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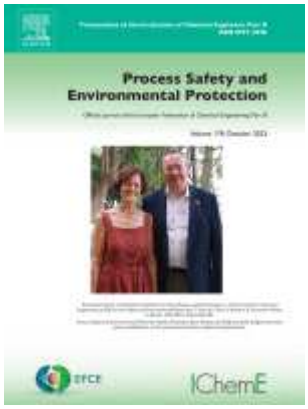

Mishal Alsehli. ***Enhanced-performance of stepped distiller via reflecting surfaces and heat-storing materials mixed with nanocomposites*****. Pages 1-7.**

One of the best solar distillers in terms of productivity is the stepped solar distiller, but it suffers from a lack of productivity commercially. This study proposes some amendments to enhance its performance utilizing nano-improved paraffin wax as a thermal storing material and reflecting surfaces. As a result, two solar distillers were fabricated and tested simultaneously under the same weather conditions: one is the conventional distiller, and another is the modified stepped distiller. Results revealed that the modified stepped distiller gave better performance than the conventional distiller, both in terms of productivity and efficiency. For example, the yield of the modified stepped distiller was improved by 55.6% compared to that of conventional distiller. Moreover, when utilizing the thermal storing material with the modified stepped distiller, its yield was augmented by 77.88% over conventional distiller. Furthermore, the productivities of conventional distiller and modified stepped distiller with thermal storing material and reflecting surfaces are 2400 mL/m².day and 6750 mL/m².day, severally with an betterment of 181.25%. In this case, the efficiency of modified stepped distiller was 46.4%.

- **Keywords:** Stepped solar still; Nano-enhanced PCM; Reflectors; Paraffin wax

Kexin Yin, Runqi Zhang, Min Yan, Lei Sun, Yixin Ma, Peizhe Cui, Zhaoyou Zhu, Yinglong Wang. ***Thermodynamic and economic analysis of a hydrogen production process from medical waste by plasma gasification*****. Pages 8-17.**

To reduce the environmental pollution caused by pathogens and radioactive substances carried by medical waste, and alleviate the shortage of non-renewable energy, this work proposes a novel overall process for hydrogen production from medical waste by plasma gasification coupled with ionic liquid-based CO2 capture. The validity of the model is verified by the experimental data. Based on the simulation results, the effects of medical waste types, different gasification agents and carbon conversion rate on the syngas compositions, H2/CO ratio, carbon conversion rate, higher heating value and exergy efficiency are explored. The results show that the rate of hydrogen production from surgical masks is more than twice that of the other two types of medical waste. Steam is

the best gasification agent. At this time, the higher heating value of syngas is 26.72 MJ/kg and the exergy efficiency is 78.25%. A comprehensive analysis of the thermodynamic efficiency and technical economy of the overall process shows that the total exergy efficiency is 70.84%. The production cost is 2115.74 USD and the raw material consumption is 2.61 t/t H2. This study can provide a promising theoretical guidance for the resource treatment of medical waste.

- **Keywords:** Medical waste; Plasma gasification; Hydrogen product; Ionic liquid; Exergy efficiency

Jian Cen, Honghua Chen, Yinbo Wu, Weiwei Si, Bichuang Zhao, Zhuohong Yang, Liaohao Tang, Shitong Liu. *Robust fault detection for chemical processes based on dynamic low-rank matrix and optimized LSTM*. Pages 18-33.

The data collected by sensors in modern chemical process systems are always contaminated by industrial noise, so robust fault detection is an important technology to ensure process safety. However, the existing robust detection techniques have limitations in extracting dynamic and time series features of chemical process data. In this paper, a robust fault detection method based on dynamic low-rank matrix and optimized LSTM is proposed for dynamic chemical processes under noise background. First, a new low-rank matrix decomposition method, dynamic principal component pursuit (DPCP), is proposed for the dynamic characteristics of process data containing noise. The PCP is improved using the time delay excursion method, i.e., the DPCP is constructed by embedding an augmented dynamic matrix with a time lag factor on the PCP and solved using the alternating direction multiplier method. The purpose is to strip the useless noise from the useful detection information and extract the dynamic low-rank matrix. Second, an optimized LSTM (OPLSTM) is proposed for the time series features of dynamic low-rank matrix. vector factors for feature selection of memory cells in the LSTM are reweighted to balance the time series features of industrial processes and avoid heavy reliance on erroneous fault information. In addition, support vector data description (SVDD) is used to describe the hypersphere with clear boundary, and distance-based statistic is constructed to achieve fault detection with high fault detection rate and low false alarm rate. Finally, to assess the effectiveness of the proposed method, we performed extensive experiments on the Tennessee Eastman Process and the electrolytic aluminum process, and compared them with multiple methods. The experimental results show that the proposed method is effective and robust for chemical processes fault detection in the background of industrial noise.

- **Keywords:** Robust fault detection; Dynamic chemical process; Low-rank matrix; LSTM; Support vector data description

Zeeshan Arshad, Nadeem Baig, Shaikh A. Ali. *Synthesis of a novel next-generation positively charged polymer and its in-situ grafting into thin film composite membranes to enhance the performance for desalination*. Pages 34-45.

High efficiency of the polyamide membranes can be achieved by rationally tailoring the active layer, which empowers the membrane with better anti-fouling characteristics, high flux, and separation efficiencies. Herein, a next-generation anti-fouling positively charged copolymer of diallyldimethylammonium chloride (DADMAC) and N1, N1-diallyldodecane-1,12-diammonium chloride (DADAC) was synthesized and thoroughly characterized by TGA, FTIR, proton (1H) and the carbon (13C) NMR. The synthesized poly(DADMAC-co-DADAC), after conversion to poly(DADMAC-co-DADA) having free NH2 group, was in-Situ grafted while forming the active layer due to its rationally designed anchoring points of NH2 group. The in-Situ grafting resulted in a cross-linked polyamide active layer

containing positively charged brushes of poly (DADMAC-co-DADA) at regular intervals. The AFM analysis has shown that the polyamide layer's surface roughness increased with the poly-(DADMAC-co-DADA) grafting concentration, which positively impacts the membranes' flux. When exposed to the water, the grafted poly-(DADMAC-co-DADA) expanded and spread a positively quaternary ammonium network on the membrane surface, effectively repelling the cations. The introduced membrane has shown high performance compared to the pristine polyamide membrane. The functionalized membranes have displayed a 3.5 times flux for 2000 ppm of NaCl while maintaining a good rejection at 93.1%. The anti-fouling behavior of the membranes was evaluated against the model positively charged CTAB (cetyltrimethylammonium bromide) foulants (2000 ppm). Poly- (DADMAC-co-DADA) grafted membranes have shown a high anti-fouling tendency. After 600 min (10 h) of continuous operation, the flux declined less than 15%, whereas the pristine polyamide membrane lost 99%. The poly-(DADMAC-co-DADA) grafted membranes recovered more than 93% of their maximum flux. Thus, the in-Situ grafting of positively charged polymer is a possible opportunity to develop the next generation of high-performance polyamide membranes.

- **Keywords:** Clean water; Membranes; Grafting; Polymers; Antifouling

Hosseinali Hassanzadeh, Amin Salem, Shiva Salem. *Recovery of binary-component textile wastewater contaminated by reactive dyes through adsorption onto magnetic separable MgO nanoparticles produced from solid waste of ductile cast iron industry, process identifications, characterization and regeneration*. Pages 46-55.

A new magnetic separable Mg-based adsorbent was produced from a waste collected from cast ductile iron industry for removing reactive dyes from the industrial textile wastewater. The magnetic coreshells were prepared based on one step gel-combustion approach. Mg2+ ions were extracted from the gray solid waste through the acid leaching. The coreshells were added to the prepared solution under sonication, and then Mg(OH)2 particles were decorated onto magnetic nanoparticles via precipitation followed with calcination at 500 °C. The reusable adsorbent was utilized for the uptake of R Blue 222, and R Red 195 dyes from single, and binary-component effluents. The adsorption studies were conducted at a variety of dye concentrations by adding different dosage of adsorbents. The competitive adsorption studies demonstrated that the capacity for the dye uptake from the binary-component wastewaters is greater than those for single-component systems, promoting the adsorptive performance. With decoration of MgO nanoparticles over the coreshells, the growth of crystallites was limited as identified from XRD patterns. An increase in pore volume, and average pore diameter, ~ 14 nm, are the main reasons for the promotion of active site numbers which is beneficial to prevent the efficient loss in capacity due to magnetization.

- **Keywords:** Textile wastewater; Reactive dyes; Ductile iron waste; Magnesium oxide; Magnetic nanoparticle; Adsorption

Zhong Li, Jike Yang, Shihang Lu, Tingyue Gu. *X80 U-bend stress corrosion cracking (SCC) crack tip dissolution by fast corroding Desulfovibrio ferrophilus IS5 biofilm*. Pages 56-64.

Stress corrosion cracking (SCC) is a serious problem threatening structural integrity and safety. Metal corrosion pits can develop into more harmful cracks under mechanical stress. It is known in abiotic corrosion that fast corrosion does not necessarily cause more severe SCC. This is because fast corrosion can prevent or dissolve crack tips and convert them into less harmful pits if the uniform corrosion rate is fast enough. This work experimentally proved the hypothesis that the same phenomenon occurs in biotic corrosion. It was found that a highly corrosive SRB (sulfate reducing bacterium) strain,

namely Desulfovibrio ferrophilus (strain IS5), caused fast uniform corrosion and dull pits, but no SCC cracks against X80 carbon steel U-bend coupons (stressed). In comparison, Desulfovibrio vulgaris, a far less corrosive SRB strain caused less corrosion, but generated sharp pits and SCC cracks in a 3-month lab test. This work also revealed that the X80 U-bend had a 44% higher sessile cell count and 34% higher weight loss after a 14-d D. ferrophilus incubation in deoxygenated enriched artificial seawater culture medium at 28 °C when compared with the (flat) square coupons (no stress). This weight loss trend was corroborated by transient electrochemical measurements.

- **Keywords:** Stress corrosion cracking, crack tip dissolution, microbiologically influenced corrosion; Sulfate-reducing bacteria; Biofilm

Mengying Si, Wei Cao, Chunyu Ou, Guangyuan Tu, Weichun Yang, Qingzhu Li, Qi Liao, Zhihui Yang. *Simultaneous oxidization-adsorption for arsenic and antimony by biological Fe-Mn binary oxides (BFMO): The efficiencies and mechanism*. Pages 65-73.

Here, a novel manganese oxidizing bacterium Morganella Morganii MnOx-1 was applied to synthesize biological iron-manganese oxides (BFMO) to simultaneously oxidize and adsorb As and Sb. The oxidization rates of As(III) and Sb(III) by BFMO were 74.13% and 51.85%, which were 1.43 and 1.30 times of that by biological manganese oxides (BMO), respectively. Moreover, the simultaneous removal rates of As(III), As(V), Sb(III) and Sb(V) (100 mg/L of each) by BFMO with the stain MnOx-1 were 87.05%, 94.23%, 79.65% and 84.33% in 7 days, and 80.26%, 99.32%, 82.97% and 88.50% in 28 days, respectively. In addition, BMO contributed to oxidize As(III) and Sb(III), and FeOOH was mainly responsible for adsorption by complexing with the metalloids in the simultaneous removal of As and Sb. The function groups on the surface of BFMO, such as -OH, C-O, C-O, C-C, etc. were also involved the adsorption processes. Our results have important implications for understanding the transformations of As and Sb intermediating by manganese oxidizing bacteria, and develop an environmental-friendly method for simultaneously removing As and Sb pollutants in water.

- **Keywords:** As and Sb; Biological iron-manganese oxides (BFMO); Mn(II) oxidizing bacterium; Oxidization; Adsorption

Hong Ji, Ting Wang, Yaxin Wang, Ke Yang, Juncheng Jiang, Zhixiang Xing. *Influence and prediction of oil film migration in submarine pipeline spills under multiple factors*. Pages 74-86.

Oil spills endanger the survival of marine species and the maritime environment. As a result, this study constructs a three-dimensional diffusion model of oil spills from pipeline ruptures and analyses the diffusion law of oil films created on the sea surface under various conditions. The model's accuracy was validated using actual oil spill tests, and the oil spill similarity model was further established using similarity theory. The results show that as the leaking aperture grows within 2–3 s, the high concentration centre area of the oil film on the sea surface expands, and the oil film protrudes to the right. From the inside out, the oil film produces a convex elliptical oil film with a high-low concentration form. As the leakage rate rises, a convex, elliptical, large-area oil film of low-high-low concentration forms. During this time frame, the oil leak has not yet developed an oil film at a flow rate of 0.3 m/s. This is due to the fact that horizontal migration speed has a large influence on vertical migration speed, increasing the horizontal migration distance underwater and lengthening the time needed to achieve the development of the sea surface oil film area. With increasing leakage aperture and leak rate, the lateral diffusion length, longitudinal diffusion breadth, and oil spill area of the oil film rise. However, when the velocity of the water flow increases, it decreases. Furthermore, the quadratic fitting curves of the longitudinal expansion length,

longitudinal diffusion width, and oil spill area of the oil film were fitted under various influencing factors to predict the diffusion law of the oil film on the sea surface, which is critical for protecting the marine environment.

- **Keywords:** Submarine pipeline; Oil spill area; Physical model experiment; Fitting curve; Similarity theory

Zhenbang Wang, Yunpeng Fan. *Industrial process monitoring with density-based kernel structure preserving projections model*. Pages 87-97.

Practice shows that the influence of latent geometric structures and nonlinear relationships in the industrial data on process monitoring cannot be ignored. Traditional methods focus on the distance information of a pair of points, while we think that the density information of more points can better reflect the geometry shape of the data. Based on this idea, this paper further combines density information with distance information to preserve data latent structure information, a nonlinear process monitoring method to extract global-local spatial geometric structure information is proposed, called density-based kernel structure preserving projections (DKSPP). The principle of this method is: First, search for the neighbors and non-neighbors of a sample in the high-dimensional feature space after nonlinear mapping. Then, the spatial distance information and density information among the data points are comprehensively constructed, and the projection points after dimensionality reduction are constrained to achieve global-local structure preservation. Finally, the obtained projections are used to set anomaly detection indices, and a DKSPP-based anomaly detection model is implemented to monitor processes. The experimental results of a benchmark dataset and an actual industrial application demonstrate the high detection rates and performance of the proposed method.

- **Keywords:** Density information; Industrial process monitoring; Nonlinear process; Structure preserving projections

Tao Hai, Pradeep Kumar Singh, Husham Jawad ahmed Al-Qaysi, Babak Farhang, Nasser M.Abd El-Salam, Walid El-Shafai. *A novel approach to heat integration development and multi-objective optimization for a marine diesel engine: Towards a framework of waste-to-electric power, dual-stage coolant, and distilled water*. Pages 98-120.

Heat integration is a well-admitted technology to reuse the waste of different engines in different arrangements, relying on the principal needs. Considering the heat capacity of the flow released from the engine of a ship during maritime travel, heat integration is a promising tool to maintain the marine environment, along with processing some energy-related needs of the ship. This is a technology that is being developed based on which this study presents a new structure. In this regard, an innovative combined cooling and power (CCP) scheme using a dual-stage coolant production technology (bi-evaporator) for air-conditioning and freezing purposes is arranged and integrated into the engine. The proposed technology, which can provide one of the basic needs of a ship during maritime travel, i.e., freezing, has not been studied and optimized for a ship in previous studies. In addition, the arranged structure uses a multi-effect desalination coupled with the engine for cascade heat integration. First, the most suitable working fluid of the designed CCP was investigated using a comparative study. Afterward, based on the selected working fluid, the entire process was simulated and scrutinized in the engineering equation solver (EES) software from the viewpoints of thermodynamics, environment, economics, and sustainability. Eventually, this structure is optimized using a NSGA-II optimization method in the MATLAB environment. Here, the most suitable working fluid determined by

the TOPSIS approach is R236ea, and the optimal unit cost of products and sustainability index are found as 0.7326 $/GJ and 1.335, respectively.

- **Keywords:** Maritime travel; Engine; Heat integration; Dual-stage coolant production; Desalination; Optimization

Gonca Alak, Serkan Yıldırım, Aslı Çilingir Yeltekin, Arzu Ucar, İsmail Bolat, Metin Kiliçlioğlu, Veysel Parlak, Esat Mahmut Kocaman, Muhammed Atamanalp. *Self-healing demonstration in imidacloprid toxicity with multibiomarkers and biologic pathways*. Pages 121-134.

