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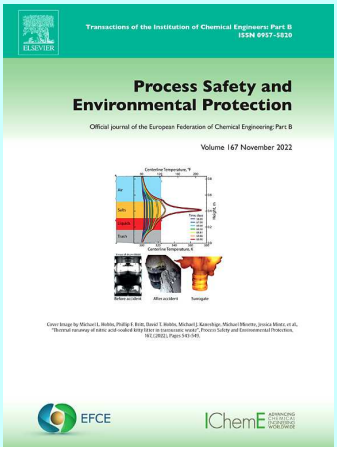

Gunavant Deshpande, Savyasachi Shrikhande, Dipesh S. Patle, Ashish N. Sawarkar. *Simultaneous optimization of economic, environmental and safety criteria for algal biodiesel process retrofitted using dividing wall column and multistage vapor recompression*. Pages 1-14.

The present study deals with the multiobjective optimization (MOO) of retrofitted in situ algal biodiesel process. Transesterification of the algal lipids is intensified using ultrasonication and catalyzed using the ionic liquid catalyst. Process includes the retrofitting of two conventional distillation columns into a dividing wall column (DWC), which is further intensified using multistage vapor recompression (DWC-MVR) in order to decrease the energy consumption and CO2 emission from the process. Excel based hybridised multiobjective differential evolutionary dynamic local search (HMODE-DLS) algorithm is used for the constrained MOO, whereas Aspen Plus is used for the process development. Break even cost (BEC), eco indicator (EI99) and individual risk (IR) are considered as objectives to evaluate economic, environmental impact, and safety of process, respectively. Initially, bi-objective case studies were analyzed and finally, all three objectives are studied in one case. Pareto optimal solutions obtained from HMODE-DLS algorithm are then ranked by the simple additive weighted method to find out the best solution. MOO resulted in the significant decrease in BEC (~20%), EI99 (~48%) and IR (~10%).

- **Keywords:** Multiobjective optimization; Microalgal biodiesel; In situ; Ultrasound assisted; Divided wall column; Multistage vapor recompression

Nan Liu, Minggang Hu, Ji Wang, Yujia Ren, Wende Tian. *Fault detection and diagnosis using Bayesian network model combining mechanism correlation analysis and process data: Application to unmonitored root cause variables type faults.* Pages 15-29.

Risks in chemical plants can generally be divided into Black Swan incidents and Gray Rhino incidents. Black Swan events are unexpected and have a significant impact. Frequently, a large number of Black Swan events cause a huge grey rhinoceros event

such as composition-related variables, which becomes a challenge for root cause diagnosis. To alleviate this problem, a strong relevant mechanism Bayesian network (SRMBN) combining mechanism correlation analysis and process state transition is proposed for fault detection and diagnosis. First, a strong relevant mechanism structure of SRMBN is constructed by combining process mechanism analysis with historical data mining for structure learning. Then SRMBN is built after conducting variable state transition and maximum likelihood estimation for parameter learning. For fault detection, a process state based Bayesian interval estimated index is developed by state transformation. Finally, Bayesian contribution index is defined to measure the contribution of each variable to the process state deviation for fault diagnosis. The variables with large index values are added as deterministic evidence to the SRMBN to update the posterior probabilities of nodes for fault propagation inference. The proposed method is applied to faults 2 and 8 (unmonitored type faults) of the Tennessee Eastman (TE) process in comparison with some other published methods. The results show its practicability and satisfactory performance in recognizing the fault propagation pathways and the root causes of faults. Meanwhile, it can provide reliability analysis for process safety and risk assessment.

- **Keywords:** Mechanism correlation analysis; Bayesian network; Process monitoring; Fault diagnosis

Yangtao Wu, Xiaofang Luo, Guangchao Li, Shiqing Zhou. *Effect of chlorine dioxide pre-oxidation on algal non-protein amino acid degradation and DBPs formation during subsequent chlor(am)ination*. Pages 30-37.

As a neurotoxin produced by cyanobacteria, 2,4-diaminobutyric acid (DAB) posed a significant threat to human health and served as an important precursor to disinfection by-products (DBPs). In this study, ClO2 showed the highest DAB oxidation efficiency among the four oxidants, in the order of ClO2 (86%) > HOCl (80%) > KMnO4 (20%) > NH2Cl (13%). The increase of ClO2 dosage (from 0.06 to 1.4 mg L-1) not only increased the oxidation efficiency of DAB, but also decreased the formation of DBPs after ClO2 pre-oxidation during post-chlorination, but the DBPs formation varied during post-chloramination. The enhanced formation of dichloroacetic acid (DCAA) and dichloroacetonitrile (DCAN) should be of concern when ClO2 pre-oxidation was performed at pH 7.0. In the presence of Br−, the overall concentration of formed THMs and brominated species increased. ClO2 pre-oxidation of β-N-methylamino-l-alanine (BMAA), alanine, leucine, and serine followed by post-chloramination has advantages over post-chlorination in controlling the overall and individual DBPs concentration. A possible degradation pathway and reaction schemes during ClO2 pre-oxidation of DAB were proposed. ClO2 pre-oxidation followed by post-chloramination could be an effective treatment process in the abatement of both DAB and toxicity. Results of this study about DAB oxidation and DBP formation contributed to the guidance of ClO2 pre-oxidation in the water treatment plants to cope with cyanobacterial blooms.

- **Keywords:** 2,4-diaminobutyric acid (DAB); ClO2 pre-oxidation; Disinfection by-products; Post-chlor(am)ination; Pathway; Toxicity

Jianguo Feng, Zhiguang Chen, Cong Wu, Chaokui Qin, Xianshun Wei. *Corrosion mechanism and damage characteristic of Q235B steel under the effect of stray current in NS4 simulated soil solution*. Pages 38-49.

Dynamic direct current (DC) may cause severe electrochemical corrosion on buried steel pipelines near urban rail transits. In this paper, the corrosion behavior of Q235B steel under dynamic DC interference was carried out in NS4 simulated soil solution (NS4 solution) including potassium chloride (KCl), sodium bicarbonate (NaHCO3), calcium

chloride (CaCl2), Magnesium sulfate heptahydrate (MgSO4.7 H2O) and deionized water. The electrochemical corrosion behaviors of Q235B steel in NS4 solution were studied by means of potentiodynamic polarization (Tafel curve) and electrochemical impedance spectroscopy (EIS) techniques. Dynamic DC was simulated by four types of applied current according to the leakage current rule of rail trains arriving at and departing from the platform. The results of Tafel curves showed that Q235B steel exhibits a decrease in corrosion resistance with increasing applied current density, and anodic reaction exhibited active dissolution controlled by charge transfer. EIS results indicated that Nyquist plots of samples included double capacitive arcs and exhibited Warburg impedance characteristics caused by the concentration gradient. Weightlessness measurement showed that the average corrosion rates of four types of samples were 1.0, 1.4, 2.0, and 2.5 g.cm−2. d−1, respectively. In addition, the corrosion morphology indicated that samples featured in pitting corrosion, which was correlated to applied dynamic DC values and counts, and corrosion products were Fe3O4 and Fe (OH)3. Finally, the study shows that corrosion of buried steel pipelines is related to rail train arriving types and counts.

- **Keywords:** Dynamic direct current; Q235B steel; NS4 solution; Pipeline corrosion; Rail transits

Artem E. Elyanov, Andrei I. Gavrikov, Victor V. Golub, Anton Yu Mikushkin, Vladislav V. Volodin. *Propagation dynamics uncertainty analysis of a premixed laminar unstable hydrogen-air flame*. Pages 50-56.

The risks and destruction assessment of gas explosions is based on the potential burning rates and pressure impulses. Such issues should be considered in designing any infrastructure for using or producing hydrogen or having a gas outburst possibility due to the hydrogen high flammability and explosive hazards. An experimental and theoretical study of the propagation dynamics uncertainty in premixed laminar unstable hydrogen-air flames is presented and its statistical analysis was performed. The main objective of this work was to quantify the potential velocities of the hydrogen-air flame front propagation. Experiments were repeated up to 30 times in the mixtures with a hydrogen content of 10–60 vol.%. Based on the hydrogen content in the mixture data scattering was estimated. Some confirming results were obtained using the numerical integration of the Sivashinsky equation of flame propagation. The obtained results could update the Rules, Guidelines, Codes and Standards of Hydrogen Safety.

- **Keywords:** Hydrogen flame; Flame speed uncertainty; Unstable spherical flame; Sivashinsky equation; Spherically expanding flame

Boqiang Lin, Yicheng Zhou. *Understanding the institutional logic of urban environmental pollution in China: Evidence from fiscal autonomy*. Pages 57-66.

