (98.79 %) and a low extraction rate of Fe (0.11 %). However, the high temperature would lead to high energy consumption. Therefore, non-isothermal kinetic and isothermal kinetic were exploited in this study to analyze the heating and holding process for further optimizing roasting conditions. The heating process was divided into four reaction stages with different reaction models. Moreover, the holding process was

also divided into two reaction stages with the Anti-Jander 3D diffusion model and Z-L-T 3D diffusion model, respectively. The major reactions in the heating and holding process were defined by thermodynamic equilibrium calculations and in situ X-ray diffraction. The rate-determining step was deduced as the desulfurization of Fe2(SO4)3 with a three-dimensional diffusion reaction model. Aiming to accelerate Fe2(SO4)3 desulfurization, the insulation conditions of this process were optimized from 675 °C for 3 h to 600 °C for 3 h, significantly reducing energy consumption.

- **Keywords:** EAFD; Zn extraction; FeSO4·7H2O; Non-isothermal kinetic; Isothermal kinetic

Zhongqi He, Xiumin Fan, Luyao Qu, Xu Zhou, Wenbiao Jin, Mohammad Rafe Hatshan, Xuan Li, Huan Liu, Guangming Jiang, Qilin Wang. *Cultivation of Chlorella pyrenoidosa and Scenedesmus obliquus in swine wastewater: Nitrogen and phosphorus removal and microalgal growth*. Pages 887-895.

Using microalgae to treat swine wastewater can effectively reduce the increasing pollution and save the cost of cultivating microalgae. In this study, the growth and denitrification and phosphorus removal effects of Scenedesmus obliquus and Chlorella pyrenoidosa at different dilutions in swine wastewater were investigated to solve the problem that microalgae could not be cultivated in the raw swine wastewater. After diluting the swine wastewater 8 and 12 times, the growth was optimized after 11 days of cultivation of Scenedesmus obliquus and 9 days of cultivation of Chlorella pyrenoidosa. Compared to Chlorella pyrenoidosa, the biomass and chlorophyll-a content were higher in Scenedesmus obliquus, at 1.48 g/L and 18.46 mg/L, respectively. The removal of nitrogen and phosphorus indicators was almost 100 %. Subsequently, Scenedesmus obliquus was cultured in an 8-fold dilution of swine and domestic wastewater, with dry weights of 0.83 g/L and 1.44 g/L, and lipid contents of 41.26 % and 25.11 %, respectively. Compared to Chlorella pyrenoidosa, Scenedesmus obliquus was more tolerant to nitrogen and phosphorus in swine wastewater, and at the same time, it had a higher growth rate, making it more suitable for treating swine wastewater and accumulating biomass.

- **Keywords:** Swine wastewater; Domestic sewage; Chlorella pyrenoidosa; Scenedesmus obliquus; Nitrogen and phosphorus removal

Sathya Ramalingam, Bindia Sahu, Jonnalagadda Raghava Rao. *Hybrid nanoparticles emulsified vegetable oil as an environmentally friendly and sustainable leather fatliquoring agent*. Pages 896-906.

Introducing sustainability by a reduction in chemical input has added value to technology innovations, especially in the leather fatliquoring process. Major concern of sustainable leather fatliquoring process lies in factors like usage of natural oil, avoidance of hazardous substances and reduction in organic load to the environment. Due to their special features, such as their ease of preparation and environmental friendliness, Pickering emulsions and their applications have received significant attention in recent years. The present study reports a novel sustainable leather fatliquoring process by usage of hybrid particles (alumina coated with silica) stabilised Pickering emulsions as fatliquor instead of conventional sulphated oil based fatliquor. Eco fatliquoring agent with a particular choice of vegetable oil stabilised by hybrid alumina functionalised with silica (Al-O-SiO2)/ hybrid nanoparticles through Pickering emulsion was reported. During the post tanning process, the uses of this developed fatliquoring agent causes a reduction in the 30% of fatliquoring agent input and 40% reduction in dye input. The presence of alumina nanoparticles resulted in an immediate improvement of the abrasion resistance, softness, and physical properties of the crust leather. Utilizing hybrid particles (Al-O-Si)

as a stabiliser readily improves the uptake of other post tanning chemicals. Thus, the prepared fatliquoring agent suitably softened the leather and significantly improved the mechanical properties, light fastness, and fullness with the reduction in the pollution load. To divulge the sustainability of the fatliquoring process, the sustainability analysis for the developed product was analyzed and presented. As compared to the conventional fatliquoring process the E factor of the experimental process was estimated to be lower (at a value of 0.25) which indicates minimum emissions. Based on cost estimation, leather fatliquoring is economically viable when using the prepared fatliquoring agent.