Imidacloprid (IMI) pesticide has significant environmental and ecotoxicological pollution effects. Also, its high potential to enter the aquatic environment reveals the importance of early evaluation of the toxic effects of this compound. This study aimed to evaluate organ responses that can be associated with outcomes at higher levels of biological organization in fish. In this respect, the toxicity mechanism and recovery response process of IMI in rainbow trout (Oncorhyncus mykiss)' s different tissues (blood, brain, gill and liver) were analyzed with important biomarkers [(hematological indices (RBC, WBC, Hg, Hct, MCV, MCH, MCHC), antioxidant enzyme activities (SOD, CAT, GPx, GSH), MDA, DNA damage (8-OHdG), apoptosis (caspase 3), AChE, TNF α, interleukin 6, Nrf-2, NF-kB activities, histopathological and immunofluorescence analyses (NeuN, BDNF, JNK and Nop10]. Exposure to different concentrations of IMI caused a decrease in RBC, WBC, Hg and Hct levels in O. mykiss. The effect of the same application on brain, gill and liver tissues was determined as inhibitions in antioxidant enzyme activities (SOD, CAT and GPx) and GSH level, inductions on MDA level, DNA damage, caspase-3, TNF α, IL- 6, Nrf-2 and NF-kB activities. As a result of three tissues' histopathological examination; the degeneration, necrosis and hyperemia in the brain and liver, adhesion, desquamation and inflammation in the lamellar epitheliums has been determined in company with stress-induced responses inducing DNA damage. In the reflection of this situation on histomap results, increases were recorded in BDNF and NeuN levels. In the recovery response, tissue damage profile and detoxification process were differentiated according to dose and marker, and it manifested itself with moderate and mild symptoms. These findings revealed that IMI-mediated oxidative stress was effective in the Nrf-2/GSH/NF-kB pathways, showing strong hemato/hepato, and neurotoxic effects. It has become clear that the severity of the effects caused by IMI exposure is felt more in the brain and liver tissues, and that such contaminants should be taken into account in the risk assessment. During the post-exposure recovery period (after 15 days), AChE activity increased by 21% at high-dose administration. The recovery period was effective in regulating the oxidant/antioxidant balance of the organism by exhibiting serious induction/inhibition in each tissue and biomarker performance.

- **Keywords:** Recovery response; Imidacloprid; Self-healing; Multibiomarker

Guillermo Hein, Harshit Mahandra, Ahmad Ghahreman. *Application of Phanerochaete chrysosporium for enhancing gold recovery via bio-oxidation of refractory sulfidic ores in a circumneutral environment*. Pages 135-146.

Regardless of the effectiveness of the industrial process design for gold recovery encompassing acidic bio-oxidation and cyanidation, the substantial neutralization of effluents required after bio-oxidation results in a considerable generation of waste streams. Conducting a bio-oxidation at circumneutral pH with in-situ neutralization is a novel technological opportunity for strengthening environmental protection and safety. For the first time, this research reports the capacity of Phanerochaete chrysosporium to oxidize a low-grade refractory gold ore at circumneutral pH. The fungal treatment was evaluated in five culture media regarding pH variation, enzyme activity, and sulfide

oxidation. Thereafter, optimal conditions were investigated and then scaled up in a bioreactor. Results indicated that pH > 5.0 decreased the enzyme concentration released by P. chrysosporium, reducing sulfide oxidation. An initial pH of 5.8 led to a 24.4 ± 2.2% sulfide oxidation after 14 days, comparatively better to reported studies in the same pH range. A higher efficiency was attained by replenishing the fungal culture for three cycles, reaching 47.6 ± 2.3% sulfide oxidation and 49.5 ± 2.4% gold recovery. The results were confirmed by UV–visible, C/S detector, SEM and gold fire assay. Overall, this study opens a possibility to explore a bio-oxidation at higher pH, contributing to the vision of a net-zero target.

- **Keywords:** Neutral bio-oxidation; Biotechnology; Sulfide oxidation; Gold recovery; Gold-bearing ores

Fengyu Li, Yueping Yu, Yue Shu, Xiaoming Liu. *Study on characteristics of photovoltaic and photothermal coupling compressed air energy storage system*. Pages 147-155.

This paper studies the energy storage and generation characteristics of the photovoltaic power generation coupling compressed air energy storage system for the 5 kW base station, and analyzes the photovoltaic power generation characteristics within 24 h and its influence on the flow characteristics of the compressed air energy storage system. The results show that, affected by precipitation and sunlight, the compressed air energy storage power reaches highest value in May and August, and the compressed air flow and cooling water flow in a single day increase with the increase of light intensity. The power generation time reaches longest value in June, shortest in December, the energy storage time reaches longest in June and shortest in January. Considering the combined demand of cold energy, thermal energy and electric energy in actual production and life, the setting scheme of the compressed air energy storage system for combined cold heat power supply is obtained, and the parameter values such as compression/expansion stage, compression/expansion pressure ratio, temperature and pressure at the inlet and outlet of the compressor/expander/heat exchanger are defined. Adding solar thermal energy storage to the photovoltaic power generation compressed air energy storage system, it is found that it can effectively increase the air temperature and thus reduce the expansion stages required at a specific time.

- **Keywords:** Solar energy; Compressed air energy storage; Coupling system; Multi energy supply; Dynamic change

Xuanbo Guo, Jianmei Sun, Wenjun Ha. *Proposal and 4E analysis of an innovative integrated model based on A gas turbine cycle for the simultaneous production of power, methanol, desalinated water, and heating*. Pages 156-175.

Gas turbine power cycles are among the most important power plants, operating in higher temperatures. Their principal defect is huge waste heat, leading to lower exergetic performances in addition to higher carbon dioxide (CO2) emissions. In this regard, the current paper focuses on a new solution to solve these defects appropriately. For this purpose, a new thermal integration model is designed for a multigeneration purpose, which is able to decrease the CO2 emission intensity below zero (a negative emission solution). The designed model comprises a steam power cycle, a Kalina power cycle, a dual organic Rankine cycle, a water desalination unit plus, and a methanol production unit plus. Thus, the products include electricity, heating, fresh water, and methanol. This system is simulated in the Aspen HYSYS software and is studied from the energy, exergy, economic, and environmental standpoints. According to the results obtained from the thermodynamic analysis, it is demonstrated that the total energy and exergy efficiencies are 49.38% and 66.5%, respectively. Furthermore, the net CO2 emission

intensity of the process is negative and equals − 1.036 kgCO2/kgMeOH. Eventually, according to the economic evaluation, the methanol production cost equals 0.136 $/kg, which is 90.87% lower than the renewable methanol production method.

- **Keywords:** Flue gas; Integrated structure; Methanol; Seawater desalination; Negative CO2 emission intensity; Multigeneration

Deepak Kumar, Umang Goswami, Hariprasad Kodamana, Manojkumar Ramteke, Prakash Kumar Tamboli. *Variance-capturing forward-forward autoencoder (VFFAE): A forward learning neural network for fault detection and isolation of process data*. Pages 176-194.

Data-driven models have emerged as popular choices for fault detection and isolation (FDI) in process industries. However, real-time updating of these models due to streaming data requires significant computational resources, is tedious and therefore pauses difficulty in fault detection. To address this problem, in this study, we have developed a novel forward-learning neural network framework that can efficiently update data-driven models in real time for high-frequency data without compromising the accuracy. The neural network parameters are updated using a suitably constructed forward-forward learning algorithm instead of the traditional backpropagation algorithm. Firstly, we develop a variance-capturing forward-forward autoencoder (VFFAE) for FDI. Further, we showcase that the previously trained VFFAE model can be quickly adapted to incoming data which demonstrate the efficacy of the proposed framework. We have three process case studies to validate the proposed approach, namely, the Tennesse-Eastman dataset, nuclear power flux dataset, and wastewater plant dataset, to validate the proposed approach. Our findings demonstrate that within the initial 90 s, the model underwent 90 updates using a forward-forward approach and only 10 updates using backpropagation-based methods without compromising accuracy. This highlights the model's capacity to effectively handle streaming data during the modeling process.

- **Keywords:** Forward-Forward Algorithm; Fault Detection and Isolation; Real-time update; Tennessee Eastman Process

Vinay, S. Raja, S.M. Tauseef, Surendar Varadharajan. *Investigating the impact of oxygen concentration on fire dynamics using numerical simulation with FDS*. Pages 195-203.

The world is experiencing an increase in demand for medical facilities due to the worsening of environmental and political conditions leading to emergencies that could suddenly increase the patients count in hospitals. The extensive use and storage of oxygen in hospitals and violation of the fire safety management practices lead to the occurrence and worsening of fire accidents. Though many researchers documented the influence of O2 enrichment on fire dynamics, there are only limited studies present. This article attempts to investigate the effects of varying oxygen concentrations - 21% (v/v), 22% (v/v), and 23% (v/v) - on fire dynamics in a hospital environment using Fire Dynamic Simulator (FDS). The changes in Mass Loss Rate (MLR), Heat Release Rate (HRR), temperature profile, flash over occurrence and thermal intensity were reported and compared with varying oxygen concentration. The results show a significant increase in MLR and HRR with the increase in O2 concentration, which directly contributed to the earlier occurrence of flashover. For oxygen concentrations of 21% (v/v), 22% (v/v), and 23% (v/v), the highest temperatures achieved were 1395 °C, 1421 °C, and 1494 °C and the thermal intensity values were found to be 966 kW.m-2, 1027 kW.m-2, and 1074 kW.m-2, respectively. The variation in peak temperature and thermal intensity at 21% (v/v) and 23% (v/v) O2 concentration, is found to be 7.1% and 11%, respectively. The findings provide a valuable insight that the oxygen concentration in a fire can impact the fire dynamics. This study can aid in the development of effective fire safety

management systems for hospital environments. In addition, the process industries have a key role to play in supporting hospitals to adopt proper approaches, drawing on lessons learned from managing flammable and explosive atmospheres in chemical processes. These simulation results will give better understanding to adopt relevant safety codes for the hospitals.

- **Keywords:** Hospital fires; Fire Dynamic Simulator (FDS); Fire Dynamics; O2 enrichment; COVID 19

Rengui Weng, Guohong Chen, Yifan Liu, Yuancai Lv, Chunxiang Lin, Xiaoxia Ye, Minghua Liu. *Adsorption and reduction behavior and mechanism of Au(III) on reductive cellulose-based aerogel*. Pages 204-213.

A reductive cellulose-based aerogel (VTCA) was fabricated from cellulose by introducing valonea tannin through cross-linking reaction. VTCA owned high porosity of more than 96% with the average pore size of 30–50 μm, and it exhibited good adsorption performance for Au(III) at a wide pH values range (1−8) with the max adsorption capacity of 243.1 mg g−1. VTCA showed good adsorption performance for Au(III) under the interference of various co-existing ions. The adsorption obeyed the pseudo-second-order kinetic model and the Langmuir adsorption isotherm model, and temperature rise was favorable for adsorption. The adsorption-reduction mechanisms mainly involved electrostatic interaction, chelation adsorption and reduction. Au(III) could be effectively adsorbed onto the surface of VTCA by electrostatic attraction and chelation, and then reduced in situ to Au0 by phenolic hydroxyl on tannic structure. This study provides a new adsorbent with the advantages of convenient preparation and high efficiency, and it has great application prospects in the enrichment and recovery of precious metals in waste liquid and the treatment of oxidized pollutants.

- **Keywords:** Adsorption; Reduction; Cellulose-based aerogel; Valonea tannin; Au(III)

Lingxin Meng, Qiang Ren, Jingmei Xu, Zhe Wang. *Construction of efficient ion transport channels in MOFs-blended poly (ether ether ketone) containing multiple ion transport sites*. Pages 214-225.

In this paper, trimethyl poly (ether ether ketone) (T-PEEK) containing multiple sites was prepared by a polycondensation reaction, and afterwards, brominated T-PEEK (Br-T-PEEK) and imidazole functionalized T-PEEK (Im-T-PEEK) were prepared by substitution reaction. And cationic metal organic frameworks UiO-66-NH2 (C-MOF) was synthesized as fillers. Composite membranes were fabricated by incorporating cationic UiO-66-NH2 into imidazole functionalized Im-T-PEEK. Im-T-PEEK/C-MOF-5% (the weight percentage of C-MOF was 5%) composite membranes exhibit good mechanical properties, such as Young's modulus of 2319.06 MPa and tensile strength of 38.34 MPa. The ionic conductivity of the composite membrane, Im-T-PEEK/C-MOF-5%, achieved a remarkable value of 106.4 mS cm−1 at a temperature of 80 °C. All the membranes exhibited good alkaline stability. After immersing the prepared membranes in a solution of 1 M NaOH at a temperature of 60°C for a duration of 360 h, it was observed that the ionic conductivity of the membranes retained more than 70% of their initial ionic conductivity. Furthermore, the open-circuit voltage and peak power density of Im-T-PEEK/C-MOF-5% reached 0.904 V and 154.26 mW cm−2, respectively. In a word, this study presents a promising strategy for the preparation of advanced anion exchange membranes (AEMs) with good properties for energy conversion and storage applications.

- **Keywords:** Anion exchange membranes; Ionic conductivity; Poly (ether ether ketone); Alkaline stability; Metal organic frameworks

Changjun Li, Fan Yang, Wenlong Jia, Chengwei Liu, Jianghao Zeng, Shuoshuo Song, Yuanrui Zhang. *Pipelines reliability assessment considering corrosion-related failure modes and probability distributions characteristic using subset simulation.* Pages 226-239.

A methodology using the subset simulation and the modified Metropolis-Hastings algorithm with delayed rejection (SS-MMHDR) is developed to evaluate the time-dependent reliability of corroded pipelines under multiple failure modes. This methodology considers the competition between the small leak and burst failures and the correlated non-normal distribution of the defect variables, and characterizes the defect geometric probability distribution from extensive inspection data. Results demonstrate that SS-MMHDR has high accuracy and low variability in evaluating the pipeline failures, outperforming the SS-MMH and Monte Carlo simulation algorithms, especially under low probability levels, but with slightly increased computation time. The Generalized Extreme Value Type II (GEVII) distribution is the optimal distribution for internal corrosion defect lengths from the Kolmogorov-Smirnov test. Lognormal, Weibull and Normal distributions provide more conservative estimates on burst and composite failure probabilities and limiting maintenance times than GEVII. Effects of operating pressure and its variability, corrosion rate on failure probability, and pipeline limiting maintenance time are also revealed through numerical cases.

- **Keywords:** Reliability; Subset simulation; Gas pipeline; Failure mode; Corrosion defects; Probability distributions

E. Serra, J.O. Pou, X. Berzosa, R. Gonzalez-Olmos, S. Borrós. *Remembering the contributions of Professors Rosa Nomen and Julià Sempere: A life devoted to chemical engineering at IQS*. Pages 240-246.

Professor Rosa Nomen, member of the editorial board of and Professor Julià Sempere both from the Institut Químic de Sarrià (IQS), Universitat Ramon Llull (Barcelona, Spain) will be retired in July 2023. They have contributed to the education of more than 1000 chemical engineers around Catalonia for 40 years. In this article, we have revisited the main scientific contributions that they have carried out in the field of chemical engineering. They had diverse research interests covering a wide range of topics in the areas of process safety and environmental protection. These included the utilization of thermal analysis and calorimetry to comprehend chemical reactions, including their safety and chemical and physical kinetics. They also focused on devising new methodologies for industrial safety and implementing flow chemistry to produce fine and specialty chemicals in a more sustainable and safer way. Additionally, they contributed to the advancement of adsorption-based carbon capture technologies as technological strategy for the minimization of the environmental impact of the chemical industry.

- **Keywords:** Scientific contributions; Rosa Nomen; Julià Sempere; Thermal and calorimetric analysis; Industrial safety

Xiaoai Cheng, Zhenzhong Hu, Xiangxi Wang, Jian Li, Bo Wei, Jingmei Liu, Mei Zhong, Fengyun Ma, Guangqian Luo, Hong Yao. *Flue gas enhanced water leaching: Prediction and condition optimization of demineralization effect from coal via machine learning algorithm*. Pages 247-254.

A novel "Flue Gas Enhanced Water Leaching" method was previously proposed to efficiently demineralize high alkali and alkaline earth metals coals. Yet the optimized treatment conditions are unclear in consideration of the balance between removal effect and costs. Consequently, the back propagation neural network algorithm was proposed in this study to analyze the effect of characteristic parameters (particle size, ultimate

analysis, proximate analysis and ash compositions) of coals and operational conditions (temperature and time) on the removal rates of Na (RNa) and Ca (RCa). Results showed that the back propagation neural network models can precisely predict RNa and RCa with respective correlation coefficient (R2) of 0.9854 and 0.9777. The coal with higher oxygen content tends to have higher RNa and RCa owing to their high organic Na/Ca contents and good hydrophilicity, and minimizing coal particles contributes to the removal of Na/Ca. Longer leaching time results in higher RNa and RCa, while higher leaching temperature contributes to RNa but shows complex effect on RCa. For practical considerations, recommended operational conditions are room temperature, within 2 h and particle size of smaller than 2 mm, and the RNa and RCa of higher than 75% and 30% can be obtained under these conditions, respectively. Therefore, this study not only provides an effective method for the prediction of RNa and RCa under "Flue Gas Enhanced Water Leaching" treatment, but also contributes to the condition optimization in its industrial applications.

- **Keywords:** Zhundong coal; Flue Gas Enhanced Water Leaching; Alkali and alkaline earth metals; Back propagation artificial neural network; Machine learning

Abu Reza M Rashid, Muhammed A. Bhuiyan, Tushar Quddus, Biplob Pramanik. *Comparison of life cycle impacts between wetland and rainwater harvesting systems*. Pages 255-267.