Fiscal decentralization is considered to be an important factor affecting government environmental governance, but the relationship between fiscal autonomy and environmental pollution has not been systematically explained. This study explores the institutional logic of urban environmental pollution from the perspective of fiscal autonomy in China. Based on systematically sorting out the influence mechanisms of fiscal autonomy on environmental pollution, the panel data of Chinese cities are used for the empirical test. The results show that urban fiscal autonomy directly leads to pollution emissions and indirectly increases environmental pollution by restraining the industrial structure upgrading and green technological innovation. Meanwhile, the impact of fiscal autonomy on environmental pollution varies with geographical location, administrative status and comprehensive strength. When faced with more significant economic growth

target, fiscal autonomy may be transformed into motivation and ability to the environmental pollution. It can be seen that the development targets affect the fiscal behavior of local governments. In sum, our findings are helpful to understand the relationship between local government behavior and environmental protection under the framework of fiscal decentralization, and provide policy implications for promoting energy conservation and emission reduction.

- **Keywords:** Fiscal autonomy; Economic growth target; Environmental pollution; Institutional logic; China

Xie Xuecai, Shen Shifei, Fu Gui, Shu Xueming, Hu Jun, Jia Qingsong, Shi Zhao. *Accident case data-accident cause model hybrid-driven coal and gas outburst accident analysis: Evidence from 84 accidents in China during 2008–2018*. Pages 67-90.

Coal and gas outbursts are severe accidents that can occur in coal mines. Half of coal and gas outburst accidents have occurred in China. Previous studies on coal and gas outburst accidents have focused on the mechanisms that result in accidents, gas extraction, accident prediction, and early warning. However, accidents involving coal and gas outbursts result from the combined effects of multiple factors. However, a systematic analysis of coal and gas outburst accidents is still lacking. In this study, 84 coal and gas outburst accidents occurred in China from 2008 to 2018 were used as a sample. The 24Model was used as the accident analysis theory, and the accident case data-driven method was used to analyse the causes of coal and gas outburst accidents. In particular, the reasons for behaviour were systematically studied. The following can be inferred from analysis: (1) The causes of unsafe conditions are primarily reflected in three aspects. (i) Gas factor. Coal mines with high gas content and pressure remain the focus of outburst prevention. (ii) Coal factors. The occurrence of coal and gas outburst accidents has no strictly positive correlation with the depth of a coal seam. 50% of coal and gas outburst accidents occur in medium-thick coal seams. (iii) Geological structural factors. Ground stress (30.95%), coal thickness change (22.62%), and faults (22.62%) are the most frequently occurring geological structural factors in outburst accidents. (2) The reasons for unsafe acts are primarily reflected in 151 unsafe acts, 17 key basic unsafe acts, nine key categories unsafe acts, and four key stages. The personnel and proportion of these unsafe acts are senior leaders (53.55%), middle managers (31.56%), and front-line miners (14.89%). (3) Reasons for individual safety capabilities. Insufficient safety knowledge is manifested in seven aspects, including insufficient anti-outburst knowledge. The performance and proportion of poor safety awareness are safety system awareness (60.66%), safety risk awareness (20.49%), and safety responsibility awareness (18.85%). From 151 unsafe acts, 90 habitual violations acts that caused coal and gas outburst accidents were categorised. The performance and proportion of poor safety psychology were fluke psychology (40.85%), adventure psychology (23.36%), convenient psychology (20.22%), and paralysis psychology (15.57%). (4) The deficiencies of the safety management system are reflected in the failure to comply with the safety policy, imperfect safety management organization structure, lack of professional and technical personnel, and lack of 29 safety procedures in seven systems. (5) The lack of safety culture is primarily reflected in 22 safety culture elements. Among these, there are 19 elements had a frequency of ≥ 50%. The systematic analysis of coal and gas outburst accidents conducted in this study can reveal the causes of such accidents more comprehensively and provide a reference and basis for both safety training and management.

- **Keywords:** Coal and gas outburst; Accidents analysis; Accident case data-driven; Accident cause model; 24Model; Human factors

James O'Connor, Nanthi S. Bolan, Manish Kumar, Ashis Sutradhar Nitai, Mohammad Boshir Ahmed, Shiv S. Bolan, Meththika Vithanage, Jörg Rinklebe, Raj Mukhopadhyay, Prashant Srivastava, Binoy Sarkar, Amit Bhatnagar, Hailong Wang, Kadambot H.M. Siddique, M.B. Kirkham. *Distribution, transformation and remediation of poly- and per-fluoroalkyl substances (PFAS) in wastewater sources*. Pages 91-108.

Poly- and perfluoroalkyl substances (PFAS) are synthetic chemicals, which reach terrestrial and aquatic environments through anthropogenic activities. Major sources of PFAS in the environment include fire-fighting foams (aqueous film forming foam (AFFF)), wastewater sources, biosolids, and composts. Limited information is available about PFAS in wastewater, which is the focus of this review. PFAS wastewater sources include domestic effluents, industrial effluents, landfill leachates, stormwater, and agricultural effluents through their use in various applications. Land application of PFAS-contaminated wastewater can lead to the contamination of soil and groundwater, thereby reaching the food chain through plant uptake and consumption of potable water. Landfill leachates and industrial effluents contain the highest concentrations of PFAS, posing serious risks to surrounding waterways. Transformation of PFAS precursors can occur through abiotic and biotic processes within the treatment of wastewater, resulting in the formation of harmful PFAS compounds. Currently, there is limited data reported on novel short-chain and ultra-short chain PFAS and PFAS precursors. The strong thermal and chemical stability of PFAS and the complex nature of PFAS mixtures makes the remediation of PFAS in wastewater challenging. However, the review examines and compares current technologies which can treat and remove PFAS from wastewaters. In this review, the distribution, transformation, and remediation of PFAS and their substitutes in wastewater sources are covered.

- **Keywords:** PFAS; Wastewater; Effluent; Sources; Transformation; Remediation

Yang Chen, Chudong Tong, Ting Lan. *Fault monitoring for chemical processes using neighborhood embedding discriminative analysis*. Pages 109-118.

The importance of chemical process safety and the availability of abundant samples keep popularizing the wider application of data-driven fault monitoring techniques. With a goal of efficiently discovering the inconsistency between the online monitored sample and the normal samples, a novel fault monitoring algorithm called neighborhood embedding discriminative analysis (NEDA) is proposed, which can adaptively provide different latent feature generating mechanisms for different monitored samples so that the inherited inconsistency could be uncovered in a timely manner. Instead of extracting representative features from a dataset only given from the normal operating condition, the objective function designed for the NEDA algorithm additionally takes the online monitoring sample into account, and then timely generates but only one projecting vector to point out the specific inconsistency for the corresponding monitored sample. The NEDA algorithm aims to figure out a discriminative projection so that the neighborhood embedding error (NEE) corresponding to the online monitored sample could be maximized, while the NEE associated with the normal samples is minimized. Furthermore, the corresponding NEE for the monitored sample of current interest is employed as the indicator for fault monitoring purposes. As demonstrated through comparisons, the salient performance achieved by the proposed NEDA-based fault monitoring method in monitoring static as well as dynamic processes can be always guaranteed.

- **Keywords:** Fault monitoring; Feature extraction; Neighborhood embedding; Discriminative analysis

C. Saf, M. Villain-Gambier, M. Belaqziz, I. Ziegler-Devin, D. Trebouet, N. Ouazzani. *Fouling control investigation by pH optimization during olive mill wastewater ultrafiltration*. Pages 119-128.

In recent years, the study of membrane processes for recovery of valuable phenolic compounds from olive mill wastewater (OMW) has been intensified. The selected OMW pH for ultrafiltration is one of the variables affecting membrane productivity, selectivity and fouling. An in-depth characterization of fouling was performed for the 150 kDa ceramic tubular membrane selected. At the three tested pH (2, 6 and 9), a high retention of suspended matter of 98% was associated to a low retention of phenolic compounds (1%). At pH 2, a volume reduction of only 15% was reached with a low permeate flux of 15 L.h-1.m-2. Adsorption phenomena due to the formation of a compact gel layer of pectin highly mineralized have caused severe membrane fouling. The productivity at pH 6 and 9 were quite similar with initial permeate flux of 160 L.h-1.m-2 and a final reached volume reduction of 80%. As a fractionation of around 25% of carbohydrate content was measured at pH 6, this specific pH seems to be more relevant than pH 9 where only 7% were retained. Furthermore ultrafiltration of OMW at pH 6 was associated with a removable fouling mainly caused by a gel of pectin and suspended matter agglomerates.

- **Keywords:** Fouling characterization; Olive mill wastewater; Pectins; PH; Ultrafiltration

Jian Wang, Guilong Liu, Ligang Zheng, Rongkun Pan, Chang Lu, Yan Wang, Ziyao Fan, Yongxian Zhao. *Effect of opening blockage ratio on the characteristics of methane/air explosion suppressed by porous media*. Pages 129-141.