- **Keywords:** Alumina nanoparticles; Amine terminal silica; Pickering emulsion; Fatliquoring; Hybrid nanoparticles and oil-in water emulsion

Michael Drescher, Adil Fahmi, Didier Jamois, Christophe Proust, Esteban Marques-Riquelme, Jed Belgaroui, Leyla Teberikler, Alexandre Laruelle. *Blowdown of CO2 vessels at low and medium pressure conditions: Experiments and simulations*. Pages 907-927.

Carbon Capture and Storage (CCS) involves transportation of liquefied CO2 from capture sites to permanent storage locations, which is usually achieved by pipeline transportation or maritime shipping. Over long distances, maritime shipping at pressures around 16 bara has proved to be a more effective solution than transportation through pipelines. These conditions, although safe, offer a significant pressure margin with respect to the triple point of CO2 for more cost-effective ship design with larger transportation capacity. However, the reliability of this technology has not been fully demonstrated regarding depressurization operations commonly performed to minimize hazards associated to emergencies. For CO2, this operation entails risks such as dry ice formation. This paper focuses on two purposes. First, it reports detailed and extensive experimental tests of CO2 depressurization of a tanks at low pressure (< 20 bara). An extensive review of public domain literature showed that this data is scarce [20] This work focuses on contributing to close that gap. Finally, this work will present detailed simulations of the experiments using commercial flowsheeters to assess the reliability of standards models that are commonly used for engineering studies and design. All the experimental work was carried out using a bench scale tank of 2 m3 with ample instrumentation according to an experimental design. The results of the runs were modelled using the EO-Blowdown utility implemented in UniSim Design®. The results showed that modelling of CO2 systems with the EO-Blowdown utility is reliable and can reproduce accurately most key process variables, although it has some limitations such inability to model solid phases and metastable liquids

- **Keywords:** Carbon capture and storage; CO2 vessels; Low-pressure ship transportation; Depressurization; Process safety; Process simulation

Anene Oguaka, Natalia Flores Quiroz, Richard Walls. *Fire parameters, behaviour, and comparative thermal hazard of food grains based on the cone calorimeter tests*. Pages 928-940.

Agricultural food grains have been involved in various large fires, but little is known about the fire parameters for many varieties required to evaluate their fire hazard. This research experimentally studied various food grains, with an emphasis on African food grains to obtain their important fire parameters. Oven-dried cowpea, lentils, millet, soybean, flax (linseed), unshelled peanuts, sunflower, shelled peanuts, and sesame were subjected to heat fluxes of 25 kW/m2, 35 kW/m2, and 50 kW/m2 in a cone calorimeter. Heat release rate, effective heat of combustion, mass loss, critical heat flux, time to ignition, peak heat release rate, total heat release, and time to peak heat release rate were obtained. Thermal fire hazard indices derived from these primary parameters, such as flashover potential, fire growth rate, and percentage mass loss were determined and

compared with wood pellets. Under a 50 kW/m2 heat flux, the peak heat release rate ranged from 230 to 608 kW/m2 for millet and sunflower respectively. The correlation of materials characteristics and fire parameters shows that the oil content is the dominant determinant of the thermal fire hazard level in the food grains tested. These grains were also found to have a higher fire hazard compared to wood pellets.

- **Keywords:** Fire growth rate; Thermal fire hazard; Flashover propensity; Food grains; Oil content

Yue Zong, Song Su, Ruijun Zhang, Yan Sun, Jiayu Tian, Bart Van der Bruggen. *Promoting the efficiency of tetracycline removal from tap water with commercial NF membranes via a facile post-treatment*. Pages 941-950.

How to simultaneously improve the water permeance and antibiotics/minerals selectivity is one of the key issues for promoting the efficiency of drinking water treatment with nanofiltration (NF) technology. In this study, the post-treatment with a ternary complex of ethanol-water-NaOH (denoted as EWN) was used on four commercial NF membranes (NF270, NF90, HS-200C, and DF100) to understand its modification mechanism and promote the tetracycline removal efficiency. It was confirmed that the polyamide layers of all four commercial NF membranes were thinner after EWN post-treatment along with a slight increase in the pore size and enhancement in hydrophilicity and electronegativity. As a result, the water permeation of NF270 was improved by 70% and that of the other three membranes was increased by 19–20% while keeping a high tetracycline rejection of over 99%. Simultaneously, mineral ions such as K+, Ca2+, Mg2+, and Cl- passed the post-treated commercial NF membranes more easily. This yields a facile strategy for the performance regulation of existing, or commercial NF membranes.

- **Keywords:** Commercial NF membrane; Post-treatment; Tetracycline