Constructed wetland helps to improve the environmental and social values of the inhabited catchments and their downstream natural water bodies. However, the environmental impacts due to its construction necessitate evidence of how beneficial it would be once operational compared to other water-sensitive urban design (WSUD) components. The study has simulated the reduction of pollutants and runoff in a wetland. Consequently, environmental impacts were estimated using the life cycle assessment (LCA) approach. The catchment settings with and without wetlands were compared with the environmentally viable rainwater harvesting (RWH) systems. Potable supply using watermain was included in the catchment settings to have a common basis for their evaluation, which was not considered in the existing literature. The study demonstrates that the runoff impacts (operational) of the catchment having a watermain (without a wetland system) are 3.6–4.5, 4.0, 3.2–4.7, and 2.7–3.5 times of catchment with wetland-only on ecotoxicity-marine, ecotoxicity-freshwater, human toxicity-carcinogenic, and eutrophication categories. For the same systems, the net impacts (fabrication & installation + operational) of all undertaken impact categories are 3–28.6 times. In contrast, the net impacts of the residual runoff generated by the most viable RWH systems after supplying household demands (i.e., % reliability of the RWH tanks) are mostly 2.3–30.5 times the net impacts of the catchment having wetland-only. In an equivalent assessment, the catchment net impacts of the watermain system (with wetland) as times of impacts of RWH systems are 0.2–0.91 times on eutrophication, ozone depletion, ecotoxicity-marine (in lower series of RWH), and ecotoxicity-freshwater. In contrast, those systems are mostly 1.02–3.12 times on human toxicity-carcinogenic, global warming, ecotoxicity-terrestrial and higher series of ecotoxicity-marine impact categories. The study suggests that wetland or RWH is suitable if emission prevention to water or air is emphasized.

- **Keywords:** Wetland; Rainwater harvesting (RWH); Life cycle assessment (LCA); Global warming; Eutrophication

Benqin Yang, Yanqing Zhao, Yanmei Liu, Tianxiao Huang, Qiuyun Liu, Dongfang Li, Xuejun Pan. *Transformation of water states and succession of functional microorganisms during synergistic bioevaporation process.* Pages 268-277.

A synergistic bioevaporation process was applied to treat the food waste (FW) by using the biofilm-developed corncob as the bulking agent and microbial carrier. During the process, interstitial water was the main water states, accounting for 55.6–76.8% of the total water amount. After the bioevaporation, 3079.27 g (61.05%) of the interstitial water and 48.46 g (3.45%) of the vicinal water was removed from the matrix, while 93.82 g (79.36%) of the bound water was formed. The removal of interstitial water mainly occurred in the cooling stage and the warming stage only lowered the binding energy of bound water, vicinal water and interstitial water. At the end of 1st cycle, the remained interstitial water trapped more tightly and the boundary between vicinal water and interstitial water nearly disappeared. The biofilm thickness in corncob particles was 350–440 μm and mainly dominated by bacteria and fungi with an abundance above 98.0%, in which the fungal Aspergillus reached as high as 22.7%. It seemed the fungi tended to survive in vicinal water abundant environment, but the bacteria preferred to habitat in interstitial water rich condition. Microorganisms had abundant metabolism genes of 29.3–38.5%, and the lipid transport and metabolic genes reached the maximum at Peak 54 ℃, while the carbohydrate transport and metabolic genes was the highest at Warming 46 ℃.

- **Keywords:** Biofilm-developed corncob; Water states; Functional microorganisms, synergistic bioevaporation

Abhishek N. Srivastava, Sumedha Chakma. *Lime sludge assisted anaerobic bioreactor landfilling of municipal solid waste for enhanced leachate stabilization and bioenergy yield.* Pages 278-286.

Bioreactor landfilling even being advanced technology for enhanced stabilization of municipal solid waste (MSW), often suffers with adverse acidogenic conditions. Such conditions reinforce poor leachate stabilization, and reduced biomethane yield. This work attempts to counter the challenges of adverse MSW landfilling conditions through incorporation of waste alkaline sludge from paper industry. The amendment in anaerobic bioreactor landfilling of MSW was practiced by adding lime sludge (LS) with MSW in three distinct proportions: 20 g LS/kg MSW (LS100), 50 g LS/kg MSW (LS250) and 100 g LS/kg MSW (LS500), keeping LS0 as control. Periodic leachate and biomethane analysis showed benefits of proportionate LS addition. The control reactor often experienced leachate ponding and inhibitory conditions for anaerobic digestion. However, reactor LS250 achieved highest decrease in leachate organic strength removal (76.47 %) and biomethane production (8.315 L) over the period of landfilling. The pH and volatile fatty acids (VFAs) were in coordination with LS proportions. The LS addition beyond 100 g LS/kg MSW (LS500) could decrease the leachate pollution removal and biomethane yield. Finally, the Gompertz growth model showed excellent fit (R2 >0.997) to recorded biomethane. The study expands the scope of utilizing similar sludges for amendment of existing landfilling practices for efficient bioconversion of organic fractions of MSW.

- **Keywords:** Municipal solid waste; Lime sludge; Bioreactor landfill; Anaerobic digestion; Leachate

Yulin Zhang, Guozhao Ji, Aimin Li. *Production of limonene epoxides from tire pyrolysis oil by polyoxometalate immobilized on SBA-15*. Pages 287-295.

The goal of producing limonene epoxide and separating p-cymene from tire pyrolysis oil (TPO) could be achieved after epoxidation. However, the existing catalytic epoxidation process has the problem of cumbersome catalyst separation process, which is not conducive to industrial applications. In this work, the heterogeneous catalysts polyoxometalate-SBA-15 were prepared with the point of simplifying separation process. Heteropoly acid anions (phosphotungstic acid or peroxophosphotungstic acid) with catalytic active successfully enter the mesoporous pores of SBA-15, exhibiting high limonene conversion in the TPO system. The PW4 species produced by phosphotungstic acid after oxidation of H2O2 was favorable for improving the selectivity of epoxidation. The catalyst S-D-PW4 prepared showed high catalytic activity and epoxidation selectivity with the condition of H2O2 as an oxidant and free of solvent. Furthermore, A statistical experimental approach was used to comprehensively evaluate the reaction conditions. The conversion of limonene in TPO could reach 99.78%, and the yield of 1,2-limonene epoxide and diepoxide were 67.96% and 20.16%, respectively. A variety of characterization techniques such as 31P NMR, XPS, and ICP were employed to analyze the difference in catalyst before and after epoxidation. S-D-PW4 could be easily separated and the catalytic activity and epoxidation selectivity remained high after 5 cycles.

- **Keywords:** Tire pyrolysis oil; Limonene; Epoxidation; Supported catalysts; Response surface methodology

Mi Yan, Feng Chen, Tian Li, Li Zhong, Hongyu Feng, Zhang Xu, Dwi Hantoko, Haryo Wibowo. *Hydrothermal carbonization of food waste digestate solids: Effect of temperature and time on products characteristic and environmental evaluation*. Pages 296-308.

Food waste digestate solids (FWDS) is the by-product of anaerobic digestion and it contains high moisture. Hydrothermal carbonization (HTC) has the ability to convert wet bio-waste to hydrochar, which is a potential technology for handling FWDS. This study investigates the effect of reaction temperature and residence time on solid and liquid products from HTC process of FWDS. The solid product was named as hydrochars, and their physicochemical characters were tested and compared. The results showed that temperature had a more significant effect on hydrochar properties, compared to residence time. The higher heating value of hydrochar was 15.46 MJ/kg and the yield was 49%, under reaction conditions of 260 °C and 60 min. It was also found that hydrochar generated at higher temperature had a more stable combustion, higher ignition temperature, higher burnout temperature. For liquid product, the main organic matter are pyridine derivatives, pyrazine derivatives, indole derivatives, cyclopentene derivatives and phenolic compounds. It was also discovered that the increase of temperature can significantly reduce the concentrations of Chemical Oxygen Demand (COD) and Total Organic Carbon (TOC) in liquid product. When reaction temperature increased from 220 ℃ to 260 ℃, the COD decreased from 23,357 mg/L to 19,658 mg/L, TOC decreased from 9827 mg/L to 6352 mg/L, respectively. After HTC under the conditions of 260 °C and 60 min, 67% of nitrogen in solid feedstock e migrated from to liquid product, and N-contained compounds decomposed into ammonia, while phosphorus was mainly remained in the solid phase (>90%), which mainly existed in the form of apatite.

- **Keywords:** Food waste digestate solids; Hydrothermal carbonization; Pyrolysis; Combustion; Nitrogen; Phosphorus

Hao Tian, Ruiheng Li, Bashir Salah, Phong-Hieu Thinh. *Bi-objective optimization and environmental assessment of SOFC-based cogeneration system: performance evaluation with various organic fluids*. Pages 311-330.

Heat recovery offers multiple advantages, such as reducing energy consumption, promoting environmental sustainability, and enhancing productivity. Consequently, in this study, a bi-evaporator organic flash cycle (BEOFC) is utilized to recover heat from a solid oxide fuel cell (SOFC) and serves as a heat recovery unit. The BEOFC is a groundbreaking system that generates cooling and electricity. It boasts a dual-evaporator design that cools air at two distinct temperatures. Examining various organic fluids for better BEOFC performance entails evaluating their thermodynamic, environmental, and economic aspects. Based on the results, R227ea is selected as the optimal working fluid for BEOFC due to its superior performance. Subsequently, a parametric study is conducted and a bi-objective optimization of the proposed system is performed, where the objective functions comprise minimizing the total unit cost of products (TUCP) and maximizing the exergy efficiency. Optimized performance can be achieved when TSS1= 364.5 K, Teva1= 273.1 K, TSOFC= 897.3 K, and JSOFC= 5004 A/m2. At this point, the exergy efficiency and TUCP surge by 2.63%-point and 27.1% compared to the initial state. However, there is a rise of 7.26% in CO2 emission rate, 13.15% in sustainability index, and 8.8% in the total exergoeconomic factor when compared to the base case.

- **Keywords:** Heat recovery; Bi-objective optimization; Bi-evaporator organic flash cycle; Sustainability index; CO2 emission

Hongshen Zhang, Xiang Gao, Shengqi Xu. *Tribo-charging and electrostatic separation of vehicle polymer particles using a new type of fluidized bed*. Pages 331-341.

High value-added reuse of waste vehicle polymers can effectively alleviate the global resource shortage and environmental degradation. How to separate mixed polymers cleanly and efficiently is an important prerequisite for their reuse. In the paper, polyamide (PA)/ polypropylene (PP)/acrylonitrile-butadiene-styrene (ABS) and polyethylene (PE)/PP/polyvinylchloride (PVC) of vehicle polymer mixed particles are taken as the research objects, and the tribo-electrostatic separation of three-component mixed particles is studied using the designed double-stage device for tribo-aero-electrostatic separation. First, the optimal installation angle of the fluidized bed reflow plate is determined to be 45° by using the coupling method of computational fluid dynamics and discrete element. Second, the gas velocity for forming a fast bed and the optimal charging time for two sets of mixed particles are identified by tribo-charging experiments. The separation voltage for the two sets of mixed particles is also determined using COMSOL software. Furthermore, based on the determined parameters, two sets of tribo-electrostatic separation experiments are carried out. Results showed that the purities of PA and ABS particles are more than 91%, the purities of the PE, PP (white), and PVC particles are more than 85%. The research provides a reference for the two-stage tribo-electrostatic separation of vehicle polymer mixed particles.

- **Keywords:** Polymer particle; Fluidized bed; Charging characteristics; Tribo-electrostatic separation

Jianzhao Zhou, Jingzheng Ren, Chang He. *Wind energy-driven medical waste treatment with polygeneration and carbon neutrality: Process design, advanced exergy analysis and process optimization*. Pages 342-359.

This study presents a novel and original rich-O2 steam gasification-based process integrated with carbon capture, utilization, and storage (CCUS) for carbon-neutral valorization of medical waste (MW) in Hong Kong. The process employs a calcium loop to capture CO2 from the gasifier-produced syngas, simultaneously facilitating H2 production. The captured CO2 is optionally utilized to generate high value-added products like ethylene, ethanol, and acetic acid through electroreduction. The process incorporates multiple steam Rankine cycles for converting waste heat to power, achieving a total energy efficiency of 71.38%. Advanced exergy analysis reveals over 70% endogenous exergy destruction in reactors and 79.05% avoidable exergy destruction in heat exchangers and condensers, which may be paid more attention. Driven by wind energy, the process has the potential to achieve zero CO2 emission. Economic optimization demonstrates potential profits up to 10410 HK$/h with sufficient wind energy supply and 2548.2 HK$/h with limited supply. This study highlights the novelty of a carbon-neutral MW valorization approach, CCUS utilization, advanced exergy analysis, optimization and renewable wind energy for sustainability and economic viability.

- **Keywords:** Medical waste; Gasification; CCUS; Advanced exergy analysis; Optimization

Chun-chen Nie, Si-qi Jiang, Xi-guang Li, Xian-jun Lyu, Ya-qing Zhang, Xiang-nan Zhu. *Surface characteristic driven in waste printed circuit boards flotation: Floatability mechanism of resin and glass fiber in non-metallic component*. Pages 360-369.

To alleviate the environmental crisis caused by electrical waste, green reverse flotation of waste printed circuit boards (WPCBs) has been an appealing approach. Unfortunately, whether the floatability of non-metallic particles (NMPs) is caused by resin or glass fiber has not been confirmed. The floatability of NMPs, glass fiber particles in NMPs, pure resin particles and pure glass fiber particles were studied to determine the contribution to the floatability of NMPs. Firstly, the surface morphology of NMPs was analyzed by SEM, the results show that glass fiber and resin are locked together, leading to confusion in the mechanism of flotation. FTIR results show that the hydrophobic functional groups in NMPs are mainly derived from resins. Secondly, the floatability of each sample was also characterized by contact angle (CA) and wrap angle. The results show that NMPs and pure resin particles have excellent floatability with CA of 77.31º and 85.19º, while pure glass fiber particles have strong hydrophilicity with CA of 0º. The wrap angles of pure resin particles and pure glass fiber particles are 245º and 76º, respectively. Furthermore, the flotation results show that accumulated float yield of pure resin reach 100% within 120 s. The cumulative yield of pure glass fiber particles and NMPs after combustion is 6.22% and 12.52%, respectively. This study reveals the flotation mechanism of NMPs in WPCBs, proves that resin is the cause of the floatability of NMPs, which provides a guidance for the subsequent efficient recycling of WPCBs.

- **Keywords:** Waste printed circuit boards; Non-metallic particles; Cleaner enhanced flotation; Resin role; Flotation mechanism

Chunyu Hua, Jingyu He, Zhaotong Fang, Mengyuan Zhu, Zhaojie Cui, Lijun Ren. *Risk assessment for potentially toxic metals in Huangshui River, the Upper Yellow River, Qinghai Province, China, employing the species sensitivity distributions*. Pages 370-380.

Huangshui River, a tributary of the upper Yellow River, is one of the most important water resources conservation and recharge area of the Yellow River. In recent decades, agricultural cultivation and urbanization in Huangshui River Basin led to soil contamination. The Huangshui River were also seriously polluted, all at Grade V for many years before. Quantitative assessment model of heavy metal contamination in environment can provide guidance for regional policy making. In the present study, the distribution characteristics of potentially toxic metals in soil of Huangshui River plateau region were studied, and the contamination risk of heavy metals was evaluated. 113 top-soil samples were collected and surveyed for toxic element concentrations. The high coefficient of variation (CV) of Cd (274.5), Co (225.1), Pb (115.9), Hg (139.3) showed the high dispersion of heavy metal. The study built the distribution model of species sensitivity in the study area and calculated the environmental non-effect concentration (NOEC). Meanwhile, the ecological risk based on the environmental non-effect concentration and the background value (BC) was compared to explore the difference. The RI result based on the background value showed a maximum value of 1491, which is much higher than the ecological risk 520 based on the SSD result. The results indicated that there are some limitations in the risk evaluation of selecting the standard value or background value as the evaluation factor, which may exaggerate the risk. At the same time, the method was also suitable for the soil in other regions under the premise that the sensitivity distribution model could be constructed. Health risks of adults and children were made with the health risk assessment model for the two land use types. The hazard index (HI) of element Cr for children was 1.06, which was potential non-carcinogenicity to human health. The CR of Cd, Cr and As were above 10E-6 for children and adults, which was viewed as a risk range. This study established a credible risk assessment system, which can provide guidance for soil and ecological health development and policy making.

- **Keywords:** Heavy metals; Species sensitivity distributions; Health risk assessment; Soil

Qiongfang Zhuo, Jincheng Lu, Kang Lu, Tao Li, Li Tian, Zehong Yang, Yufeng Liu, Bo Yang, Sihao Lv, Yongfu Qiu. *Efficient degradation of carbamazepine using a modified nickel-foam cathode (Ni-FM/CNTs) in penetrating electro-Fenton process*. Pages 381-391.