Gas explosion is a common serious accident in underground coal mines and industrial production processes. Porous media, due to its special cellular structure, has a significant effect on stopping the propagation of pressure and flame, which can effectively reduce the explosion hazard. In this study, the explosion suppression effect of Fe-Ni and Cu foams with different pore sizes (20 and 40 holes pores per inch (ppi)) was experimentally investigated and comparatively analyzed at opening blockage ratios (OBR) equal to 0.36, 0.64 and 0.84, respectively. The results demonstrate that Fe-Ni foam with 20ppi quenches the flame only under the OBR of 0.84, which indicates that the larger the OBR is, the better the explosion suppression effect is. However, under the OBR of 0.64, the porous media achieve an enhanced quenching efficiency and the shortest quenching time. In addition, when the vent area is relatively large, the obstacle effect of porous media is stronger than its pressure absorption capacity, thus leading to an increased pressure in the explosion area. The lowest peak overpressure attenuation rate, − 25.9%, is observed for 40ppi Fe-Ni foam under the OBR of 0.36. In general, the OBR is positively correlated with the depressurization capacity. Among all the cases used in this study, the 20ppi Cu foam boasts the highest upstream and downstream peak overpressure attenuation rates under three OBRs, 0.86%, and 6.33%, respectively.

- **Keywords:** Vented explosion; Distorted tulips; Quench; Overpressure; Explosion suppression

Ukrit Suksanguan, Thanapong Champahom, Sajjakaj Jomnonkwao, Chamroeun Se, Vatanavongs Ratanavaraha. *Predicting the selection of industrial waste disposal service in cement kiln using a random parameters approach with heterogeneity in means and variances*. Pages 142-153.

Industrial waste disposal is conducted by coprocessing in the cement kiln. This process can save resources and dispose of industrial waste in a way that is beneficial to the

environment by using renewable energy and being a viable alternative to the cement industry in several countries. Nowadays, there is competition among industrial waste processors due to their increasing numbers. Therefore, this study aimed to investigate the significant factors related to forecasting the selection of industrial waste disposal services in cement kilns by developing random parameters with heterogeneity in means and variances. To our knowledge, there are no studies analyzing the selection of industrial waste disposal in coprocessing. Thus, this analysis is a novel approach, able to reduce the least bias and incorrect inference that may lead to operation on effective dealing measures to explain individual relationships based on the differences of several customers. The questionnaires were completed by the customers. According to our findings, a statistically significant factor that customers considered was the image of industrial waste disposal processors by coprocessing in cement kiln, and factors of distances from the waste processors had a significant role in customer decision, whereas the logistics job position may choose the service due to the E-license convenience. The limitation of the study is findings in Thailand. Coprocessing in other countries can use the research results and incorporate them into their strategic business plan in the future to ensure the sustainability of their service by coprocessing cement kilns.

- **Keywords:** Coprocessing; Strategic management; Environment; Waste to energy; Alternative fuel

Pang-Che Liu, Anabella C. Vilando, Ming-Chun Lu. *Treatment of synthetic zinc and nickel wastewater and identification of its crystallization products by fluidized bed homogeneous crystallization technology*. Pages 154-163.

Heavy metals such as zinc and nickel can be found in wastewater from steel electroplating trace concentrations. These heavy metals harm the ecosystem and human health, which must be addressed. This study aimed to use fluidized bed homogeneous crystallization process (FBHCP) to recover nickel-zinc crystal from simulated electroplating wastewater. The best-operating conditions include a 10.2 initial pH of the crystallization reagent, variable nickel ion concentrations of 200 – 500 mg·L−1, and variable zinc ion concentrations of 100 – 400 mg·L−1. The nickel-zinc solution has a starting concentration of 300 mg L−1 of both nickel ions and zinc ions and a 1.75 molar ratio (MR) of [CO32-]/[Ni2++Zn2+]. The highest removal rate for zinc was 99.6 %, and for nickel was 88.7 %. According to SEM morphology, the crystals generated have a high-density smooth crystal with pores. According to XRD analysis, the crystals generated were layered hydroxide salts (LHS) of nickel-zinc with the structural formula. FBHCP was employed to successfully recover NiZn – LHS crystals from simulated wastewaters, which can now be utilized for future adsorption applications.

- **Keywords:** Electroplating wastewater; Layered hydroxide salts; Zinc-nickel alloy; Green technology; Homogeneous crystallization

Yan Cao, Sameer Alsharif, El-Awady ATTIA, Mohamed A. Shamseldin, Banar Fareed Ibrahim. *A conceptual process design towards CO2 emission reduction by integration of solar-based hydrogen production and injection into biomass-derived solid oxide fuel cell*. Pages 164-176.

Integration of biomass gasification with Solid Oxide Fuel Cell (SOFC) is a promising technology, particularly for small scale decentralized power systems. In this paper, to reduce the CO2 emission and biomass consumption of this system, it is incorporated with solar-based hydrogen production. The produced hydrogen is injected into the biomass gasification-SOFC system, proposing two different configurations. In the first configuration, the hydrogen is injected into the anode inlet (to provide a hydrogen rich fuel), while in the second proposed configuration it is injected into the afterburner of the

SOFC (to increase the gas turbine inlet temperature). The two proposed configurations are comprehensively assessed and compared from thermodynamic, environmental and economic standpoints. In thermoeconomic analysis, the negative environmental damage costs of CO2 emission, as the primary greenhouse gas, is taken into account. Also, a parametric study is conducted to ascertain the major design variables after which tri-objective optimization is performed based on CO2 emission, levelized cost of electricity and exergy efficiency. The results indicated superior performance for the system with hydrogen injection into the anode compared to the injection into the afterburner. The former configuration has 20.6% higher exergy efficiency with 23.2% lower emission and 14.0% lower levelized electricity cost. For this configuration under the optimum operation, the exergy efficiency, CO2 emission and electricity cost are found to be 24.85%, 0.257 kg/kWh and 0.0911 $/kWh, respectively.

- **Keywords:** Biomass; Solid oxide fuel cell; Photovoltaic-thermal; Hydrogen production; Thermoeconomic; Tri-objective optimization

Daswara Djajasasmita, Sutrisno, Alfathah Bania Lubis, Iwan Darmawan Ma'mur, Danurrendra, Siska Telly Pratiwi, Ferry Rusgiyarto, Febrianto Adi Nugroho, Putu Teta Prihartini Aryanti. *High-efficiency contaminant removal from hospital wastewater by integrated electrocoagulation-membrane process.* Pages 177-188.

In this work, high removal of contaminants in hospital wastewater has been achieved using an integration of electrocoagulation (EC) with ultrafiltration (UF) and reverse osmosis (RO). In EC system, Al electrodes were arranged in a monopolar-parallel and bipolar configuration. There are two parameters studied in the EC system, i.e., the configuration of electrodes (2A-2C-2B and 4A-2C-2B) and current densities. The EC-UF system with a configuration of 4A-2 C-2B and a current density of 88.5 A.m−2 resulted in high removal of TSS, TDS, BOD, and COD by 95.12 %, 97.53 %, 95.18 %, and 97.88 %, respectively. The effluent quality of the EC-UF was improved by substituting UF with RO membrane. The TSS, TDS, BOD, and COD removal were enhanced to 97.64 %, 99.85 %, 97.88 %, and 98.38 %, respectively. The permeate flux decline in UF membrane system was 47.83 % during 60 min of filtration time due to cake layer fouling on the membrane surface, while in the RO membrane system was 29.49 %. Since the EC-UF and EC-RO showed high efficiency in contaminants removal, these configurations could be used as clean technology to produce clean water for water reuse purposes. At a wastewater capacity of 5 m3.day−1, the operating cost for the EC-UF system was 3.92 US$.m−3, while the EC-RO system was 4.02 US$.m−3. The increase of wastewater capacity to 50 m3.day−1 reduced the operating cost to 0.89 US$.m−3 for the EC-UF system and 0.93 US$.m−3 for the EC-RO system.

- **Keywords:** Clean technology; Electrocoagulation; Hospital wastewater; Ultrafiltration; Reuse water

Hua Guo, Wenyu Hu, Zhicheng Xu, Siyuan Guo, Dan Qiao, Xue Wang, Hao Xu, Wei Yan. *How to improve lead dioxide anodes performance in organic wastewater treatment: Review and prospect*. Pages 189-207.

Lead dioxide (PbO2) is a common anode for wastewater treatment in electrochemical oxidation studies thanks to its high oxygen evolution potential, great hydroxyl radical productivity, and low cost. There has been much research focusing on PbO2 preparation and application from different perspectives in recent years. In this paper, with "PbO2 degradation performance optimization" as the clue, electrode modification strategy and operation condition are systematically reviewed, together with the standard evaluation indexes of electrical and electrochemical properties for PbO2. The electrodeposition processes can be divided into substrate and interlayer selection, electrodeposition bath

adjustment, energy input modulation and new configuration introduction, impacting the catalytic activity and stability. Organic pollutants degradation is a significant application aspect of PbO2. Four major influence factors in the electrochemical degradation process are discussed, including external circuit control, co-existing ions, solution physicochemical properties and reactor configuration. Other couplings and combination technologies are introduced based on electrochemical oxidation with PbO2 anode. Further, the future research directions of PbO2 anode in wastewater treatment are forecasted.