A modified nickel-foam (Ni-FM) cathode coated with multi-walled carbon nanotubes (Ni-FM/CNTs) was synthesized for carbamazepine (CBZ) highly energy-efficient degradation in penetrating electro-Fenton. Scanning Electron Microscopy (SEM) and X-ray diffractometer (XRD) test proves that multi-walled CNTs were successfully coated on the surface of nickel foam. The linear sweep voltammetry (LSV) results revealed the greater electrochemical activity of Ni-FM/CNTs compared to Ni-FM. The H2O2 accumulation performance tests showed that Ni-FM/CNTs cathode had higher H2O2 accumulation performance than Ni-FM cathode, and the H2O2 yield of Ni-FM/CNTs was 5.7 times higher than that of Ni-FM after 1 h of electrolysis. The reaction rate of CBZ degradation in penetrating electro-Fenton process was 2.5 times that of planar electro-Fenton process because the flow-through process enhanced O2 mass transfer and promoted the production of H2O2. The Box-Behnken Design response surface method was used to analyze the factors affecting the degradation efficiency of CBZ in the penetrating electro-Fenton process. The CBZ degradation efficiency could reach 100%, and electric energy consumption was 0.4356 Wh/L at current density of 9 mA/cm2, pH = 3, concentration of Fe2+ was 0.3 mM, and the through-flow velocity of 60 mL/min. The quenching

experiment and EPR test results confirmed the degradation of CBZ was mainly the oxidation of·OH, and O2-·is the prerequisite for the production of·OH. Eight possible degradation products of CBZ degradation were identified and the probable degradation route was proposed. The ECOSAR program was used to predict the toxicities of CBZ and its degradation products, and the consequences revealed that the electro-Fenton process has a detoxification effect on CBZ, but may also produce more toxic organic compounds than the parent compound.

- **Keywords:** Penetrating electro-Fenton; Modified nickel-foam cathode (Ni-FM/CNTs); Multi-walled carbon nanotubes (CNTs); Carbamazepine (CBZ)

Aslı Tiktaş, Huseyin Gunerhan, Arif Hepbasli, Emin Açıkkalp. *Exergy-based techno-economic and environmental assessments of a proposed integrated solar powered electricity generation system along with novel prioritization method and performance indices*. Pages 396-413.

This study focused on the two important gaps in the literature. The first is solar energy-powered electricity generation in a more economical way via the integration of flat plate solar collector (FPSC), an Organic Rankine Cycle (ORC), and an absorptional heat transformer (AHT) system. Another gap is advanced exergy analysis of the AHT cycle/ORC process based on renewable energy integration to reveal clues for improving the system. To close these gaps, a novel system including a lithium bromide AHT cycle-ORC with a FPSC system application was proposed in this study. In this proposed system, the temperature of the heat source for the ORC system was upgraded via an integration of the AHT and FPSC cycles. The main components of the AHT cycle are the condenser (ABScon), refrigerant cycle pump (P1), evaporator (EV), absorber (ABS), solution heat exchanger (SHX), absorbent cycle pump (P2), expansion valve (V), generator (Gen), ORC turbine (ORCT) and ORC condenser (ORCcon). To demonstrate the electricity production from solar energy in a more economical way thanks to the proposed system, a comparison was made with similar-scaled existing solar power plants. The results supported the main purpose of this study. The annual electricity production with the proposed system was calculated as 2601 MWh, with initial investment cost and payback period values of US$3.924 million and 4.531 years, respectively. The conventional and advanced exergy, exergoeconomic, environmental impact, and sustainability analyzes were also performed. Based on these, the novel performance parameters and prioritization method were proposed to assess the improvement potential of the system. The results indicated that SHX and FPSC had the highest exergy destruction rates (EDRs) of 23.711% and 21.849% over 5853.89 kW due to the stronger thermal and chemical reactions. Similarly, Gen, FPSC, and SHX had the highest ED cost rates (CRs) of 67.59%, 59.09%, and, 47.98%, respectively. Gen, V, and ORCcon were higher contributors to the exergy destruction rates of almost all the components. However, these showed an adverse manner for irreversibility activities. So, the temperatures of Gen and ORCcon should be optimized carefully. ABScon, P2, P1, ABS, Gen, ORCT, and ORCcon had high development priority to improve the whole system.

- **Keywords:** Organic Rankine cycle; Absorptional heat transformer; Solar energy; Advanced exergy analysis; Advanced exergoeconomic analysis; Optimization

Jiang Lv, Qiang Wang, Fei Tang, Xiepeng Sun. *The evolution of flame geometrical characteristics and air entrainment of inclined jet flames*. Pages 414-422.

This paper reported the jet fire issuing from different angles, a common hazard in pipeline leakage accidents during the gas storage and transportation process. The flame geometrical profiles including flame projection length in the horizontal direction, vertical height from the nozzle position and flame trajectory length as the essential parameters

to evaluate jet fire risk and design safety distance between process equipment were measured experimentally. The result shows that flame projection length in the horizontal direction first increases to a maximum value at the horizontal jet flame condition and then decreases, flame vertical height from the nozzle position increases monotonously and the length of flame trajectory first decreases and then increases with the increasing inclined angle from downward to upward. Then, the normalized flame trajectory and its length for different inclined jet flames were obtained by plotting the flame tip location parameters normalized by a characteristic length representing the interaction between jet flow momentum and buoyant force generated by temperature variation. Finally, the air entrainment coefficients for different inclined jet flames were quantified by an integral model derived from the conservation equations showing a trend of first increase and then decrease with the increasing inclined angle from negative to positive. This work provides a good reference for quantifying the flame size of jet flame in inclined conditions.

- **Keywords:** Inclined jet flame; Flame geometrical characteristics; Flame trajectory; Air entrainment; Integral model

Aleksandar Jovanović, Marija Stevanović, Tanja Barudžija, Ilija Cvijetić, Slavica Lazarević, Anđelka Tomašević, Aleksandar Marinković. *Advanced technology for photocatalytic degradation of thiophanate-methyl: Degradation pathways, DFT calculations and embryotoxic potential*. Pages 423-443.

This study focuses on establishing an efficient two-step technology, which includes: (1) consecutive adsorption-desorption, using cellulose-based membranes, bCells, and (2) photocatalytic degradation of the fungicide thiophanate-methyl (TPM), using synthesized Ag-P25 and Ce-P25 catalysts. The catalysts, obtained by controlled deposition of Ag2O/Ag and CeO2 onto P25 TiO2 carrier (Degussa), were characterized using ATR-FTIR, XRPD, BET, FESEM, HRTEM, HAADF-EDS and UV–DRS techniques. In order to establish a feasible purification technology, preconcentration of TPM was performed by adsorption, achieving 75.5 and 92.9 mg/g of TPM removal using bCell-EpL and bCell–EpL–TA membranes, respectively, followed by efficient desorption (> 95%) that provided acceptable TPM concentration for photodegradation experiments. Under optimal conditions (0.07 g/L of both catalysts), complete degradation of TPM (5 mg/L) occurred within 2 h, compared to 4 h for the base TiO2 P25. Measurements of quantum yield and the results of HPLC-MS analysis, alongside DFT calculation, assisted in understanding the TPM degradation pathways. New degradation products were detected and proposed from HPLC–MS analysis. Embryotoxic assays, performed on zebrafish (Danio rerio), applied to estimate the toxicity evolution of time-dependent generated TPM degradation products, showed low embryotoxic potential. Chemical oxygen demand (26 mg O2/L) confirmed low ecotoxicological pressure of effluent water.

- **Keywords:** Thiophanate-methyl; bCells; Ag-P25 and Ce-P25 photocatalyst; Quantum chemical calculations; Danio rerio embryos

Jucai Wei, Yun Liu, Xu Wu. *Electrochemical advanced oxidation processes using PbO2 anode and H2O2 electrosynthesis cathode for wastewater treatment*. Pages 444-455.

The assessments of a novel electrochemical advanced oxidation process are presented, where PbO2 anode and H2O2 electrosynthesis cathode are simultaneously used in one system. The anode is β-PbO2 coated on a titanium substrate. The cathode is fabricated by rolling the activated Vulcan XC-72R carbon catalyst and PTFE binder on the titanium current collector as the catalyst layer and water-repellent layer, according to different carbon/PTFE ratios. Different electrolysers are used to evaluate the synergistic contributions of the PbO2 anode and H2O2 generated cathode on the pollutant

degradation process. The contributions of both direct anodic oxidation and indirect oxidation can be observed. The synergy of the PbO2 anode and H2O2 on-site generated cathode can significantly enhance the oxidation ability and COD removal. Almost all COD in the real pesticide wastewater and dye wastewater can be removed using a PbO2-H2O2 batch electrolyser, which is run at a cell voltage of 3.0 V and at room temperature. The reaction mechanisms in both chloride-containing and sulfate-containing wastewater are discussed particularly.

- **Keywords:** Electrochemical advanced oxidation processes; Lead dioxide; Persulfate; Active chlorine species; Hydrogen peroxide; Wastewater treatment

Yongsheng Jia, Donghang Chen, Zhongyu Jiang, Xiaolong Wang, Zhaoyu Zhou, Long Zhao, Limin Guo. *Activated carbon preparation based on the direct molten-salt electro-reduction of CO2 and its performance for VOCs adsorption*. Pages 456-468.

The conversion of CO2 into activated carbon (AC) for the adsorption of volatile organic compounds (VOCs) is a green strategy to treat waste by waste. In this study, CO2 was converted into a series of mesopore-enriched AC (MS-AC500, MS-AC550, and MS-AC600) by molten salt (MS) electrochemical method under different temperatures, and the prepared adsorbents were employed for the rapid adsorption of VOCs. The results showed that MS-AC500, MS-AC550, and MS-AC600 had a rich internal pore structure with specific surface area and pore volume of 816.70, 1062.05, 1255.50 m2/g and 0.58, 0.73, 0.84 cm3/g, respectively. The pore structures and surface chemistry of the adsorbents were positively correlated with the adsorption capacity, the adsorption amounts of MS-AC500, MS-AC550, and MS-AC600 were 244.89, 306.38, 414.39 mg/g for toluene and 279.29, 366.19, 460.10 mg/g for chlorobenzene, respectively. The superior adsorption capacity for chlorobenzene is mainly because chlorobenzene is a polar molecule and the C-O bonds inside the adsorbents have an attractive effect on the unpaired electrons inside the polar molecule. Simulation of the adsorption process of the adsorbents confirmed that the adsorption of both toluene and chlorobenzene was a physical adsorption process. Moreover, the adsorption-desorption cycle of chlorobenzene was more stable than that of toluene, and the durability of the adsorbent was above 95% after 5 cycles. This study can remove VOCs while reducing CO2 greenhouse gas, providing a feasible green route to treat waste by waste.

- **Keywords:** Activated carbon; Molten-salt electro-reduction; CO2; VOCs adsorption

Wai Lun Ng, Adeline Seak May Chua, Jiun Hor Low, Li Wan Yoon. *Potential of using mixed culture resource recovery as a sustainable waste management strategy for industrial glycerin pitch*. Pages 469-479.

Conventional glycerin pitch (GP) waste management strategies contribute to severe environmental pollutions. Current resource recovery strategies only focus on using pure cultures or conversions through chemicals. Thus, in this study, the potential of using mixed cultures resource recovery as an alternative strategy in GP management was examined. A respiration inhibition test conducted shown that GP resource recovery using mixed cultures below 4.14 g C/L is recommended to avoid microbial inhibition. The culture enrichment reactor took 11 weeks to enter steady state operations where microorganisms were cultivated from activated sludge for resource recovery from GP. The enriched culture was capable of reducing the GP organic content by 66 % and produce 3.3 wt% of polyhydroxyalkanoates (PHA) and 149 mg/g extracellular polymeric substances (EPS). This study has demonstrated that GP treatment using mixed cultures is a promising alternative that also produces valuable products such as PHA and EPS.

- **Keywords:** Glycerin pitch; Waste management; Mixed culture; Polyhydroxyalkanoates; Respiration inhibition test; Extracellular polymeric substances

S. Priya, P. Ilaiyaraja, N. Priyadarshini, N. Subalekha. *Effective removal of uranium (VI) using magnetic acid functionalized Fe3O4@TiO2 nanocomposite from aqueous solutions*. Pages 480-493.

The recovery and extraction of uranium is vital to ensure sustainability of nuclear energy production and safety of environment. Herein, we report a facile method to synthesise diglycolamic-acid-functionalized iron oxide@titanium dioxide magnetic nanocomposite (Fe3O4 @TiO2-DGA) as an efficient adsorbent for effective removal of uranium (VI) from aqueous medium. Fe3O4 @TiO2-DGA showed high uranium adsorption performance, with a sorption capacity of 371.8 mg g–1 at pH 6.0 and reached equilibrium within 40 min. The adsorption isotherm fits well with Langmuir and the kinetics follows pseudo-second-order model, respectively. The plausible mechanism of U(VI) adsorption involves the electrostatic interaction between the diglycolamic acid and hydrolysed uranium species. Thermodynamic studies revealed that the adsorption was spontaneous and exothermic in nature. The U(VI)-loaded Fe3O4 @TiO2-DGA could be conveniently separated from aqueous solutions using an external magnet, and further U(VI) is desorbed by adding dil. HCl. Fe3O4 @TiO2-DGA showed exceptional selectivity for U(VI) in presence of various coexisting metal ions and it can be effectively reused for more than 5 times with negligible change in sorption capacity. Thus, Fe3O4 @TiO2-DGA can be considered as an effective and potential sorbent for U(VI) remediation from aqueous solutions.

- **Keywords:** Iron oxide; Uranium; TiO2; Diglycolamic acid; Adsorption; Magnetic separation

S.M. Shalaby, Farid A. Hammad, Mohamed E. Zayed. *Current progress in integrated solar desalination systems: Prospects from coupling configurations to energy conversion and desalination processes*. Pages 494-510.

In this work, the recent advances in solar-powered water desalination systems are reviewed in detail. The recently published designs of solar-powered desalination systems such as solar stills integrated with phase change materials, multi-effect distillation (MED), multi-stage flash (MSF), humidification-dehumidification (HDH), reverse osmosis (RO), and membrane distillation (MD) are reviewed and discussed. The water desalination systems driven by photovoltaic and concentrating solar power (CSP) are also of great interest in this review. The reviewed results reveal that photovoltaic-powered RO desalination systems are still at the top as the most common technique used for water desalination powered by solar thermal sources. Where this technique achieves high daily productivity per unit area of the solar field with considerably low cost compared. The conjunction between the MSF and the CSP plants is ranked second in this competition as the desalination system benefits from the heat recovered from the CSP plants. In addition, for development technology for solar-based distillation, an integrated system that is involved two membrane processes or the combination of these processes with solar thermal heating/electrification hybrids is acquiring much popularity. In high-salinity seawater distillation, the scrupulous choice of proper initial and post-treatments yields more thermoeconomic benefits in terms of energetic efficiency, specific freshwater product, cost per liter and specific energy consumption as well as the operational independence for off-grid applications. Overall, the surveyed findings and concerned comparisons for the diversified solar combinations are discussed critically. Finally, some future recommendations related to integrated solar desalination systems are also mentioned, which assist in creating newly pathways for decision-makers to explore efficient hybrid desalination methods.

- **Keywords:** Solar desalination; Concentrating solar power; Coupling configuration technique; Direct thermal desalination systems; Membrane-based desalination systems; Water productivity

Hao Zhan, Shouqiang Liu, Qiang Wu, Yuan Li, Kuan Qi, Xiaohui Zhang. *Quantitative prediction of the impact of deep extremely thick coal seam mining on groundwater*. Pages 511-527.

Reasonable exploitation and utilization of groundwater near coal mines in arid areas are of great significance to regional ecological and geological environment protection and sustainable mining of coal resources. It is a challenge to accurately predict the impact of deep coal mining on groundwater resources before mining. Adopting a coal mine in Inner Mongolia, China, as a case study, first, a well-fitted GA-BP neural network model was established to predict the height of the water-conducting fracture zone (WCFZ). The prediction results of WCFZ were verified by in-situ measured data of optical fiber and cable sensing systems. In Chinese coal mines, hydrogeological research generally lags behind geological exploration. Therefore, in the context of limited hydrogeological data, a variable weight model (VWM) for evaluating the potential groundwater yield of the objective aquifer (OAPGY) was established considering geological survey data before mining. Then, drilling pumping test data was used to verify the OAPGY predictions. Finally, groundwater resource protection measures were proposed according to the zoning results. The research results could provide a reference and basis for sustainable utilization of groundwater and reducing the impact of coal mining on groundwater resources.

- **Keywords:** Deep coal mining; Quantitative prediction; Sandstone aquifers; Potential groundwater yield

Mayank Srivastava, Jahar Sarkar, Arnab Sarkar, N.K. Maheshwari, A. Antony. *Techno-economic and 4E comparisons of various thermodynamic power cycles for low-medium grade heat recovery*. Pages 528-539.

Various thermodynamic power cycles can be utilized to convert the low-to-medium temperature heat (available from many sources and has huge potential) to electricity and a detailed comparison between all of them is essential to identify the suitable one. Hence, to fulfill this research gap, six thermodynamic power cycles (Organic Rankine cycle with dry fluid, Organic Rankine cycle with wet fluid, Transcritical CO2 Rankine cycle, Kalina cycle, Organic flash cycle and Trilateral flash cycle) have been compared for various heat source and sink temperatures. Objective functions are power generation, efficiency, irreversibility, cost, profit, environmental benefit, techno-economic parameters, etc. Study shows that the trilateral flash cycle is best for medium heat source temperature and the CO2 cycle is best for low heat source temperature. The trilateral flash cycle shows an 11.5% higher exergy efficiency and 16.16% increment in annual profit at 160 °C heat source temperature as compared to the organic Rankine cycle with dry fluid. A decrease in condenser temperature is more advantageous than an increase. The study reveals that the CO2 Rankine cycle would be advantageous for low-grade heat sources while the trilateral flash cycle for medium-grade heat sources in terms of performance, cost, design, operation and environmental benefits.