- **Keywords:** PbO2; Anodic electrodeposition; Modification; Electrochemical oxidation; Coupling techniques; Real wastewater

Lei Dong, Li Lin, Jia He, Xiong Pan, Xue Wu, Yan Yang, Zheng Jing, Sheng Zhang, Guochuan Yin. *PAHs in the surface water and sediments of the middle and lower reaches of the Han River, China: Occurrence, source, and probabilistic risk assessment*. Pages 208-218.

Polycyclic aromatic hydrocarbons (PAHs) pose versatile risks to the environment and human health. However, studies on their occurrences, spatial distributions, seasonal variations, possible sources and potential risks of the Han River are still not clear. In this study, 16 PAHs were investigated in the surface water and sediments from 15 sampling sites of the Middle and Lower Reaches of the Han River during the dry, normal, and flood seasons. It was found that the sum concentration of PAHs (ΣPAHs) determined by GC-MS ranged from 18.3 to 146.8 ng/L (mean 77.4 ng/L) in surface water, while it was 137.1–1478.4 ng/g (mean 679.6 ng/g) in sediments. The two to three rings PAHs in surfer water and four-five-ring in sediments PAHs comprised the majority of the detected compounds. The level of PAHs in dry season was higher than that in the flood and normal seasons, and the distributions of PAHs varied substantially along the river without clear trend in surface water and sediments. The sources of PAHs in surface water and sediments were mainly from biomass and coal combustion, followed by petroleum combustion. The human health risk of PAHs were evaluated using the risk entropy method of Kalf in surface water, and the mean effects range-median quotient method in sediments, respectively. Overall, the potential health risks caused by PAHs are still acceptable with special concerns about certain specific issues.

- **Keywords:** Polycyclic aromatic hydrocarbons; Han River; Seasonal variation; Health risk

Pei Yiru, Wu Yichun, Wang Fanyu, Xu Yong, Xiao Anhong, Li Jian, Zhou Junyi. *Safety analysis of signal quality bits in nuclear power plant distributed control systems based on system-theoretic process analysis method*. Pages 219-227.

As a part of self-diagnosis functions, the instrumentation signal quality bit (SQB) is widely introduced in engineering applications, especially in nuclear power plant (NPP) distributed control systems (DCSs). However, the introduction of SQB significantly increases the DCS software complexity and may potentially be unsafe against its design intention. To reduce unscheduled shutdown accidents caused by potential unsafety, it is necessary to conduct a systematic safety analysis on the SQB. Therefore, this paper selects a CPR1000 NPP unscheduled shutdown accident as the research object to abstractly model and reproduce. The system-theoretic process analysis method is applied to analyze the SQBs involved in the unscheduled shutdown accident, which provides a way to identify the behavior of the system components, the interactions between them, and the safety constraints from the perspective of the whole NPP. Therefore, the weaknesses and potential factors affecting safe NPP operation are located, and countermeasures can be proposed. The safety analysis process can inform the

identification of potentially unsafe scenarios and complement the verification and validation of the DCS software. Finally, the NPP economy should be improved while maintaining its reliable and safe operation.

- **Keywords:** Nuclear power plant; Distributed control system; Signal quality bit; System-theoretic process analysis

Mehdi Mehrpooya, Mehran Saedi, Ali Allahyarzadeh, Seyed Ali Mousavi, Azad Jarrahian. *Conceptual design and performance evaluation of a novel cryogenic integrated process for extraction of neon and production of liquid hydrogen*. Pages 228-246.

Novel integration of a hydrogen liquefaction process and cryogenic rectification of air is presented. The thermodynamics analysis including the 2nd Law and sensitivity analysis regarding this process are conducted. The proposed cryogenic process can produce 111.3 kg/s of nitrogen and 42 kg/s of oxygen with argon. In addition, this process produces more than 132 × 103 tons of liquid hydrogen and 751 tons of crude neon per year. Moreover, as the number of the used compressor is very fewer than of the conventional process, the required power consumption of the proposed cryogenic plant is almost low. Based on the exergy analysis, using expanders, providing the requested refrigeration condition by solar heat exchangers and proper streams, and integrating two processes with the similar operating condition, the exergetic efficiency of the cycle is more than 70 %. The sensitivity analysis of operating parameters such as pressure, temperature, reflux ratio, and the number of stages of column presents their the importance of them on the recovered neon, oxygen, and nitrogen. Moreover, the production of cryogenic liquids is more sensitive to operating pressure and temperature than the reflux ratio and the number of stages.

- **Keywords:** Integration cryogenic; Hydrogen liquefaction; Hybrid energy system; Renewable energy; Crude neon

Baozhu Pan, Xu Han, Yue Chen, Lixin Wang, Xing Zheng. *Determination of key parameters in water quality monitoring of the most sediment-laden Yellow River based on water quality index*. Pages 249-259.

Water quality management of sediment-laden rivers is a challenging issue for global water security because sediment is a major carrier for the migration and transformation of biogenic elements and pollutants in river systems. A water quality index (WQI) based on multiple parameters is widely used when making water quality assessments. To reduce the analytical costs and time required for multi-parameter measurements, many minimum WQI (WQImin) models that rely on fewer key parameters are now being developed for river systems. However, no systematic study of WQImin has been conducted yet in sediment-laden rivers, such as China's Yellow River which has the highest sediment concentration worldwide. This study assessed the spatiotemporal variation in water quality of the Yellow River's main channel in the spring and autumn of 2019. The WQI was calculated based on 15 water parameters determined at 44 sampling points from 26 river sections and six reservoirs. A heavy metal evaluation index (HEI) was used to gauge the pollution level of eight heavy metals. Despite no distinct seasonal variation, the WQI values decreased from the Yellow River's source region to its estuary, and higher values were observed in most reservoirs than in adjacent natural river sections. Values for WQI (>50) were mainly classified as being at "good" and "moderate" water quality levels, while the HEI values (<10) indicated a low pollution level. Four weighted and four non-weighted WQImin models were developed using stepwise regression. A model consisting of six parameters—total suspended solids, ammonia-nitrogen, permanganate index, electrical conductivity, dissolved oxygen, and nitrate-nitrogen—had the best modeling performance. Both the prediction accuracy and

goodness-of-fit of the WQImin model were improved after adding parameter weights. Our study provides support data for water resource management in the Yellow River Basin, and contributes to the development of a robust WQImin in sediment-laden rivers.

- **Keywords:** Sediment-laden rivers; Water quality; Heavy metal pollution; WQImin; Yellow River

Yingmu Wang, Shi Chen, Jian Zhou, Lei He, Xing Fan, Jun Yang, Gongduan Fan. *Start-up and microbial mechanisms of low-voltage electrochemically integrated constructed wetlands: Effect of inoculated source*. Pages 260-270.

Nitrogen (N) and phosphorus (P) species in wastewater treatment plants (WWTPs) effluents are important sources of nutrient input to water bodies, resulting in deteriorated eutrophication. The combination of electrochemical technology and constructed wetland provides emerging prospects for tertiary treatment of WWTPs effluents. In this work, three bench-scale electrochemically integrated vertical flow constructed wetlands (E-VFCWs) were established in parallel with different inoculated sources. Among them, the E-VFCW inoculated with anaerobic sludge (AN) of a swine wastewater treatment plant exhibited significantly shorter start-up period (9 d), followed by anoxic sludge (A) from a municipal WWTP (18 d), and no inoculum (NI) exhibited the longest start-up duration (30 d). In addition, AN group allowed the highest removal efficiencies (NO3--N (97.0 ± 1.6 %), TN (83.3 ± 4.6 %), and PO43--P (93.3 ± 3.3 %)) in tertiary wastewater treatment, and lower concentrations of SO42--S and total Fe in effluents. Results of microbial structure and Tax4Fun suggested that multi-path metabolisms including H2-, Fe(II)-, and FemSn-dependent denitrification might facilitate NO3--N reduction in E-VFCWs. The microbial mechanisms that AN exhibited the highest denitrification efficiency in the E-VFCWs may include the highest bacterial copies number and the more abundant denitrifying genes. Moreover, it should be noted that electron transfers mediated by sulfur (S) cycle might significantly enhance NO3--N reduction in E-VFCWs, especially in AN group. To conclude, the study offers new microbial insights into N conversion and S cycling patterns in electrochemically integrated systems in response to inoculated source.

- **Keywords:** Electrochemically integrated constructed wetland; Tertiary treatment; Inoculated source; Microbial community structure; Multi-path denitrification

Tengfei Chen, Jo Van Caneghem, Jan Degrève, Filip Verplaetsen, Jan Berghmans, Maarten Vanierschot. *A numerical model for the calculation of the minimum ignition energy of pure and mixture dust clouds*. Pages 271-282.