- **Keywords:** Low-medium grade heat; Organic Rankine cycle; CO2 Rankine cycle; Kalina cycle; Organic flash cycle; Trilateral flash cycle

Felipe M.M. Sousa, André Z. Selvaggio, Flávio V. Silva, Sávio S.V. Vianna. *Leakage source localisation employing 3D-CFD simulations and gated recurrent units*. Pages 540-546.

The risk of explosion due to gas leakages and its human, environmental and economic losses in accident scenarios constitute serious safety hazards in industries. Fast location of leak sources enables quick corrective maintenance, avoiding the most hazardous cases. In the present study, gated recurrent units were developed to identify CH4 leaks in a chemical process module. The training and test databases were obtained through 3D-CFD simulations for four leaks and a non-leakage scenario. The inputs utilised were the concentration profiles at eleven sensors for four leak sources, four wind speeds, and eight wind directions using different temporal lengths. Additionally, noise was added to the database to assess the performance in more realistic cases. The findings indicated better performance with higher values of input time-steps, and accuracy over 93.9% for unseen data, indicating good generalisation of the models and their potential of predicting the leaks applying easily acquired inputs.

- **Keywords:** Methane release; Leak localisation; Process safety; Recurrent neural networks; Gated recurrent units

Pulikkutty Subramaniyan, Yamunadevi Kandeepan, Shen-Ming Chen, Yun-Hao Chang, Heng-Yuan Hsu, Ming-Chin Yu. *Enhanced electrochemical detection of sorafenib, an anticancer drug via CoGd-LDH modified glassy carbon electrode*. Pages 547-558.

An electrochemical sensor based on well-formed nanorods like cobalt gadolinium layered double hydroxide (CoGd-LDH) was used as an electrocatalyst for the detection of anti-cancer drug sorafenib (SNb). CoGd-LDH were synthesized via coprecipitation and subsequent aging without the addition of surfactants. Using their improved capabilities, a new electrochemical SNb sensor was created by drop-coating CoGd-LDH on glassy carbon electrode (GCE). Electrochemical investigations revealed that CoGd-LDH/GCE had superior electrocatalytic performance for SNb detection, with a broad linear range with good correlation coefficient (0.11–5.22 ng/mL; R2 =0.9922 and 6.39–34.86 ng/mL, R2 =0.9944), limit of detection (0.09 and 0.55 ng/mL), and sensitivity (0.87 μA/μM cm2). In addition, the CoGd-LDH/GCE showed good reproducibility, acceptable cyclic and storage stability, repeatability, and interference ability with possible interfering species. Practical application of CoGd-LDH/GCE sensor for SNb detection in serum samples achieved satisfactory recovery, indicating enormous potential for quantitative detection of SNb in a variety of fields.

- **Keywords:** Cobalt gadolinium layered double hydroxide; Nano rod; Sorafenib sensor; Cancer drug detection

Yao Tong, Hailing Ma, Fei Xiao, Sivasambu Bohm, Hongxin Fu, Yang Luo. *Precision engineering of precious metal catalysts for enhanced hydrogen production efficiency*. Pages 559-579.

This review focuses on elucidating the strategies employed for constructing efficient and stable active sites on noble metal catalysts in water electrolysis. Through the utilization of techniques such as phase modulation, morphology modulation, alloying effect, and single-atom catalysis, the electronic structure of noble metal active center atoms can be effectively tailored. This modification mitigates the strong adsorption between the active centers and reaction intermediates, thereby bolstering the intrinsic catalytic activity of the catalysts. Furthermore, the structural stability of the catalysts is enhanced through solid electronic interactions between noble metal atoms and heteroatoms. Consequently,

noble metal catalysts exhibit remarkable stability during hydrogen production from water splitting in both alkaline and acidic electrolytes.

- **Keywords:** Electrocatalytic hydrogen precipitation; Noble metal catalyst; Efficient structure; Catalytic stability; Electrolysis of water

Mir-Jamaleddin Athari, Maryam Tahmasebpoor, Babak Azimi, Mohammad Heidari, Covadonga Pevida. *Waste oleaster seed-derived activated carbon mixed with coarse particles of fluid catalytic cracking as a highly-efficient CO2 adsorbent at low temperatures*. Pages 580-594.

Activated Carbon (AC) derived from low-priced biomass materials has been identified as the efficient and cost-effective candidate for low-temperature CO2 adsorption technique performed, though suffering from limited CO2 capture capacity and heterogeneous fluidization in fluidized-bed systems have remained the main challenges for the industrialization of carbonaceous sorbents. Herein, for the first time, the novel, low-cost, and highly fluidizable carbonaceous sorbent derived from waste-based oleaster seed (OS) has been developed through mixing with cost-effective coarse fluid catalytic cracking (FCC) particles. Hydrophobic SiO2 nanoparticles (NPs) which are well-known as highly efficient assistant materials for enhanced fluidization of hard-to-fluidize particles was also tested for the comparison. To determine the best activator and activator/precursor weight ratio, AC sorbent obtained from the pyrolysis of OS was prepared with two disparate activators of KOH and ZnCl2, and the activator/precursor weight ratios of 2, 3, 4, and the outcomes reveal the highest average CO2 capture capacity of 2.78 mmol/g over three successive cycles for KOH-activated sorbent with activator/precursor weight ratio of 2. This great OS-derived sorbent was mixed with different wt% of coarse FCC and SiO2 NPs to boost its fluidity; for which, the bed expansion reached from 1.6 to 3.5, at the gas velocity of 5 cm/s by mixing with 2.5 wt% FCC, similar to 2.5 wt% SiO2 NPs-assisted sample. In addition to homogeneous fluidizability, a superior multicyclic stability of 95.5% during 25 multiple adsorption/desorption cycles was also assessed. The highly cost-effective FCC-mixed OS-derived activated carbon with both enhanced fluidity and multicyclic CO2 capture activity is introduced as the low-temperature CO2 capture candidate.

- **Keywords:** CO2 capture; Activated carbon; Oleaster seed; Fluidization; FCC particles; SiO2 nanoparticles

Shuaiyuan Ning, Rong Xie, Lelin Zeng, Kewen Tang. *Selective extraction of Au(III) and Pd(II) using p-tert-butyl-thiacalix[4]arene tetrathioamide as extractant.* Pages 595-604.

The recovery of precious metals in e-waste has become an urgent problem to be solved due to its serious waste of resources and environmental pollution. Herein, a p-tert-butyl-thiacalix[4]arene tetrathioamide (TBTAT) was synthesized for exploring selective extraction of Au(III) and Pd(II) from hydrochloric acid media. The influence of different parameters on the extraction method was investigated by liquid-liquid extraction experiments. As a result, TBTAT exhibited outstanding extraction performance for Au(III) and Pd(II) with 100% extractability from 0.1 M hydrochloric acid media for 1 h. The outcomes of Job's continuous variation means experiments showed that TBTAT was complexed with Au and Pd at a ratio of 1:3 during the extraction process. The TBTAT showed excellent selectivity for Au(III) (99.6%) and Pd(II) (99.9%) in the mixed system including coexisting competing ions such as Cu, Zn, Fe, K and Pb. The extraction efficiencies of other ions were less than 10%. At the same time, gold and palladium could be efficiently stripped from the loaded organic phase through thiourea. The extractabilities of Au(III) and Pd(II) remained 100% after being reused 5 times,

indicating the excellent reusability of TBTAT for extraction of Au(III) and Pd(II) from HCl media.

- **Keywords:** Thiacalix[4]arene; Liquid-liquid extraction; Au(III); Pd(II)

Quan Xiao, Lei Zhang, Lu Zhao, Saravanan Kumar. *Simulation and study of the simultaneous use of geothermal energy and flue gas waste energy in an innovative combined framework for power, chilled water, and fresh water generation*. Pages 605-621.

The integration of renewable energy sources, such as solar, biomass, and geothermal, with other technologies and energy production cycles holds the potential to significantly enhance power generation processes' efficiency. A novel trigeneration structure is introduced that harnesses geothermal energy and waste energy from flue gases. The proposed system comprises several key components, like combined flash and binary geothermal system, a water desalination unit, a Kalina power and cooling cycle, and organic Rankine cycles. The system is analyzed from various perspectives, encompassing energy, exergy, economic, and environmental viewpoints. This assessment allows for a holistic understanding of the trigeneration structure's performance, considering its energy efficiency, exergetic effectiveness, economic viability, and environmental impact. By combining elements, the trigeneration system aims to optimize the utilization of geothermal energy while efficiently converting waste energy from flue gases into useful power. The implementation and evaluation of this trigeneration structure offer promising prospects for sustainable and more effective power generation, promoting the integration of renewable resources with existing energy production technologies. The potential benefits of this approach could lead to a more environmentally friendly and economically viable solution for meeting our energy demands.

- **Keywords:** Geothermal energy; Flue gas waste energy; Trigeneration process; Aspen HYSYS simulation; Fresh water

Li Peng, Theyab R. Alsenani, Mingkui Li, Haitao Lin, Hala Najwan Sabeh, Fahad Alturise, Tamim Alkhalifah, Salem Alkhalaf, Siwar Ben Hadj Hassine. *Using data-driven learning methodology for a solid waste-to-energy scheme and developed regression analyses for performance prediction.* Pages 622-641.

Adopting innovative technologies like machine learning is crucial for achieving our sustainability goals. It has great potential for improving waste management and energy generation. The development of energy systems with machine learning algorithms is advancing rapidly. By conducting an in-depth comparison between the linear and non-linear regression models, this study makes a significant contribution to the field of waste-to-energy systems. The focus of this research is to forecast the performance of a newly designed solid waste-to-multi-generation energy system. This multi-generational energy system is designed to provide multiple outputs simultaneously, including power, heat, hydrogen, oxygen, and distilled water. In order to estimate the outputs of this system, both linear and non-linear algorithms are utilized and their respective performances are thoroughly analyzed and compared. The linear algorithms demonstrate notable precision through the creation of models that exhibit R-square values exceeding 96 %. In contrast, the non-linear algorithms demonstrate increased precision with R-square values surpassing 97 %, and even suggesting R-square values as impressive as 99 %, thereby attesting to the superior performance of these algorithms. Linear regression models are capable of providing predictions and identifying trends. However, non-linear regression models exhibit enhanced accuracy in predicting outcomes and are more efficient in capturing dynamic trends.

- **Keywords:** Waste-to-energy; Regression models; Waste management; Poly-generation scheme; Machine learning; Optimization algorithms

Pandiyan Bharathi, Sea-Fue Wang. *Strontium phosphate/functionalized carbon nanofiber composite: A promising electrode material for amperometric detection of flufenamic acid*. Pages 642-651.

Anti-inflammatory drug pollution and its potentially disastrous consequences have recently emerged as a major health issue worldwide because of its widespread use in inadequate environments. Among, Flufenamic acid (FFA) is a class of anti-inflammatory drugs widely used for therapeutic treatments, and its over usage causes severe issues in the biological systems. In this work, a particle–like strontium phosphate (Sr2P2O7) was prepared. The efficiency was increased by making a composite with functionalized carbon nanofiber (F-CNF) and used to detect FFA. The prepared individual materials (Sr2P2O7 and F-CNF) and the composite (Sr2P2O7@F-CNF) were confirmed by various spectroscopy techniques. The electrochemical studies of Sr2P2O7@F-CNF were done by electrochemical impedance spectroscopy (EIS) and cyclic voltammetry (CV). A sensitive i-t amperometry technique was used for the determination of FFA. The attained results show that Sr2P2O7@F-CNF shows a higher active surface area (A= 0.197 cm2), a wide linear range of 0.001–80.8 μM, a low detection limit of 0.9 nM, and higher selectivity. Finally, the Sr2P2O7@F-CNF was taken to the real-time analysis with the water and urine samples. The result shows an acceptable recovery range of ± 97.50–99.66 % for the water and urine samples.

- **Keywords:** Sr2P2O7; Pyrochlore structure; Carbon nanofiber; Nanocomposite; Electrochemical analysis; Real-world samples

Jinyong Wang, ChangKyoo Yoo, Hongbin Liu. *An overview of artificial intelligence in subway indoor air quality prediction and control*. Pages 652-662.

In the last few years, subways have rapidly spread in many countries and have replaced different modes of commuting in some important areas. Despite the fact that passengers only spend a short time in the subway, pollution in the subway is devastating to human health and can cause various diseases, including respiratory diseases. With the development of artificial intelligence (AI), more and more scholars are keen to use this technology to predict and monitor pollution focuses, which in turn can screen the air quality in subways. This paper reviews the application of AI in prediction and control of indoor air quality (IAQ) in subways during 2010–2022. The results show that most of the prediction studies analyzed were conducted for PM10 and PM2.5, and most of the control studies were conducted to optimize the subway ventilation system. Fewer studies have been conducted on the prediction of other air pollutants and on IAQ control facilities. This study attempts to provide guidelines for future AI to manage IAQ in subways.

- **Keywords:** Subway; Artificial Intelligence; Indoor air quality; Prediction; Control

Hui Chen, Shixin Li, Yingna Li, Ziqian Du, Liying Bin, Weidong Li, Fenglian Fu, Ping Li, Bing Tang. *Cyclic utilization of waste aluminum polishing solution by an efficient co-extraction system: Influence factors and extraction mechanism*. Pages 663-674.

For the purpose of regenerating waste aluminum polishing solution and eliminating its potential threats to environmental safety, this work focuses on establishing a highly effective co-extraction system for the simultaneous recovery of H3PO4 and H2SO4 from this kind of hazardous wastes, and further reveals the main influence factors and extraction mechanisms. Through a series of screening experiments, a co-extraction

system including tributyl phosphate and 1-butanol was successfully established, and the experimental results verified the suitability of this system for the regeneration of most H3PO4 and H2SO4 from waste aluminum polishing solution. The McCabe-Thiele diagram was used to determine that the whole extraction process was a counter-current process of 4-stage extraction and 2-stage stripping, which was capable of recovering most of H3PO4 and H2SO4. The main influence factors include phase ratio, temperature, and contact time, which have different degrees of influence on the recovery efficiency. The co-extraction mechanism of H3PO4 and H2SO4 has also been confirmed by the methods of FTIR, 1H NMR, 17O NMR and 31P NMR.

- **Keywords:** Waste aluminum polishing solution; Industrial wastes; Resource recovery; Solvent extraction; Cyclic utilization; Co-extraction mechanism

Shanshan Liu, Jingde Xu, Junhui Gong, Yong Pan, Yanwei Zhang, Yingquan Qi, Juncheng Jiang, Yang Hu. *Experimental study of methane explosion containing coal dust in flame instability and pressure variation process*. Pages 675-684.

It is important to understand the evolution process of an explosion flow field for accident prevention. This study investigated the effects of low coal dust concentrations on gas explosion characteristics by incorporating coal dust into air-methane gas mixtures (the volume fraction of methane is 12.5%, 9.5% and 6.5%, respectively) in a cylindrical combustion chamber for conducting explosion experiments. Pressure measurement and laser schlieren technology were used to record explosion pressure variations and to capture flame schlieren images. The results revealed that the flame radius shrank with elevated coal dust concentration at the initial stage of explosion. At a methane concentration of 6.5%, the flame appeared to float up, and the explosion reaction intensity increased with higher coal dust content. The flame spread out in a spherical morphology was observed at 9.5% and 12.5% methane concentrations. With elevated coal dust concentration, increased the maximum explosion pressure and pressure rise rate first, then decreased it. The dynamic coupling of flame instability propagation and pressure had a limited effect on the rising explosion pressure. In addition to providing experimental data for validating and enhancing the kinetic mechanism of gas-dust chemical reactions, these findings provide in-depth insight into prevention and management of coal-mine catastrophes.

- **Keywords:** Flame morphology; Coal dust concentration; Methane concentration; Explosion pressure

Xinhong Li, Mengmeng Guo, Guoming Chen. *A hybrid algorithm for inspection planning of subsea pipelines subject to corrosion-fatigue degradation*. Pages 685-694.

The corrosion-fatigue degradation is a significant concern causing subsea pipeline failure. This paper presents an inspection planning methodology for subsea pipelines subject to corrosion-fatigue degradation using dynamic Bayesian network (DBN) and improved Adaptive Genetic Algorithm (IAGA). The classical decision tree is used to represent the inspection process of pipeline. The corrosion-fatigue degradation is simulated using DBN to estimate the failure probability of subsea pipeline. IAGA is used to automatically present the inspection schemes and determine the optimal solution due to its strong optimization ability. A case study is utilized to illustrate the feasibility of the methodology. The results show that the cost is the lowest when the pipeline is inspected three times (11, 19 and 25 years) in its service, which is 58.0235 million dollars. The methodology can be used to guide the daily inspection planning of subsea pipeline subject to corrosion-fatigue degradation.

- **Keywords:** Corrosion-fatigue; Subsea pipelines; Inspection; DBN; IAGA

Yuqing Liu, Jiwei Cao, Yuchen Song, Zhibai Gao, Liyi Li. *Analysis of the immersion cooling of electric motors for hybrid aircraft*. Pages 695-705.