A numerical model is developed for the minimum ignition energy (MIE) calculation of pure and mixture dust clouds, considering the influence of particle size distribution. The original particle number based size distribution is approximated with median sizes (number d50) of the subdivisions obtained by dividing the original distribution range. The MIE is calculated for 5 pure dusts, 2 mixtures of combustible dusts and 2 mixtures of combustible & inert dusts. For pure dust clouds, as the number of subdivisions and hence d50s increases, variation trend of the MIE as a function of dust concentration (MIE(conc)) gradually shifts from a "V" to a "U" or "bathtub" shape, along with an increase in the concentration where the dust cloud MIE (minimum MIE(conc) value) is reached. Furthermore, the calculated MIE fluctuates at lower number of d50s but gradually stabilizes as the d50 number further increases. The calculated MIE variation trends correspond well with the experimental data. However, due to uncertainties in the dust cloud formation and spark release in the experimental tests, differences in the definitions of the d50 in different studies and high idealization of the numerical model, there are deviations between the absolute experimental and calculated MIE values.

- **Keywords:** Minimum ignition energy; Dust clouds; Dust mixtures; Theoretical model

Qiangling Duan, Qian Zeng, Kaiqiang Jin, Qingsong Wang, Jinhua Sun. *Mechanism of self-ignition and flame propagation during high-pressure hydrogen release through a rectangular tube*. Pages 283-290.

The dynamic mechanisms of self-ignition and flame propagation during high-pressure hydrogen release through a rectangular tube were experimentally investigated using pressure records, flame detection and high-speed photographs. Experimental results show that the minimum burst pressure for self-ignition decreases with an increase in axial distance to the diaphragm and then remains at an almost constant value. The self-ignition onset at the same location of the tube exhibits a certain randomness even if the intensity of the shock wave produced in the tube is similar. Multiple ignitions were observed at the early stage of hydrogen release. They usually had difficulty to sustainably develop and were extinguished owing to oxygen deficiency. At a subsequent stage, the ignition kernel appears again and grows rapidly in the axial and radial directions, finally converging to a complete flame across the tube width. It was found that the radial growth rate of the flame was lower than the axial growth rate.

- **Keywords:** High-pressure hydrogen; Self-ignition; Flame propagation; Rectangular tube

Yufa Wu, Enle Xu, Xu Liu, Zhenyong Miao, Xiaofeng Jiang, Yongzhi Han. *Flotation and separation of microplastics from the eye-glass polishing wastewater using sec-octyl alcohol and diesel oil*. Pages 291-298.

The eye-glass polishing wastewater (EGPW) is an increasingly noteworthy problem because of its high chemical oxygen demand (COD), high turbidity and abundant microplastics (MPs), which threatens the aquatic environment as well as human life. In this study, we analyzed the separation performance of MPs from EGPW using sec-octyl alcohol and diesel oil as frother and collector, respectively. The experimental results demonstrated that the removal rate of MPs, COD and turbidity could reach to 93.9 %, 80.4 %, 83.8 %, respectively. The measurement of induction time, Fourier-transform infrared and X-ray photoelectron spectroscopy were measured to explain flotation mechanism of MPs. Sec-octyl alcohol has little effect on the functional groups of MPs and it mainly reduces the surface tension of gas-liquid interface and improves the stability of bubble. Diesel oil increases the C-C/C-H content of MPs, illustrating that it could absorb on the surface of MPs and improve the hydrophobicity of MPs. The induction time decreases with the increasing dosage of both sec-octyl alcohol and diesel oil, thus improving the separation rate of MPs from the EGPW. These results indicate that bubble flotation exhibits great potential to effectively remove MPs and purify the EGPW, anticipating to facilitate the municipal wastewater management.

- **Keywords:** Microplastics; Eye-glass polishing wastewater; Flotation; Induction time; Separation

Hiba Saadaoui, Faten Boujelbane, Manh Bui Ha, Nadia Mzoughi. *Performance and degradation pathways of bromuconazole by gamma radiation in aqueous solutions*. Pages 299-308.

Gamma irradiation has received increasing attention due to its high potential in the degradation of recalcitrant pollutants. Thus, in the present study, gamma irradiation was used for the degradation of bromuconazole with the presence of hydrogen peroxide (H2O2) as a source of •OH and humic acid as natural organic matter. The effects of initial concentration, irradiation doses and pH were examined. A kinetic study was performed,

and the by-products were identified by HPLC-QTOF-MS/MS. Results showed that the degradation process of bromuconazole was pseudo-first-order and 99.9% of bromuconazole was decomposed under an absorbed dose of 1 kGy. The percentage of removal increased with doses and the degradation process was accelerated under neutral conditions. The addition of H2O2 showed a synergistic effect on the decomposition of bromuconazole and the degradation efficiency increased with the increase of H2O2 concentration. Humic acid indicated a negative influence on the degradation efficiency, which decreased from 99.6% to 70.365% at a dose of 0.8 kGy when the humic acid concentration was 20 mg/L. Six degradation products were identified and the kinetic rates of three intermediate compounds were calculated using a Himmelblau-Jones-Bischoff numerical analysis technique. A study conducted by 1H NMR indicated a complete mineralization at 1.2 kGy.

- **Keywords:** Advanced oxidation processes; Radiolysis; Bromuconazole; Natural organic matter; Degradation products

Jianchao Liu, Jingying Guo, Yuanfei Cai, Jinghua Ren, Guanghua Lu, Yiping Li, Yong Ji. *Multimedia distribution and ecological risk of bisphenol analogues in the urban rivers and their bioaccumulation in wild fish with different dietary habits*. Pages 309-318.

Bisphenol analogues (BPs) have been widely used in industrial production, and caused harmful effects on biological reproduction and development. The occurrence characteristics of six BPs in multi-matrices, including truly dissolved phase, colloids, suspended particulate matter (SPM), sediment and fish samples from urban river were investigated. Bisphenol A (BPA) and bisphenol S (BPS) were the mostly detected in six BPs in the Yangtze River (Nanjing section). The total average concentration of BPs was 393.8 ng/L in truly dissolved phase, 57.4 ng/L in colloids, 255.2 ng/g in SPM and 34.5 ng/g in sediment. The adsorption capacity of SPM and sediment to BPs were weaker than that of colloids. For the spatial variation, the concentrations of BPs in the surface water of the downstream of urban rivers were 1.3–1.6 times higher than that of the upstream, and the BPs concentrations in the sediments downstream of the sewage treatment plant were significantly higher than that in other sites. In wild fish, muscle has a high accumulative potential for BPs, followed by brain and liver tissues, and BPA was the dominant BPs in brain tissues. Furthermore, BPs concentration in muscle of wild fish with different feeding habits was in the following order: filter-feeding fish > omnivorous fish > herbivorous fish, and which was significantly positively correlated with BPs concentration in traditionally dissolved phase and colloidal phase. Meanwhile, BPs concentration in benthic herbivorous fish might be also controlled by the BPs adsorbed in the sediment. Ecological risk assessment was conducted and demonstrated that BPs might pose a moderate risk to fish, a low risk to algae and daphnias. The detected BPs does not pose a health risk to human trough drinking water and eating fish alone.

- **Keywords:** Bisphenol analogues; Occurrence characteristic; Bioaccumulation; Risk assessment

Wen Nie, Xiaojiao Cai, Huitian Peng, Qingxin Ma, Qiang Liu, Yun Hua, Lidian Guo, Lei Cheng, Ning Sun, Qiu Bao. *Distribution characteristics of an airflow–dust mixture and quantitative analysis of the dust absorption effect during tunnel sub-regional coal cutting*. Pages 319-334.

Optimizing the tunnel ventilation scheme is one of the main ways to achieve safe production in coal mines. Based on the actual production situation, computational fluid dynamics technology was used to study the distribution characteristics of an airflow–dust mixture for different air-absorption volumes (Qe) of the ventilation system during sub-regional coal cutting. According to the dust concentration values registered at different

locations, the entropy weight method was applied to quantitatively analyze the dust absorption effect of the fan. The research results showed that: the dust distribution was jointly affected by the cutting unit and the completed cutting zone; moreover, the dust control effect was better in the middle cutting zones than in the others. Under the ventilation system, the overall distribution of dust in the tunnel could be roughly divided into three sections: the dust removal section (I), the dust blocking section (II), and the gentle section (III). The optimal Qe (575 m3/min) was determined based on the weight of the different zones. Finally, the entropy weight method was applied for determining the ideal mine ventilation system scheme and, hence, improve safety production in coal mines during sub-regional cutting dust production.

- **Keywords:** Tunnel sub-regional coal cutting; Distribution characteristics; Entropy weight method; Dust absorption effect; Clean environment

Hao Gao, Zhengwei Long, Zhuangbo Feng, Bencheng Lin, Tao Yu. *Numerical simulation of the characteristics of oil mist particles deposition in electrostatic precipitator*. Pages 335-344.