The focus of this paper is to investigate the practicality of incorporating immersion cooling methods to mitigate the temperature elevation of motors utilized in hybrid aircraft. Air cooling, oil jacket cooling, slot-channel oil cooling and immersion cooling techniques are each applied to a permanent magnet synchronous motor. When a hybrid aircraft is operating, the amount of fuel it carries is limited and decreases over time. In this case, the normal operating time of the motor is investigated in this paper. The study shows that for the motors in this paper, immersion cooling is the most effective with a limited amount of coolant and takes the longest time to reach the upper temperature limit, which can be improved by 5.6 times compared to slot-channel cooling. This paper serves as a reference for the design of motors for hybrid aircraft utilizing immersion cooling technology.

- **Keywords:** Hybrid aircraft; High current density; Permanent magnet synchronous motor; Immersion cooling; Thermal management; Thermal network (LPTN)

Wengang Bu, Lei Wei, Wenlian Peng, Tong Zhang, Zhaoliang Yu, Qianfeng Tong, Xiaodong Dai. *Microstructure and kinetics/thermodynamics of environmentally friendly and recyclable grain regulated Pr-Mg-Ni-based hydrogen storage alloys*. Pages 706-714.

The high-energy mechanical milling procedure was used to manufacture the as-milled Pr5Mg85Ni10 alloys of 5 h, 10 h, 20 h, and 30 h respectively. We have been successful in obtaining a variety of nanocrystalline and amorphous alloys with varying amounts of each. The primary phase in the interior structure of the alloys is still Mg2Ni and Mg, which corresponds to the second phase PrMg12. The products of saturated hydrogen absorption include MgH2, Mg2NiH4, and PrH2.93, while the products of complete hydrogen release include Mg, Mg2Ni, and PrH2. According to the findings, the amount of time spent ball-milling the alloys is the primary component that determines how well they function in terms of the dynamic performance of hydrogen absorption and desorption. The dynamic performance of the alloy in terms of hydrogen absorption and desorption is enhanced with the increasing time spent ball-milling the material. In the same vein, the alloy that has been milled for ten hours has the most desirable thermodynamic characteristics.

- **Keywords:** RE-Mg-Ni-based alloy; Crystal structure; Phase composition; Kinetics; Thermodynamics

Wei Liu, Tianhao Wang, Shuo Wang, Zhijun E, Ruiqing Fan. *Day-ahead robust optimal dispatching method for urban power grids containing high proportion of renewable energy*. Pages 715-727.

Urban energy supply includes more renewable energy, but renewable energy, such as wind and photovoltaic, is intermittent and connected to the grid and impacts the safe operation of the power system. For urban multi-type energy dispatching, this paper proposed a day-ahead multi-energy robust optimization dispatching method for an urban power grid with a high proportion of renewable power. Firstly, the power supply and load operation scenarios of the urban energy supply system are constructed. Multiple typical scenarios are formed based on fully considering the uncertainties caused by renewable energy and load prediction. A robust optimal scheduling model with system constraints was constructed based on the tuning capacity of adjustable generator sets and energy storage devices in the power grid, with multi-system functional cost optimization as the objective function. Extending the augmented Lagrange multiplier Method, the Alternating Direction Method of Multipliers (ADMM) is proposed to solve the constructed model. The

effectiveness of the proposed method is verified by some examples based on the data of an actual power grid in China.

- **Keywords:** Power system; Renewable energy; Robust optimization; Scenario analysis; Uncertainty

Shuyang Shi, Baozhong Ma, Ding Zhao, Xiang Li, Shuang Shao, Chengyan Wang, Yongqiang Chen. *Thermal behavior of Al(NO3)3·9H2O and its application in preparing Al2O3 and regenerating HNO3*. Pages 728-738.

The new process 'coal gangue/fly ash – HNO3 pressure leaching (NAPL) –low-temperature pyrolysis' was proposed by our team, which aimed to achieve the transformation of coal-based solid wastes from harmless to Al resource. For cost control, the regeneration of HNO3 at a low cost was crucial for the process. Following NAPL of coal gangue and fly ash, massive amounts of Al(NO3)3·9 H2O were collected, with a decomposition temperature as low as 523 K. The energy consumption for low-temperature pyrolysis could be supplied by the combustion of residual carbon (6.96 wt%) during the thermal activity of coal gangue, allowing HNO3 to be regenerated and recycled without extra heat supply. However, little research has been done on the pyrolysis behavior and kinetics of Al(NO3)3·9 H2O, which was examined in this study. The pyrolysis characteristics of Al(NO3)3·9 H2O were assessed by TG-DSC analysis. Further experiments and XRD/FTIR/MS analysis revealed that phase evolution of Al(NO3)3·9 H2O followed the sequence of Al(NO3)3·9 H2O→ Al(NO3)3·nH2O→ Al(NO3)3·3Al(OH)3·5/2 H2O→ AlOOH→ Al2O3. Subsequently, the thermodynamic (ΔG, ΔH, ΔS) and kinetic (Ea, A) parameters were calculated based on the thermogravimetric data by the iso-conversional methods. And the mechanism models and functions were identified via the Malek method. Finally, the economic evaluation of pyrolysis indicated that 5.04 × 10–3 Nm3 of natural gas was consumed during pyrolysis of one mole Al(NO3)3·9 H2O, equivalent to 44.33 $ per ton of Al2O3. As a basic research of Al(NO3)3·9 H2O pyrolysis, this paper enhances related theories of the NAPL process.

- **Keywords:** Al(NO3)3·9H2O pyrolysis; Thermogravimetric analysis; Phase evolution; Pyrolysis kinetics; Coal gangue and fly ash

Ziyue Han, Xinhong Li, Guoming Chen. *A stochastic model for RUL prediction of subsea pipeline subject to corrosion-fatigue degradation*. Pages 739-747.

A robust model based on stochastic processes with Copula function is developed for remaining useful life (RUL) prediction of subsea pipeline subject to corrosion-fatigue degradation. Gamma-based stochastic degradation process is used to simulate the corrosion degradation of pipeline, and fatigue crack propagation is estimated with Wiener process. The Particle Filter (PF) and Kalman Filter (KF) are utilized to update the model parameters. Then, an improved joint distribution model incorporating marginal distributions and copula function is presented to capture the complex dependencies between corrosion and fatigue. By establishing an acceptable pipeline failure threshold, a comparison is conducted among three stochastic process models to assess the practicality and effectiveness of the developed robust model. The results indicate that copula-based model has superiority in predictive accuracy with a deviation of 0.5. Considering interaction of corrosion-fatigue has a substantial impact on improving the accuracy of RUL. The present model can significantly contribute to the proactive maintenance and management of subsea pipelines, thereby enhancing operational efficiency and reducing potential risks.

- **Keywords:** Subsea pipeline; Remaining useful life prediction; Corrosion-fatigue degradation; Copula model

Lan Xu, Bhupendra Singh Chauhan, Bashir Salah, Phong-Hieu Thinh. *Development of an innovative high-performance poly-generation plant for efficient multi-level heat recovery of a biogas-powered micro gas turbine: Environmental and Multi-criteria analysis*. Pages 748-764.

Nowadays, the biogas-powered gas turbine cycles in poly-generation systems play a crucial role due to increasing fuel prices, declining renewable energy sources, and environmental concerns associated with fossil fuels. Concerning the high temperature of expanded gas, a novel high-performance poly-generation plant is achievable by intelligently selecting different subsystems. This paper presents a novel biogas-fueled poly-generation plant for producing electricity, refrigeration load, distilled water, and hydrogen simultaneously using multi-level heat recovery. An extended assessment of the devised plant output is performed based on energy-exergy, environmental, and exergoeconomic criteria, in which the plant's gas turbine inlet temperature, preheated air temperature, air compressor pressure ratio, as well as turbine inlet pressure, are considered as variables. In the following, to demonstrate the advantages of using a Stirling engine, this study investigates two scenarios to reveal its superiority, and a bi-objective optimization is performed, where the objective functions comprise minimizing the poly-generation unit products cost and maximizing the sustainability index. When the plant is operated with a Stirling engine, the plant produces 986 kW of electricity, 137.5 kW of refrigeration load, 8.39 m3/h of distilled water, and 2.96 kg/h of hydrogen. In this case, the energetic and exergetic efficiencies of the proposed system are enhanced by 2.96% and 7.89%, respectively compared to non-Stirling engine mode. Also, the carbon dioxide emissions and sustainability index are ameliorated from 606.2 kg/MWh to 588.6 kg/MWh and from 1.47 to 1.5, respectively. In addition, the sensitivity analysis indicates that in a certain ratio of PRAC, the plant's performance reaches its optimal mode. Moreover, the unit cost of products and sustainability index are improved by 9.9% and 8%, respectively, compared to the base design case with the SE.

- **Keywords:** Biogas; Waste heat recovery; Poly-generation; Stirling engine; Environmental assessment

Yanyan Yang, Zhuanjun Zhao, Yang Chang, Huan Wang, Haiyan Wang, Weiyang Dong, Guokai Yan. *PAHs and PAEs in the surface sediments from Nenjiang River and the Second Songhua River, China: Distribution, composition and risk assessment*. Pages 765-775.

The contamination of polycyclic aromatic hydrocarbons (PAHs) and phthalic acid esters (PAEs) in river sediments have attracted wide attention. However, the distribution characteristics of PAHs and PAEs in sediments of some rivers in China stay unclear, notably in some tributaries. To elucidate the distribution, sources, and risk of 16 priority PAHs and 6 priority PAEs in sediments of the Nenjiang River (NR) and the Second Songhua River (DR) in Northeast China, that were all the tributary of the Songhua River, a total of 42 surface sediment samples from 14 sampling locations were collected. The sediment samples included 76.5–9447 ng/g (mean=2069 ng/g) and 832–17,817 ng/g (mean=6392 ng/g) of the 16 PAHs and 6 PAEs, respectively, in total concentration. Of the 16 PAHs, BaA contributed the most, and DEHP and DBP were the most prevalent PAE compounds. According to the positive matrix factorization (PMF) model, three sources were identified: biomass combustion and vehicle emission, coal and coking combustion and petrogenic source, and contributed 66.81%, 16.96% and 16.23% of Σ16PAHs, respectively. The ecological risks posed by PAHs in the study are negligible, especially for BaA, which might cause frequent ecological risks to exposed organisms. The order of the PAEs' possible environmental risks was DEHP > DBP > DEP > DMP, and none of them are harmful to sensitive algae, crustaceans, or fish.

- **Keywords:** Sediment; PAHs; PAEs; Distribution; Risk quotient

Guven Acikalin, Ibrahim Dincer. *A solar based integrated gasification system for municipal plastic wastes to produce multiple useful outputs for environmental protection*. Pages 776-785.

A unique, solar based waste to energy type multigenerational system was developed and analyzed for producing ammonia, electricity and providing heating. Thermodynamic modeling and assessment studies were performed using energy and exergy analysis methods, and the performance of the developed system was evaluated through both energy and exergy efficiencies. In addition to this, the effect of varying operating conditions on the sub-systems' performance was investigated. In the present integrated system, a solar tower was used as a renewable energy-driven unit for producing steam. The plastics based municipal solid wastes were utilized as a gasification feedstock for the production of syngas, and the steam produced by the solar tower unit was utilized as gasification agent. A CO2 capture system was deployed where the solar tower was integrated to the gasification system for decreasing CO2 emissions of the system. Some parametric studies were performed to investigate how to improve the overall and subsystem energy and exergy efficiencies. The Rankine and Brayton cycles were also used for providing heat and electricity to the community.

- **Keywords:** Gasification; Plastic wastes; Hydrogen; Ammonia; Solar energy; Exergy; Energy

Shuang-Ning Li, Ya You, Wei-Guo Hu, Guan-Jin Gao, Xin-Yu Jiang, Jin-Gang Yu. *A sensitive single-layered graphene oxide-based sensor for electrochemical sensing of phosphate anion*. Pages 786-794.

In recent years, the electrochemical determination of phosphate anion in aqueous solution has attracted widespread interest because of its potential to address the environmental, economic and health concerns associated with phosphate management protocol. Herein, we report a direct electrochemical approach to identify phosphates using a special architecture of single-layered graphene oxide (SLGO) with abundant oxygen-containing surface functional groups. The electrochemical adsorption of phosphate onto SLGO was confirmed by X-ray photoelectron spectroscopy (XPS), and the formation of covalent bonds between phosphorus and carbon atoms occurred through the partial conversion of C-O covalent bonds to C-O semi-ionic bonds, which was beneficial to the electrochemical performances of phosphate at SLGO. The electrochemical adsorption of phosphates at other carbon nanomaterials modified glassy carbon electrodes (GCE) and bare GCE was also carried out. Further characterization by XPS, electrochemical impedance spectroscopy (EIS), and cyclic voltammetry (CV) revealed the electrochemical mechanism of SLGO/GCE toward phosphates. Under the optimized conditions, the concentration of phosphate was linearly related to the peak current in the range of 10.0–100.0 μM with limit of detection (LOD) of 2.0 μM (S/N = 3). More importantly, SLGO/GCE could be further extended to the quantitative detection of phosphate in industrial wastewater and human serum with acceptable recoveries (95.09–103.48%). This research could provide an effective method for the detection of trace phosphates in environmental media as well as physiological media.

- **Keywords:** Single-layered graphene oxide; Phosphates; Electrochemical adsorption; Electrochemical sensing; Quantitative detection

Xiaonuo Zhang, Goujian Chi, Haoran Xia, Xinyi Huang, Yaxi Deng, Chaoyang Huang, Hongxia Zhao. *Deciphering the Helianthus annus rhizosphere soil biodiversity under petroleum hydrocarbon compounds contamination*. Pages 795-806.

Phytoremediation mediated by microorganisms in the rhizosphere is a promising technology for the effective management of petroleum hydrocarbons-contaminated soil. However, it is essential to explore the dynamics of the micro-environment in the rhizosphere during phytoremediation process. A pot xperiment was conducted to investigate the ecological response of rhizospheric environmental of landscaping plant (Helianthus annus) to the petroleum hydrocarbon compounds (PHCs) contamination. The results showed that the species had a high ability to remove PHCs, and the removal of n-alkanes largely depended on symbiotic microorganisms in the root zone. The remediation efficiency of Helianthus could be regulated by rhizosphere microbes through the enhancement of nutrients and energy cycling, remodeling of the beneficial bacterial abundance, and improvement of enzyme activities. In addition, the ecological response of rhizosphere soil was closely related to the root exudation effect of plant and PHCs exposure. The present study provides information about the succession pattern and response of the microbial community of rhizosphere soil in the PHCs phytoremediation of Helianthus annus, and demonstrated the feasibility of Helianthus annus in the effective management of PHCs in contaminated soil.

- **Keywords:** Petroleum hydrocarbons; Helianthus; Phytoremediation; Microbiome; Micro-environment

Xin Hu, Qiang Sun, Jishi Geng, Shaoni Wei, Xiaoying Ding. *Study on influencing factors of radon exhalation from coal measures in the northern margin of Ordos Basin*. Pages 807-817.

Coal-uranium synergistic development has become an emerging research area in recent years. Radon gas emitted by uranium decay in the stratum may be used as an indicator to study the uranium-bearing area. Investigating the relationship between radon exhalation law and the depth, lithology, and mineral composition of coal measures is very important. This paper analyses the influencing factors and mechanism of radon release in coal measure strata in the Ordos Basin which is rich in coal and uranium co-occurrence deposits, by drilling a core at a depth of 18.3–84 m in the mining area, and using low-field nuclear magnetic resonance (NMR), polarizing microscope and environmental radon meter tests. The results show that the proportion of micropores decreases with an increase in particle size, and the proportion of macropores and porosity increases. High porosity has a greater effect on the release of radon gas, resulting in a higher exhalation rate in samples with coarse particle sizes. The radon exhalation rate of sandstone is higher than that of coal, and the radon concentration increases with the improved sealing property of deep rock and soil masses. The radon exhalation rate of sandstone is strongly influenced by feldspar and is positively correlated with each other. The radon exhalation was aided by the submicron structure created by feldspar alteration. The research results may be used as a reference for rock radiation risk assessment in mining areas.

- **Keywords:** Coal measures; Uranium; Sandstone; Pore structure; Radon diffusion; Mineralogical characteristics

Amirhamzeh Farajollahi, Navid Nedaei, Mohammad Baharvand. *Design and 3E scrutiny of a trigeneration system, consisting of a solar chimney, multi-effect desalination, and water electrolyzer: A process for evaluating regional applications.* Pages 818-835.

Low/medium temperature solar thermal applications are more economically feasible for seawater desalination. In this way, the current research presents a novel combined process in a solar chimney, wherein a multi-effect desalination and a polymer electrolyte membrane electrolyzer are established, producing electric power, fresh water, and high-purity hydrogen simultaneously. This model is simulated under the steady-state conditions by the engineering equation solver environment, then a comprehensive assessment is accomplished from the viewpoints of thermodynamics and cost. The results exhibit that the higher chimney's diameters and the higher pressure drops across the turbine lead to higher thermodynamic efficiencies as well as lower costs. The base design conditions show that this arrangement results in energetic and exergetic efficiencies of 31.08% and 7.08%, individually. From the cost facet, the sum unit cost of products is computed as 16.86 $/GJ, so the payback period (PP) of 3.47 years is available. The potential of the configured system is investigated using a regional application method, for which four different countries are regarded. The selected areas include Alice Springs, Madrid, Riyadh, and Tehran. Considering the case study, the proposed arrangement is more efficient when applied to the climatic conditions in Tehran.