The electrostatic precipitator (ESP) is widely used in the purification of oil mist particles in the industrial workshops. Different from the solid particles, the deposition of oil mist particles in the ESP can reach a steady state and form a saturated oil film on the electrode plate. Based on the deposition experiment data, this paper has established the oil film flow model in ESP coupled with the corona discharge, the gas flow and the oil mist particle deposition model. The characteristics of oil mist particles deposition and the oil film flow were studied. The results show that the oil film is thin in the electrode plate where the current density is high. The oil film is thick at the inlet of ESP and the corresponding collection plate in the middle of the adjacent electrode wires. The peak value appears at the corresponding plate in the middle of the first two electrode wires, which is more than 50 μm. The average oil film thickness is about 9 μm in the current study. As the inlet velocity increases or the applied voltage decreases, the oil film distribution becomes more uniform, and the oil holding capacity of the electrode plate increases.

- **Keywords:** Oil mist; Electrostatic precipitator; Deposition; Eulerian wall film

Xiao Leng, Isaac D. Tegladza, Abudukeremu Kadier, Hongliang Dai, Jun Lu. *In-situ generation of both hydroxyl radical and adsorptive flocs in electro-coagulation process with air breathing cathode*. Pages 345-353.

In order to achieve considerable generation of free radicals during electro-coagulation (EC) process, EC with air breathing cathode (EC-ABC) was designed to allow for the coexistence of electro-Fenton (EF) and EC functions. This EC-EF-ABC synergetic system allows for both in-situ free radicals and adsorptive flocs generation in an undivided electrolytic cell. The yield of hydroxyl radicals and adsorptive flocs were quantified for accurate mechanism analysis. The control mechanism of the transition from EF to EC function during EC-ABC system was investigated. The air cathode material was studied and optimized to obtain high hydroxyl radical generation. The influences of both dissolved oxygen (DO) and pH condition on hydroxyl radical and flocs generation were studied. Whiles the latter was found to dominate the successive EF and EC functions, and further controls the hydroxyl radicals and flocs yield, the former only has a dominant effect on the hydroxyl radical yield. The adsorptive iron (oxy)hydroxide flocs' structure was also found to be fully depend on the DO condition. The control mechanism of initial pH and DO condition on radical and flocs generation was simplified as a 'Sudoku-like' relationship. The optimized initial pH and DO condition was studied to maximize the generation of hydroxyl radicals and adsorptive flocs. The design of EC-ABC process could have both advanced oxidation and adsorption abilities for wastewater pollutant removal.

- **Keywords:** Electro-coagulation; Flocs; Electro-Fenton; Electrochemical wastewater treatment; AOPs

B. Rajasekhar Reddy, Veluru Sridevi, Tanneru Hemanth Kumar, Chinta Sankar Rao, Venkata Chandra Sekhar Palla, Dadi V. Suriapparao, GSNVKSN Swami Undi. *Synthesis of renewable carbon biorefinery products from susceptor enhanced microwave-assisted pyrolysis of agro-residual waste: A review*. Pages 354-372.

Valuable renewable carbon biorefinery products can be obtained by using agro-residual biomass as a feedstock. Bio-oil, gas, and char products can be obtained from Microwave-assisted pyrolysis (MAP) by converting agro-residual waste. In MAP, the process variables like microwave power, temperature, heating rate, raw materials, susceptors, and catalysts play an important role to alter the product spectrum. The temperature, heating rate, and pyrolysis time can be tuned to obtain the desired products during biomass decomposition. The obtained carbonaceous products can be used as intermediated feedstocks to synthesize a variety of end products. Hence, in this review, the application of MAP for the conversion of agro-residual waste is discussed. Special focus is given to the interaction of microwaves with susceptors. This manuscript provides background, current status, progress, and future scope of MAP technology for waste valorization. The objectives of the review are to address (i) The necessity of environmental protection, (ii) The role of biorefinery in the biomass conversion, (iii) The advancements in the MAP for the resource recovery, (iv) The mechanism of heat generation from microwaves, (v) The effects of process parameters, susceptors, and catalysts in MAP, (vi) The interactions of biomass and susceptors during the pyrolysis, (vii) The formation of valuable renewable carbon products and (viii) The future scope and challenges for the integration of MAP in solid waste management.

- **Keywords:** Microwave; Susceptor; Biomass; Pyrolysis; Oil; Biorefinery

Linlin Cao, Chengyuan Su, Jinyan Wu, Lixin Wei, Yijie Zhou, Linqin Tang, Qing Wang, Yunchuan Xian. *Impact of perfluorooctanoic acid on treatment wastewater by a tandem AnSBR-ASBR system: Performance, microbial community and metabolism pathway*. Pages 373-383.

The interaction of perfluorooctanoic acid (PFOA) with anaerobic and aerobic microorganisms was investigated to explore the effect of PFOA on microbial community evolution, carbon metabolism and nitrogen metabolism, and to a provide reference for treatment of wastewater containing PFOA. Compared with phase I (PFOA 0 mg L−1), the average COD removal rate of the anaerobic sequencing batch reactor (AnSBR) in phase II, III and IV (5–20 mg L−1) decreased by 8.85%, and that of the aerobic sequencing batch reactor (ASBR) decreased by 8.31%. However, PFOA had little effect on ammonia nitrogen (NH4+-N) removal at the preset concentrations and the average removal rate of NH4+-N in the system was 97.90 ± 0.59%. The average removal of PFOA in the AnSBR and ASBR decreased from 78.30% and 86.36% (phase I), to 18.77% and 19.25% (phase IV), respectively, indicating that the removal of PFOA was mainly dependent on the adsorption of microorganisms in the initial the experiment. 3D excitation-emission matrix results showed that PFOA affected the functional groups of extracellular polymeric substances, especially the red shift of fulvic acids along the Em axis. Meanwhile, high concentration PFOA could reduce the activities of acetate kinase and coenzyme F420 in the sludge, thereby affecting the metabolism of carbon and methane by microorganisms. When the concentration of PFOA was 20 mg L−1, the abundances of hydrogenotrophic methanogens such as Methanospirillum (AnSBR phase I-IV: 24.07%−27.43%) and Methanobacterium (AnSBR phase I-IV: 15.06%−21.27%) exceeded that of methylotrophic methanogens, indicating that the existence of PFOA changed the methane metabolism pathway.

- **Keywords:** A tandem AnSBR-ASBR system; Carbon metabolism; Functional prediction; Microbial community; Perfluorooctanoic acid

Muhammad Ikhsan Taipabu, Karthickeyan Viswanathan, Wei Wu, Nikmans Hattu, A.E. Atabani. *A critical review of the hydrogen production from biomass-based feedstocks: Challenge, solution, and future prospect*. Pages 384-407.

Hydrogen is a clean alternative fuel without carbon gas emission. This paper presents a critical evaluation of the different methods available for generating hydrogen from various feedstocks. The advantages and disadvantages of each process are discussed deeply by recent literatures. Steam reforming of fossil fuels (SRF) has been proved as an attractive method and commercialized on the larger scale. However, CO2 emission that produced during the process is critical issue by this method and therefore, CO2 capture, and storage/utilization technology are required. Besides, water splitting can produce ultra-purity hydrogen and oxygen as byproduct, but this method cannot be competed with SRF because of its expensive costs. The only possible to reduce this gap is by using solar energy with low-cost as energy source for water splitting and carbon taxes are imposed by the government to support research and development. Hydrogen production derived from biomass through gasification and pyrolysis currently shown an economic visibility and expected compete with available technology in the future. Moreover, by utilizing membrane reactor and integrated with a cheaper solar energy could significantly improve biomass-to-hydrogen conversion.

- **Keywords:** Hydrogen production; Steam reforming; Water electrolysis; Biomass-to-hydrogen conversion; Gasification; Pyrolysis

Swellam W. Sharshir, A.W. Kandeal, Almoataz M. Algazzar, Ayman Eldesoukey, M.O.A. El-Samadony, A.A. Hussien. *4-E analysis of pyramid solar still augmented with external condenser, evacuated tubes, nanofluid and ultrasonic foggers: A comprehensive study*. Pages 408-417.

In this work, pyramid solar still performance was enhanced by using evacuated tubes, external condenser, nanoparticles, and ultrasonic foggers. Experimental measurements were recorded and analyzed to investigate the influence of combining nanoparticles and ultrasonic foggers to the modified pyramid solar still (MPSS) by evacuated tubes and external condenser compared with the conventional pyramid solar still (CPSS). Compared to CPSS, the results showed that MPSS by six evacuated tubes and an external condenser has higher freshwater output, energy efficiency, and exergy efficiency by 91.09%, 18.48%, and 45.26%, respectively. While, adding 1 wt% carbon black (CB) nanoparticle to this MPSS can change these percentages to 132.86%, 28.22% and 75.43%. Moreover, adding three ultrasonic foggers with nanoparticles changed the enhancement percentages to 162.15%, 34.26%, and 81.51%. The economic analysis showed the effectiveness of the suggested modifications, and the cost per liter of freshwater can be decreased by up to 32.04% compared with CPSS. Depending on the environmental analysis, the highest environmental parameter (CO2 emissions) was 1.379 ton-CO2/year for the MPSS by all proposed modifications. So, all proposed modifications can be considered effective according to environmental, exergoeconomic, and enviroeconomic point of view.

- **Keywords:** Pyramid solar still; External condenser; Evacuated tubes; Nanofluid; Ultrasonic foggers

Asad Elmgerbi, Gerhard Thonhauser. *Holistic autonomous model for early detection of downhole drilling problems in real-time*. Pages 418-434.

Due to the recent increase in drilling operations complexity, the frequency of undesirable downhole events occurring while drilling a well is in ascend trend leading to substantial growth in non-productive time. Consequently, overall drilling costs become sky-high, a moment in which earlier and precise detection of the downhole drilling problems becomes a crucial factor in cost reduction. This paper presents an intelligent algorithm that can automatically analyze real-time drilling data and accurately detect and verify the presence of the most common downhole drilling problems upon their effective inception, which allows corrective measures to be applied at the appropriate time, resulting in a reduction of the negative impact and the associated cost of the detected downhole failure. The presented algorithm relies on constructing a risk predictive window by integrating a stochastic model with a data-driven model driven from real-time data of the surface and /or subsurface drilling parameters to detect the downhole problems. The process starts by building predictive models for predefined drilling parameters. Based on the natural distribution of the Residual Errors (REs) obtained while building the productive model, the best probability model that fits the REs data is picked. The statistical properties of the selective probabilistic models and the real-time predictive values of the predefined drilling parameters are used to generate multiple dimensional risk predictive windows; the indicated risk predictive window could have one or two dimensions, depending on the number of pre-built productive models. The downhole drilling problem is detected by observing and comparing the real-time measured value of the used drilling parameters with the risk predictive window; consecutive data points located outside the risk predictive window are considered abnormal. An alarm is triggered when the number of sequent outliers reaches a predetermined boundary. The developed algorithm was tested on a historical drilling dataset in which different downhole incidences occurred. The results show that the algorithm successfully detected all of the events at an average of 120 min before the officially recorded time.

- **Keywords:** Probabilistic model; Downhole drilling problem identification; Uncertainty window; Machine learning; Drilling non-productive time mitigation; Drilling safety improvement

Wei Pan, Lingrong Yang, Huimin Jin, Ruge Yi, Zhigang Liao. *Experimental study on microbial desulphurization of sulfide ores and self-heating simulation of ore heaps under ultrasonic and microwave*. Pages 435-448.

The objective of this study was to improve the efficiency of microbial desulphurization of sulfide ore by pretreatment with ultrasonic and microwave techniques. Different combinations of ultrasound and microwave were used to pretreat the sulfide ore and compare the microbial desulphurization effect of the treated ore and the raw ore. The experimental results show that ultrasonic and microwave can effectively improve the efficiency of bacterial desulphurization, whereas the pretreatment method of ultrasonic followed by microwave has the best enhancement effect on bacterial desulphurization of sulfide ores. The best experimental combination for microbial desulphurization is ultrasonic power of 300 W, ultrasonic action time of 50 mins and microwave power of 500 W, microwave action time of 20 s. In subsequent self-heating simulations of sulfide ore heaps, the optimal ultrasonic and microwave combination was used to pretreat the ores and the two-dimensional temperature field of the heaps was reconstructed. The results further show that the microbial desulphurization efficiency is increased when the sulfide ore is pretreated with ultrasonic followed by microwave. The purpose of inhibiting the self-heating reaction and preventing spontaneous combustion of sulfide ore was achieved.

- **Keywords:** Sulfide ore; Microbial desulphurization; Ultrasonic; Microwave; Desulfurization efficiency; Self-heating simulation

Seyed Amir Hossein Seyed Mousavi, Seyed Mojtaba Sadrameli, Amir Hossein Saeedi Dehaghani. *Catalytic pyrolysis of municipal plastic waste over nano MIL-53 (Cu) derived @ zeolite Y for gasoline, jet fuel, and diesel range fuel production*. Pages 449-467.

In this study, municipal polymer wastes that were no longer recyclable and were previously buried underground according to the usual municipal waste management program were converted to liquid fuel by catalytic pyrolysis technique. In the first step, zeolite Y catalyst was used to improve the quality of liquid fuel. In the second step, MIL-53 (Cu) was incorporated onto zeolite and pyrolyzed in nitrogen in the atmosphere. The analysis shows that clusters of carbon nanopores with a copper core, and its oxides were deposited on the zeolite. For both types of catalysts, the crystallization time of zeolite was investigated, and it was found that this leads to the synthesis of samples with different percentages of crystallinity. For each test, the liquid fuel produced was divided into four cuts: gasoline, jet fuel, diesel, and wax. The test results in a fixed bed reactor for every twelve samples of catalyst and their effect on the efficiency of different sections of liquid fuel show a significant improvement in the desired product. The properties and morphology of the catalysts were investigated. It was found that at 400 °C and a crystallization time of 18 h for support with 76.62% crystallinity, gasoline production efficiency will be 37.00%. At 500 °C and low crystallinity, the tendency of reaction to produce jet fuel with a maximum efficiency of 48.64%. Furthermore, the physical properties of each cut of liquid fuel and their comparison with the reported values indicating the appropriate qualities of the produced fuel were evaluated. In the optimal state, the octane number of the produced gasoline is 93.5 and its pour point is 41 °C. Also, a jet fuel with an octane number of 43.2 and a flashpoint of 69 °C has been obtained. In the case of diesel, the octane number and its viscosity have reached 46 and 2.407 cp, respectively. Examining the results obtained from GC MS, it was found that the zeolite catalyst modified by Diels Alder mechanism and branching will improve the quality of liquid fuel and on the other hand, will cause the cracking of the wax compounds and reduce their percentage in product analysis.

- **Keywords:** Waste plastic; Catalytic pyrolysis; Metal organic framework; Zeolite Y; Gasoline; Diesel

Zhonglin Zuo, Li Ma, Shan Liang, Jing Liang, Hao Zhang, Tong Liu. *A semi-supervised leakage detection method driven by multivariate time series for natural gas gathering pipeline*. Pages 468-478.

Real-time and accurate leakage detection of natural gas gathering pipelines is critical to the safe and reliable operation of the gas and oil industry. Modern data-driven fault detection and diagnosis techniques have recently gained increasing attention because model-based techniques are practically prohibitive. However, most existing data-driven leakage detection approaches are obtained through supervised learning, which requires a substantial set of labelled data. Especially in real-world scenarios, leakage samples are rare. To reduce the dependence of the leakage detection method on leakage data and make full use of numerous normal datasets generated under normal working conditions, we propose a semi-supervised leakage detection method which consists of two components: an improved long short term memory autoencoder (LSTM-AE) network and one-class support vector machine (OCSVM). The LSTM-AE is first trained to learn the intrinsic features of a normal dataset of pipeline parameters which are multivariate time series. The OCSVM is then applied to calculate the score which is used to infer leak existence. The performance of the proposed method is evaluated on the real natural gas

gathering pipelines, and the results confirm that the proposed method achieved 98% accuracy and 99% AUC (Area Under Curve) in a real-life dataset.

- **Keywords:** Leakage detection; Natural gas gathering pipelines; Long short term memory autoencoder (LSTM-AE); One-class support vector machine (OCSVM); Multivariate time series

Esmaeil Zarei, Faisal Khan, Rouzbeh Abbassi. *A dynamic human-factor risk model to analyze safety in sociotechnical systems*. Pages 479-498.

The performance of sociotechnical elements varies owing to a wide range of endogenous and exogenous influencing factors. These are called uncoupled variability as per Safety-II. The uncoupled variability has drawn rare attention, despite its vital importance in major accidents analysis as per Safety-I and Safety-II paradigms. Accordingly, as the first attempt, this study proposes a systematic model to analyze performance variability in human, organizational, and technology-oriented functions caused by various variability shaping factors (VSFs). The model contains three main phases. First, a FRAM (Functional Resonance Analysis Method) - driven Human-Organization-Technology Taxonomy is developed. Subsequently, Dempster - Shafer Evidence theory is employed to elicit knowledge under epistemic uncertainty. The proposed causation model is integrated into Dynamic Bayesian Networks to support decision-making under aleatory uncertainty. Finally, a criticality matrix is developed to evaluate the performance of the system functions to support decision-making. The proposed model is built considering the advanced canonical probabilistic approaches (e.g., Noisy Max and Leaky models) that address the critical challenges of incomplete and imprecise data. The proposed dynamic model would help better understand, analyze, and improve the safety performance of complex sociotechnical systems.