- **Keywords:** Case study; Multi-effect desalination; Pure hydrogen; Renewable energy systems; Solar chimney

Zibin Yin, Shuqiang Liu, Dongli Tan, Zhiqing Zhang, Zihe Wang, Bo Wang. *A review of the development and application of soot modelling for modern diesel engines and the soot modelling for different fuels*. Pages 836-859.

Nowadays, the increasing consumption of conventional fuels has led to rising pollutant emissions, among which soot has received much attention due to its harmful effects. In this paper, previous typical soot models are reviewed. Based on empirical, semi-empirical and detailed models, phenomenological models, the most popular models of recent years, are also summarized. This work also summarizes the application of existing soot models in combination with other models and methods in turbulent flame and diesel engine development based on existing models. Besides, as the development of clean alternative fuels continues, new fuels have received significant attention as a method to reduce soot formation. For different fuels, the reasons for reducing soot formation have also attracted the interest of researchers, and thus this paper reviews the current research about relevant carbon soot modeling for biodiesel, natural gas, and other new fuels. A detailed understanding of soot generation and soot modelling can help further research into methods to reduce soot emissions.

- **Keywords:** Soot formation; Modelling; Alternative Fuel; Application

Shenghua Liu, Xudong Mao, Lidong Zhang, Xuesong Yan, Guohua Yang. *Study on filtration enhancement of a dual-layer granular bed filter for bipolar-charged dust*. Pages 860-871.

To improve the filtration efficiency of the dual-layer granular bed filter, a new method to enhance filtration with dust bipolar-charging was proposed. The characteristics of positive and negative corona discharge and dust charging at different temperatures were measured and analyzed. The filtration experiments of non-charged dust, positive charged dust, negative charged dust, and bipolar charged dust in a dual-layer granular bed filter were carried out. The results confirmed that the best filtration effect was achieved when

the dust was bipolar-charged. Furthermore, because of the loose structure of dust cake formed by the charged dust, the filter regeneration cycles were prolonged. At 450 ℃, when the inlet dust concentration was 10 g/m3, and the bi-charging voltages were + 20 kV and - 14 kV, the mean outlet dust concentration in a filtering cycle was 38.1%, 46.6% and 68.2% lower than that of negative-charged, positive charged, and non-charged dust, respectively.

- **Keywords:** High temperature dust removal; Granular bed filter; Bipolar charge

Wei Zhou, Gang Li, Haoran Zhao, Xiupeng Zhang, Jazmine Aiya D. Marquez, Qingsheng Wang. *Experimental study of explosion parameters of hybrid mixture caused by thermal runaway of lithium-ion battery*. Pages 872-880.

The explosion characteristics of the runaway battery vented gas (BVG) was studied using an 8 L column type device. The effects of ambient temperature, turbulence condition, and graphite dusts-ejected along with the BVG on the explosion process-were investigated. At 25 ℃, the explosion limits of pure BVG, the maximum explosion pressure (Pmax), and the maximum rate of explosion pressure rise (dP/dt)max is 10.8–45.8% by volume, 0.62 MPa, and 37.6 MPa/s, respectively. At 80 ℃, the three parameters changed to 10.4%– 46.5%, 0.49 MPa and 35.5 MPa/s. Moreover, these three parameters changed to 10.2–47.5%, 0.45 MPa and 33.3 MPa/s at 120 ℃. The increase in temperature reduced Pmax of BVG. While turbulence had little effect on the explosion pressure of BVG, it has significantly affected the dP/dt value. Adding graphite dusts helps BVG get to Pmax at a much lower volume concentration. As temperature increased, this effect became greater. Also, the graphite dusts can reduce the time of BVG to attain the Pmax value after igniting – the maximum reduction is from 325 ms to 158 ms. As ambient temperature increased, the combustible gas molecules were reduced, resulting in a lower Pmax value. The heat released from the BVG explosion drives the graphite involving dust explosion when oxygen is excessive. The above findings can provide a reference for the prevention of environmental explosions caused by the thermal runaway of lithium-ion batteries in process industry.

- **Keywords:** Lithium-ion battery; Thermal runaway; Battery-Vented Gas; Graphite dusts; Hybrid explosion

Duo Hou, Zhi Zhang, Yanan Geng, Zhiqiang Wu, Huabo Yang. *Experimental study on the channeling leakage properties of compact-size casing-cement sheath-stratum assembly in deep and ultra-deep wells*. Pages 881-892.

Within deep and ultra-deep wells, the casing-cement sheath-stratum rock assembly(CCS) bears thermal, mechanical, and chemical multi-field coupling, causing some damage or creating micro-annular gaps at the interface between the casing and the cement sheath as well as the interface between the cement sheath and the stratum. Radial and axial cracks in the cement sheath occur, and even channeling-leakage channels form due to shear failure. These are critical reasons for sustained annular pressure and the risk of wellbore sealing integrity. This paper establishes an evaluation device for channeling-leakage properties of a compact-size CCS assembly. It observes the microstructure and morphology characteristics of cement sheath integrity, tests the channeling-leakage pressure and paths of two cement slurries, and explores the relationships between the channeling-leakage properties of the assembly and the damage to the cementing interfaces as well as the cracking characteristics of cement sheath. Results showed that the proposed method was suitable for evaluating unpredictable security risks of CCS assembly caused by a complex load in deep and ultra-deep wells, such as overload-induced cracking, cementing interface unsealing, and channeling-leakage of the cement

sheath. The findings revealed the evolution law from deformation points to cracks and channeling-leakage channels inside the cement sheath under the action of load and proposed technical measures to avoid channeling-leakage of the cement sheath. This research provides a theoretical basis and testing method for evaluating the wellbore sealing integrity and formulating technical safety measures for deep and ultra-deep wells.

- **Keywords:** Casing; Cement sheath; Stratum rock; Thermal stress; Channeling-leakage; Sealing integrity; Annulus pressure; Well integrity

Kai Zheng, Qianhang Jia, Zimao Ma, Zhixiang Xing, Yongmei Hao, Minggao Yu. *Experimental and numerical investigation on the premixed methane/air flame propagation in duct with obstacle gradients*. Pages 893-904.

This work experimentally and numerically investigates the effect of the obstacle gradient on the characteristics of the methane/air explosion in obstructed ducts. The obstacle gradient is expressed through various blockage ratios, and three different obstacle gradients are investigated, i.e., C357, C555, and C753. Noted that C357 means that the blockage ratios of three obstacles arranged sequentially in the duct are 0.3, 0.5 and 0.7 respectively, and so do C555 and C753. A two-dimensional (2D) model is adopted and the Scale-Adaptive Simulation method with the thickened flame model is considered. Experimental results show that the obstacle gradient significantly affects the flame evolution structure, flame propagation speed and overpressure. The obstacle gradient is accountable for the "tulip flames" appearing downstream of the obstacle. For the case with a fixed methane volume fraction, the average flame front speed is fixed. However, with the increasing obstacle gradient, the maximum flame front speed increases until it achieves the maximum at C357, and so does the maximum overpressure. The numerical simulation can predict the flame evolution behaviour precisely. It is evident that the generation of different flame shapes appearing is derived from the flow field evolution of unburned gas downstream of the flame front.

- **Keywords:** Methane deflagration flame; Obstacle gradient; Flame speed; Overpressure; Numerical simulation

Navid Moghaddas-Zadeh, Mahmood Farzaneh-Gord, Amir Ebrahimi-Moghadam, William P. Bahnfleth. *Techno-economic assessment of a proposed novel hybrid system for natural gas pressure reduction stations.* Pages 905-918.

To prevent Natural Gas (NG) frozen during pressure reduction process, a heater is contrived for preheating NG. In this study, a novel system is suggested to supply part of heat demand of a NG City Gate Station (CGS). The system consists of a heat pump in which the compressor input work is supplied by the turbo-expanders. In the proposed system, pressure reduction is carried out by turbo-expanders instead of Regulator Valve (RV) to recover the energy of high pressure NG. The recovered energy by turbo-expanders meets the heat pump cycle work demand. A CGS is selected as a case study, and the suggested system is assessed in terms of energy, exergy, and economics. The amount of the annual fuel savings is calculated 2.42 × 106 kg (70.08%). Exergy analysis shows that the most exergy destruction occurs in the RV and heater. The exergy factor of the proposed system in the days that the system works, is about 2.2–5.1%. Based on the economic analysis, the value of simple payback period and discounted payback period are calculated 2.63 and 3.08 years, respectively. The annual revenue that comes from saving fuel is 310,000 $/year based on the current price of NG.

- **Keywords:** Natural gas pressure drop station; Energy recovery; Fuel saving; Heat pump cycle; Techno-economic assessment

Yanyong Hu, Rui Zhang, Jiaxi Wu, Xiaotong Qie, Hong Liu. *Evaluation of sustainable development efficiency in Chinese provinces- based on closed-loop feedback three-stage dynamic network slack-based measure model*. Pages 919-932.

Coordination of economic, environmental, and social development is essential for sustainable development in China. A closed-loop feedback three-stage dynamic network slack-based measurement model was proposed to measure the sustainable development efficiency of 30 provinces in China during 2005–2020. The spatiotemporal evolution characteristics and coordination of sustainable development efficiency were explored using the Dagum–Gini coefficient decomposition method, Malmquist index model, and kernel density estimation method. As indicated, the overall sustainable development efficiency of China has increased with an average of 0.7140. The efficiency level of regional sustainable development displayed a "stepped-like" spatial distribution pattern, exhibiting a successive "east-central-west" decrease. The sustainable development efficiency levels of the respective stages differed notably, and the efficiency values of stages 2 and 3 were considerably lower than those of stage 1. The contribution rate of the between-region difference to the overall degree of variation was the highest, followed by the contribution rate within the region. Notably, the contribution rate of transvariation intensity reached a minimum value. During the study period, the distribution centre of sustainable development efficiency in China moved continuously to the right, the peak height increased, and the width contracted. This study provides a valuable policy reference for China's sustainable development and ideas regarding its global response to energy and environmental issues.

- **Keywords:** Sustainable development efficiency; Dynamic network slack-based measure model; Dagum–Gini coefficient decomposition; Kernel density estimation; Collaborative development

Xinhong Li, Jie Ma, Hans Pasman, Renren Zhang. *Dynamic risk investigation of urban natural gas pipeline accidents using Stochastic Petri net approach*. Pages 933-946.

The safety of urban gas pipelines is challenged by a series of adverse factors, and the unexpected accidents may pose a catastrophic threat to humans, the environment and assets. The existing studies mainly focused on causation investigation of natural gas pipeline accident, the dynamic evolution process of urban natural gas pipeline accident is still challenging task for accident prevention. To find out the unfavorable factors that cause accidents, this study presents a dynamic risk modeling of urban natural gas pipeline accidents using Stochastic Petri net (SPN). An SPN model of an accident evolution process is constructed based on the discrete events in an accident flowchart, and the critical places and transitions are evaluated through this model. Considering the slow development of the early events leading to accidents, the delay time of the transitions at this stage cannot be determined, Bayesian theory is used to dynamically update SPN model. Critical accident nodes and their occurrence probabilities are estimated, which are used to support the efficient risk management strategies. The gas explosion accident in Shiyan, Hubei, as a representative case is investigated, and the results show that pipeline corrosion, ignition sources, inefficient information feedback and unreasonable solutions are critical accident causations. The probabilities of critical accident nodes increase over time, which means that these factors need to be managed efficiently to prevent the accidents. The application shows that the model can be used as a tool for gas companies and governments to investigate urban gas pipeline accidents.

- **Keywords:** Urban natural gas pipelines; Stochastic Petri net; Accident flowchart; Markov chain; Bayesian theory; Dynamic model

Mingyang Liu, Xianming Lang, Shuaiyong Li, Lincan Deng, Bo Peng, Yipeng Wu, Xiao Zhou. *Improved machine learning leak fault recognition for low-pressure natural gas valve*. Pages 947-958.

Monitoring valve operation status is very significant in saving natural gas resources and realizing sustainability of the fossil energy. At present, many machine learning algorithms have been applied to nondestructive testing (NDT) field. Among them, the twin support vector machine (TWSVM) is a representative binary classification method. However, the traditional TWSVM assigns same classification weights to all sample points, including classification boundary points and other non-boundary sample points. These same classification weights often lead to classification errors or overfitting in TWSVM. Therefore, to overcome the drawback, we propose an improved nonlinear TWSVM (I-TWSVM) to optimize the classification weights assignment processing. In new assignment processing, the boundary points are given greater classification weights than other non-boundary points, which makes the I-TWSVM becomes more sensitive than the traditional TWSVM to boundary points. The I-TWSVM has been applied to recognize the acoustic emission (AE) sample data for valve internal leak fault accident. The leak recognition experiment revealed that the proposed algorithm is better than the traditional nonlinear TWSVM in classification accuracy and sensitivity, and its calculation time is faster than that of nonlinear TWSVM, which can promote the nondestructive testing technology development for low-pressure natural gas valve.

- **Keywords:** Valve internal leak recognition; Classification weights assignment; Improved nonlinear TWSVM; Nondestructive testing; Acoustic emission

Jinming Zhou, Yucai Zhu, Zhijiang Shao. *A combined passive-active method for diagnosing multiplicative fault*. Pages 959-975.

Fault detection and diagnosis (FDD) plays an important role in risk and safety management system. According to the ways faults influence the actual system, they can be divided into additive (mainly actuator and sensor faults) and multiplicative (mainly process faults). The two types of faults should be diagnosed with specific methods then handled with different maintenance strategies. This paper presents a combined passive-active fault diagnosis method, which allows a simultaneous consideration of additive and multiplicative faults and to distinguish between them. It also enables detailed diagnosis that assists to enhance the subsequent risk assessment and management. System identification is used as the modeling tool and forms the basis of the method. The passive-active feature of the method reflects in that: it uses online generated residual as a fault indicator for real-time monitoring; it also uses test signals to magnify the fault characteristics and helps to reveal the fault location. Specifically, a method is proposed to distinguish between additive and multiplicative fault according to the different residual behavior after adding test signals. Once fault type is determined, by investigating the identified models with error bounds, a method is further developed to determine the location of multiplicative fault in the multi-variable system. The statistical properties of the identified models are utilized to generate perturbed realizations of the model and derive probabilistic bounds of model errors, enabling both methods to deal with model errors. The proposed method does not require to break the control loops when adding test signals and does not require fault data/model to start with. The effectiveness of the proposed method is validated through a numerical example and Tennessee Eastman process (TEP).

- **Keywords:** Fault diagnosis; Passive-active approach; Multiplicative fault; System identification; Threshold setting; Tennessee Eastman process

Md. Anik Hasan, Rumana Hossain, Veena Sahajwalla. *Critical metals (Lithium and Zinc) recovery from battery waste, ores, brine, and steel dust: A review*. Pages 976-994.

The management and recycling of waste which contains critical metals has become a high priority. Improper management of this waste leads to adverse effects for both the environment and human health. An equally important driver is the rapidly growing demand to recycle critical metals from waste to reduce environmental impacts and transition to zero-carbon technologies. The aim of the paper is to provide knowledge about waste containing lithium and zinc and the pros and cons of different treatment and recovery methods to policymakers, industrialists, researchers, and students. To that end, we identify sources of lithium- and zinc-based waste and compare and discuss the benefits and challenges of treatment and recovery procedures including pyrometallurgy, bioleaching and acid-leaching. We also explore the socio-economic aspects of lithium and zinc metals and environmental impacts of wastes containing these metals. Finally, we provide a summary of literature containing life-cycle analysis (LCA) studies for the recovery of lithium and zinc from waste sources.

- **Keywords:** Metal recovery; Lithium batteries; Alkaline batteries; Hydrometallurgy; Pyrometallurgy

Bing Li, Enyuan Wang, Zheng Shang, Xiaofei Liu, Zhonghui Li, Jun Dong. *Deep learning and heterogeneous signal fusion approach to precursor feature recognition and early warning of coal and gas outburst*. Pages 995-1008.

Coal and gas outburst is one of the main disasters during the production process of coal mines. Accurate recognition and advanced early warning are crucial to effectively preventing and controlling outburst. Acoustic Emission (AE) or Electromagnetic Resonance (EMR) continuous monitoring technologies have been widely used in outburst prediction due to their advantages of positive response and significant precursor characteristics of impending hazards. However, using a single signal and its one-dimensional time-domain characteristic for predicting outburst may lead to false and omissions alarms due to low credibility and lack of potential information, which may reduce the reliability and advance of early warning. To solve this problem, a new method for precursory feature recognition and early warning of outburst based on a two-dimensional CNN (Convolutional Neural Network) and heterogeneous signal fusion is proposed. Establish an outburst precursor feature recognition model based on Faster R-CNN and AE-EMR two-dimensional time-frequency signals, providing more reliable evidence sources for the fusion early warning of outburst; Then construct an outburst early warning model based on TBM (Transferable Belief Model), revealing the early warning criteria of heterogeneous signal fusion. The proposed method is applied to the Shiping Coal Mine. It is found that the outburst precursor recognition accuracy of AE and EMR achieve 98.00% and 98.57%; The heterogeneous signal fusion model usually warns to be advanced by 1–2 days, and the minimum warning time can be about 60 min in advance. The research results have practical significance in improving the reliability and advancement of outburst early warning and enhancing the ability to control safety risks in the coal mine production process.

- **Keywords:** Coal and gas outburst; Faster R-CNN; Precursor feature recognition; Heterogeneous signal fusion; Early warning

Saeed Karimi, Milad Asghari, Reza Rabie, Mohammad Emami Niri. *Machine learning-based white-box prediction and correlation analysis of air pollutants in proximity to industrial zones*. Pages 1009-1025.

The adverse health effects caused by long-term exposure to high pollution volumes from industries near urban areas are a growing concern. Determining accurate distribution models of pollutants is crucial for establishing safe distances between sectors and urban regions and continuously monitoring pollutant levels. This study was conducted in Siraf City, situated in the Pars special energy zone in southern Iran, to improve the accuracy of simulation results and identify the correlation between emission models and pollutant concentrations. To achieve this goal, concentrations of seven pollutants (CO, CO2, NO2, SO2, O3, PM2.5, PM10) were determined seasonally at 45 points within the study area using field sampling and numerical simulation with AERMOD software. Subsequently, the obtained results were seamlessly transferred into new domains with the primary objective of feature engineering. These engineered features were then fed into an XGBoost model for regression analysis to obtain coefficients, deriving seven equations to enhance pollutant concentration simulations' accuracy significantly. The developed equations improved the simulation accuracy for CO (12.54%), CO2 (12.91%), NO2 (0.94%), SO2 (6.7%), O3 (3.05%), PM2.5 (12.47%), and PM10 (4.62%). The findings demonstrate varying improved accuracy levels depending on the pollutant and simulation accuracy with well-known machine learning algorithms. The machine learning model effectively reveals the relationship between emission models and pollutant concentrations, offering valuable insights to enhance the accuracy of air pollutant emission predictions.

- **Keywords:** Air pollution distribution; XGBoost; White-box prediction; Simulation accuracy; AERMOD

Cuixian Yang, Dylan Aljović, Thomas P. Vickery, Megan Roth, Daniel J. Muzzio. *Thermal hazards assessment of three azo nitrile compounds*. Pages 1026-1044.

Commercially available azo radical compounds provide efficient initiation of many chemical reactions. However, such energetic azo group initiators have thermal stability issues at ambient or even sub-ambient temperatures. Azo decomposition initiated by heat and/or light can generate significant amounts of nitrogen gas with rapid pressure increases, presenting a safety challenge for shipping, storage and usage. In this study, three azo nitrile compounds were examined using various thermal calorimetry techniques with only 5 mg to 1 g scale samples. We obtained calorimetric data on exothermic activity and gas generation. The testing results were subsequently analyzed by using differential iso-conversional methods to obtain key decomposition kinetics parameters, including activation energy and pre-exponential factor. The model was then validated and utilized for prediction of several key safety parameters for scale-up applications, including Self-Accelerating Decomposition Temperature (SADT), Time to Maximum Rate (TMR), temperature profiles at iso- or non-isothermal conditions for shelf-life evaluation, adiabatic temperature rise, and rate of pressure increase. For compounds such as 2,2'-azobis-(2,4-dimethylvaleronitrile) and 1,1'-azobis(cyclohexane-1-carbonitrile) which went through phase transitions associated with thermal decomposition, the thermal decomposition behavior of liquid and solid state was found to differ in characteristic. This methodology for thermal decomposition kinetics assessment enables safe storage, handling, and scale-up process preparation.

- **Keywords:** Thermokinetics analysis; Thermal hazard; Runaway; SADT; TMR; 2; 2'-azobis-(2; 4-dimethylvaleronitrile); 1; 1'-azobis(cyclohexane-1-carbonitrile); 4; 4'–azobis(4–cyanovaleric acid)

Ali Mohssine, Hamza jyia, Zakia Zmirli, Slimane El Harfaoui, Soumia Belouafa, Brahim Sallek, Hassan Chaair. *Wastewater remediation using multi-soil layering (MSL) eco-technology: A comprehensive and critical review*. Pages 1045-1082.

Multi-soil layering (MSL) is an efficient and eco-friendly soil-based system ingeniously engineered to circumvent common limitations imposed by soils when used as filtering materials for wastewater treatment. However, relatively few comprehensive and critical reviews emphasize the significant assets of successful application and durable operation and discuss the cutting-edge orientations to promote the acceptance and widespread use of this emerging Ecotechnology. To bridge the existing research gap, after giving the essential knowledge on the principle, typology, and treatment mechanisms of MSL reactors, the present paper reviews and criticizes current applications and discusses the most influencing factors to highlight their crucial role in maintaining sustainable design and effective operation. Furthermore, this paper provides guidance and discusses future scopes and novel perspectives to promote MSL systems' effectiveness, large-scale development, and sustainability by optimizing operational conditions and transitioning toward renewable energies and circular economy approaches. Further, the present paper gives an estimative evaluation of the capital cost of an MSL system based only on locally available materials. Lastly, this review summarizes the most relevant recommendations relative to sustainable design and operation in the form of holistic guidelines from emergence to recent state of art as a start-up and consultative base for stakeholders and researchers interested in MSL technology.

- **Keywords:** Multi-soil layering system; Influencing factors; Clogging; Design guidelines; Circular economy; Cost-benefit analysis

Yunfeng Zhu, Bo Li, Yonggang Wei, Shiwei Zhou, Hua Wang. *Pyrolysis of waste printed circuit boards: Parametric effects on product distribution, characterization and gas emissions.* Pages 1083-1093.

The efficient and environmentally friendly disposal of waste printed circuit board (WPCB) is of great significance for resource sustainability. This study focuses on the pyrolysis process of WPCB and the comprehensive characterization of the products. Meanwhile, the emission properties of the main gas products in the pyrolysis process of WPCB were investigated in real time. The results of pyrolysis experiments indicated that a solid yield of 79.03% was obtained by pyrolysis at 500 °C for 60 min, and 91.46% of copper and 95.36% of tin were recovered. The gas products mainly consisted of CO, CO2, CH4, H2, and C2H2. The liquid products contained phenols, aromatic hydrocarbons, ketones and furan derivatives. The pyrolysis gas and liquid products might be utilized as the raw material for fuel and other composite materials after purification. The process combines medium-temperature pyrolysis and crushing processes to recover metal fractions and high-value products from WPCB. This provides a solution for the large-scale pyrolysis of electronic waste.

- **Keywords:** Waste printed circuit boards; Pyrolysis; Gaseous product; Sustainable Recovery

Jian Meng, Wenke Xu, Fanyan Meng, Baoli Wang, Peidong Zhao, Zhigang Wang, Hong Ji, Yixin Yang. *Effects of waste cooking oil biodiesel addition on combustion, regulated and unregulated emission characteristics of common-rail diesel engine*. Pages 1094-1106.

The use of waste cooking oil biodiesel as diesel fuel is one of the essential measures to achieve global energy transition and sustainable development. This work aims to explore the influence mechanism of waste cooking oil biodiesel/diesel blended fuel on the

combustion and emission characteristics of a common-rail diesel engine. The effects of four fuel blending ratios (0%, 10%, 20%, and 30%) on engine combustion and emission characteristics under different operating conditions were investigated experimentally. The study results showed that adding biodiesel from waste cooking oil prolongs the combustion duration and is also beneficial for combustion at medium and high load conditions (50% and 75%). For the low load condition (25%), the emission concentration showed a decreasing trend with the increase of the blending ratio. In particular, the NOx and CH3CHO emissions increased, and the Soot emission was insensitive to the blending ratio. For medium and high load conditions, as the blending ratio increases, the emission concentration decreases. Moreover, the NOx emission increased slightly. Within the scope of the current work, the addition of waste cooking oil biodiesel improves the combustion and emissions characteristics of a common-rail diesel engine for both 50% and 70% load conditions.

- **Keywords:** Waste cooking oil biodiesel; Diesel engine; Combustion characteristic; Emission

Shaojie Liu, Huanpao Huang, Donghai Li, Bin Tian, Wenchao Xue, Li Sun, Min Zhu. *A hybrid receding horizon optimization and active disturbance rejection control of boiler superheated steam temperature*. Pages 1107-1118.

Efficient control of superheated steam temperature is critical for maintaining the safety and efficiency of a power plant boiler. Exceeding the safe temperature range can cause irreversible damage. However, unknown disturbances and uncertainties, as well as large delay dynamics, often make superheated steam temperature safety control challenging. To this end, this paper proposes a hybrid bi-level safety control for superheated steam temperature control in a power plant boiler. The bottom level uses active disturbance rejection control, while upper level uses receding horizon optimization. The proposed method combines the advantages of active disturbance rejection control in solving unknown disturbances and the dynamic optimization of receding horizon optimization to effectively and safely control superheated steam temperature and optimize the control system performance. The main novelty of the scheme lies in making receding horizon optimization independent of the model of the plant, in terms of making full use of the closed-loop desired dynamics under active disturbance rejection control. Practical synthesis design methods are also presented to illustrate the tuning and optimization of this control strategy. On-site testing results show that the proposed method improves both disturbance rejection and tracking performance, with improvements of at least 20 % over comparison methods. In conclusion, the proposed bi-level control strategy is a promising approach for improving the safety and efficiency of power plants.

- **Keywords:** Safety control; Superheated steam temperature; Disturbance/Uncertainty rejection; Delay processes; Receding horizon optimization; Active disturbance rejection control; Desired dynamics

Moslem Sharifishourabi, Ibrahim Dincer, Atef Mohany. *Performance and environmental impact assessments of a newly developed multigeneration system for sustainable communities*. Pages 1119-1129.

Substituting the use of fossil fuels with renewable energy is crucial for sustainable development, and developing these renewable energy-based solutions for multigenerational proposes to cover the communal needs is even more crucial. This particular article proposes a new renewable based multigeneration system that incorporates several subsystems, such as a solar system, a steam Rankine cycle, a Rankine cycle with reheat, a double effect absorption system, and an electrolyzer. The primary goal of this system is to efficiently and sustainably generate electricity, heating

and cooling loads as well as hydrogen. This study further focuses on conducting an environmental impact assessment, although it also includes analyses of energy, exergy, and their effects on the system's performance. The overall energy and exergy efficiencies of the system are determined to be 53.32 % and 48.28 %, respectively. In addition, the environmental assessment shows that the system can prevent the emission of 332.7 kg CO2/ MWh of electricity. These findings strongly indicate that the proposed multigeneration system is not only highly efficient but also environmentally friendly. Moreover, the results presented in this article emphasize on the importance of implementing a sustainable energy system in order to alleviate the impacts of climate change.

- **Keywords:** Multigeneration system; Energy efficiency; Exergy; Environmental impact assessment; Sustainable energy production; Renewable energy

Ali Mohammadi, Mohammad Haghighi, Maryam Shabani. *Degradation evolution of tetracycline-HCl/Fluoroquinolones and CO2 reduction over novel Z-scheme NCQDs-black NiO/Bi7O9I3 mesopores nanosheet heterojunction*. Pages 1130-1147.

The novel mesopores nanosheet Z-scheme NCQDs-BNiO/Bi7O9I3 (NCQDs: nitrogen doped carbon quantum dots & BNiO: black nickel oxide) heterojunction nanophotocatalyst has been synthesized by the facile sono-solvothermal method in order to remove antibiotic/fluoroquinolones and solid/liquid phase photocatalytic reduction of CO2 under the irradiation of simulated solar light. Several analyzes, have been performed to investigate the physical, chemical and optical properties of the synthesized photocatalysts. Raman analysis of NCQDs-BNiO/Bi7O9I3 sample shows the increase of structural defects which is the result of the presence of NCQDs in the structure of this sample. The characteristics of the pore volume, surface area and pore diameter of the optimal photocatalyst have been estimated at about 0.209 cm3/g, 44.6 m2/g and 18.8 nm, respectively. The UV–vis DRS analysis indicated the increase in optical absorption range and two absorption edges (373.7 and 526.4 nm). Pharmaceutical pollutants like tetracycline hydrochloride (TCH), ofloxacin, levofloxacin, and ciprofloxacin were removed by the photocatalytic degradation process in the order of 81.6%, 73.6%, 73.4% and 71.5%, respectively by NCQDs-BNiO/Bi7O9I3 photocatalyst which it can be asserted because of efficacious happening of surface reactions, facilitation of mass transfer and surface adsorption, which shows the key effect of the created structural model and the usage of ultrasound waves. At the end the photoreduction activity of the quintessential photocatalyst was evaluated which could produce 43.437 μmol/gcatalyst methanol after 8 h.

- **Keywords:** NCQDs-BNiO/Bi7O9I3; Mesopores Nanosheets; Z-scheme Nanophotocatalyst; Antibiotic Photocatalytic Removal; Photoreduction

Jiaquan Liu, Lei Hou, Sichen He, Xinru Zhang, Qiaoyan Yu, Kai Yang, Yu Li. *Two-dimensional explainability method for fault diagnosis of fluid machine*. Pages 1148-1160.

The safe operation of the fluid machine is greatly affected by fault states. With the development of data collection technology in process industrial systems, data-based methods are widely applied in fault diagnosis. The observed data of the fluid machine belongs to typical multivariable time series, so the Euclidean features related to the observed timestamps and the non-Euclidean features related to the observed variables need to be extracted simultaneously by the fault diagnosis method. However, the existing diagnostic studies do not involve the explainability analysis of the diagnostic process, which makes it hard to evaluate the contribution of these features to the accurate diagnosis. An explainable diagnosis model based on temporal and graph

convolutional neural network is proposed. The class activation map algorithm is improved to perform explainability analysis of the diagnosis process related to the observed variables and timestamps. Using the simulation data of the fluid machine, features related to observed variables and timestamps of six operating states are fully extracted. Through data experiments, this method can be utilized to achieve high-precision fault diagnosis, and can intuitively display the contribution of each observed variable and its each timestamp to network decision-making. This helps to trace system faults and has significant benefits for process safety assurance.

- **Keywords:** Fault diagnosis; Graph convolutional neural network; Explainability; Fluid machine

Tao Liu, Zhiqiang Shen, Yuexi Zhou, Jiane Zuo. *Enhancing crotonaldehyde biodegradation in petrochemical wastewater: Role of electron donors in microbial electron transfer systems*. Pages 1161-1169.

Crotonaldehyde is typical inhibitory compound of wastewater discharged in the petrochemical industry. To resolve the inhibition of crotonaldehyde on microorganism, electron donors (cellose, glucose and ethanol) were dosed to accelerate the biodegradation of crotonaldehyde by semi-continuous operation experiments. The results indicated that crotonyl alcohol was the most dominant biodegradable product of crotonaldehyde, and its conversion rates dosing ethanol, glucose and cellose as electron donors (2000 mgCOD/L) were 1.84, 1.46 and 1.21 times higher than that in control test when the initial concentrations of crotonaldehyde was 500 mg/L, respectively. Furthermore, the ethanol as electron donor was superior to cellose and glucose in relieving the inhibition of crotonaldehyde on the processes of acidogenesis, acetogenesis, and methanogenesis duo to the more electron release, faster electron transfer efficiency, less electron competition. Last, the enrichment of electro-active bacteria such as Syntrophobacter, Geobacter and the bacteria associated with reverse β-oxidation pathway (RBO) such as Clostridium_sensu_stricto_12 also proved that higher electron transfer system (ETS) activity was obtained in the reactor dosed ethanol as electron donor. This study suggests that dosing electron donors is an efficient strategy to accelerate the biodegradation of crotonaldehyde, and the results could be referred to pretreat wastewater containing aldehyde pollutants.

- **Keywords:** Crotonaldehyde; Biological detoxification; Electron donor; Electron transfer

Dengting Guo, Peng Jiang. *Process analysis and optimization of high-N2 natural gas liquefaction*. Pages 1170-1177.

The demand for natural gas (NG) is increasing rapidly due to the world energy crisis. Liquefied Natural Gas (LNG) technology is one of the most flexible and reliable supply solutions, which has already been a major research hotpot in energy use. However, NG with high-N2 content lowers the gas calorific value and value of the gas and increases the energy consumption for production and transport. To address this issue, this study established nitrogen removal from the NG process using a single-column cryogenic distillation process based on Aspen HYSYS® in this study. An expanding refrigeration process using N2-CH4 was selected to provide the required cold energy for this plant, and the process power consumption and LNG specific power consumption was used as evaluation indicators. Results from sensitivity analysis showed that by the increase of natural gas feed temperature T1, the distillation column operation pressure Pc, and refrigerant high pressure P3, the LNG specific power consumption also demonstrated an increasing trend. The variables of natural gas inlet pressure P1, the outlet temperature of natural gas from pre-cooler T2, the ratio of return RR, the methane content ZCH4, the temperature of refrigerant after pre-cooler T4 and refrigerant low pressure P5 had a

negative impact on the LNG specific power consumption. After conducting an optimization algorithm, the minimum LNG specific power consumption was determined to be 56.17 kJ/mol. Exergy analysis demonstrated that the total exergy destruction was 2076.13 kW. The compressor and expander components accounted for 31.57% and 26.29% of the total exergy losses respectively. This research provides valuable insights into optimizing LNG production processes by mitigating the impact of high nitrogen content, and it contributes to the advancement of LNG technology and energy efficiency in the industry.

- **Keywords:** Natural gas liquefaction; Expanding refrigeration; Sensitivity analysis; Optimization; Exergy loss distribution