- **Keywords:** System safety; Performance variability; Functional resonance analysis; Performance shaping factors; Human-organization factors

Shoaib Khanmohammadi, Farayi Musharavati, Rasikh Tariq. *A framework of data modeling and artificial intelligence for environmental-friendly energy system: Application of Kalina cycle improved with fuel cell and thermoelectric module*. Pages 499-516.

Geothermal energy-driven systems with integrated waste heat recovery units such as the use of fuel cells and thermoelectric module can help to improve the renewable energy contribution in the energy mix. Data-driven optimization can improve their economic and environmental performance and their macro-projection can help in the achievement of net-zero plans. This article extends the use of a framework containing the usage of data modeling and artificial intelligence to conduct different optimization scenarios of the geothermal-driven energy system. It includes the improvement of the economic, exergetic, energetic, and environmental performance through the development of various optimization scenarios. This is done through the development of an extensive thermodynamic model and validation based upon energy, exergy, economic, and environmental evaluations. Different machine learning techniques are adapted for digital twinning of the six performance indicators as a function of nine design variables including operational, source, and economic variables. It is shown that the artificial neural network offers the best statistical fit as compared to the other machine learning techniques including RMSE: 0.1768, R2:0.9999, MSE:0.0312, and MAE:0.1107 for the total work output. Energy-efficient design has yielded a total work output of 1044.86 kW, with a first law efficiency of 0.3322. The economic design offers the lowest cost of electricity at only 34.004 $/hr. The sensitivity analysis has shown that the following parameters are the most sensitivity: turbine inlet temperature (18.19%) and pressure (18.23%), geothermal inlet temperature (16.34%) and pressure (18.00%), and the ammonia water concentration at the inlet of separator (15.96%).

- **Keywords:** Artificial neural network; Computational intelligence; Scenario-based optimization; Efficient energy systems; Sensitivity analysis

Zhizuan Zhou, Xiaodong Zhou, Boxuan Wang, K.M. Liew, Lizhong Yang. *Experimentally exploring thermal runaway propagation and prevention in the prismatic lithium-ion battery with different connections*. Pages 517-527.

Thermal runaway (TR) propagation is a critical challenge in the safety application of lithium-ion batteries (LIBs). In this study, the battery modules with different connection modes are designed to reveal TR propagation mechanisms, and a passive strategy based on thermal insulation is proposed to inhibit TR propagation. The temperature, voltage, heat transfer of battery module, as well as the equivalent flux power during TR propagation are captured and analyzed. The batteries in parallel experience fiercer combustion and propagation in comparison with the batteries without connection, which is because the parallel connection mode intensifies the exothermic reactions inside the battery. Particularly, the energy from the former battery contributes to the dominant heat source for triggering TR of its adjacent battery, accounting for 52 %– 67 %. Compared to the module without connection, the module in parallel releases much higher heat flux to adjacent batteries, leading to shorter TR propagation time and severer TR propagation. Furthermore, the aerogel can completely prevent TR propagations with different connection modes. The average flux power of the former battery to its neighboring battery can be reduced from 400 W to 35 W by inserting aerogel. The results provide new insights into TR propagation mechanism and its prevention, which are beneficial to the safety design of battery modules.

- **Keywords:** Thermal runaway propagation; Lithium-ion battery; Propagation prevention; Heat transfer

Yubo Bi, Shilu Wang, Changshuai Zhang, Haiyong Cong, Bei Qu, Jizhen Li, Wei Gao. *Safety and reliability analysis of the solid propellant casting molding process based on FFTA and PSO-BPNN*. Pages 528-538.

This paper proposes a physics-based machine learning model to analyze the safety and reliability of solid propellant casting molding processes. The model identifies the relationship between process variables that may lead to failure events and process safety. The fuzzy fault tree analysis (FFTA), as a typical physical model, can provide reasonable physical criteria and reliable a priori knowledge for back propagation neural network (BPNN). All information mapped into BPNN is used to explore the nonlinear relationships of the data and establish dynamic rules. The particle swarm optimization (PSO) algorithm is used to improve the performance of the BPNN model (PSO-BPNN), and a risk prediction model with a maximum error of 0.0006 is obtained. The results show that the proposed model can provide high precision evaluation results. A sensitivity analysis is also performed based on the mean impact value (MIV) algorithm. The importance of curing temperature, casting vacuum, curing time, casting time, and vacuum degree is determined. The above methods help realize dynamic risk analysis of the solid propellants production process and provide timely warning and feasible reference for unsafe processes.

- **Keywords:** Solid propellants; Casting molding process; Safety and reliability; Fuzzy fault tree analysis; PSO-BPNN; Mean impact value

Kongxing Huang, Guohua Chen, Faisal Khan. *Vulnerability assessment method for domino effects analysis in chemical clusters*. Pages 539-554.

Chemical clusters are attributed with large inventories of hazardous materials whose release could result in catastrophic events, as observed in the Tianjin Port accident. Such events are typically high-impact low-probability (HILP) accidents since multiple robust safety barriers can significantly ensure the integrity of installations. However, the consequences are extremely serious if the safety barriers broke down due to disaster factors. The current risk assessment methods cannot capture the complex multi-hazard scenarios and the interaction of escalation factors causing domino effects. To overcome such gaps, the present study proposes a quantitative vulnerability assessment method for multi-hazard scenarios triggered by natural events. The vulnerability assessment method considers the exposure of hazards, the sensitivity of causes, and the resilience of asset in modelling the primary event and the possible domino accidents. The proposed method assists in analyzing the risk of domino effects triggered by natural disasters and optimizing the deployment of safety barriers in chemical clusters. The application of the method is demonstrated through a detailed case study.

- **Keywords:** Vulnerability; Accident model; Domino effects; Chemical clusters; Multi-hazard interaction

Chuan-Zhu Zhang, Jun-Cheng Jiang, An-Chi Huang, Yan Tang, Lin-Jie Xie, Juan Zhai, Zhi-Xiang Xing. *A novel multifunctional additive strategy improves the cycling stability and thermal stability of SiO/C anode Li-ion batteries*. Pages 555-565.

SiO/C anode materials for high-energy-density lithium-ion batteries (LIBs) have attracted considerable attention. However, battery capacity degradation and thermal safety problems caused by the large volume variation in the SiO/C anode during the long cycle limit its application. We propose the use of two composite additives to overcome the limitations of the current SiO/C anode materials. The electrochemical performance and thermal stability of the blank electrolyte (BE) and two composite additives were systematically compared using electrochemical, characterisation, and thermokinetic methods. The results revealed the synergistic effect of (2-cyanoethyl) triethoxysilane (TEOSCN) and 4, 5–difluoro-1, 3–dioxolan-2–one (DFEC) improved the cycling and thermal stability of the cells. The use of the additives resulted in the formation of a dense and thin SEI layer with LiF as the main material on the surface of the anode, which significantly improved the cycling stability of Li/SiO@C batteries. In addition, differential scanning calorimetry (DSC) measurements and thermokinetic analysis indicated that the addition of TEOSCN/DFEC significantly enhanced the thermal stability of the cells, which was mainly manifested as the delay of the exothermic peak and the increase in the activation energy of the mixture of the SiO/C anode and electrolyte. Our results suggested that the multifunctional additive offers a viable approach for developing LiBs with high energy density and excellent safety.

- **Keywords:** Lithium-ion battery; SiO/C anode; Solid electrolyte interphase; Electrolyte additive; Thermal stability; Safety performance

Plínio M.S. Ramos, Caio B.S. Maior, Márcio C. Moura, Isis D. Lins. *Automatic drowsiness detection for safety-critical operations using ensemble models and EEG signals*. Pages 566-581.

Recently, industrial sectors that stage occupational and environment safety critical tasks, such as the oil and gas industry, have been interested in monitoring biological parameters to prevent human errors and enhance process safety with emergency preparedness and response. In this context, human reliability plays a fundamental role to

avoid possible catastrophic accidents triggered by human factor, for example workers' fatigue. Drowsiness, as a main causes of fatigue, maybe recognized through patterns in electroencephalogram (EEG) signal. In this paper, we propose a drowsiness recognition system that combines information from different EEG signal channels and machine learning in an ensemble methodology, novel for this context. We consider two ensemble approaches: the bagging, using five and three channels, and the voting, using a single channel. To validate the proposed system, DROZY, a real and public database containing drowsiness data, was used in three cases: (1) evaluated in all available subjects; (2) evaluated in specific subjects with general model; and (3) evaluated for specific subjects and dedicated models. The results show that our proposed system has high accuracy above 90%, in most subjects for Case 3. While for Cases 1 and 2, the ensemble model is equivalent to the best results of the classifiers from the single-channels. Furthermore, collecting many channels of EEG signals is often expensive and cumbersome for humans, and the schemes using many channels of EEG signals do not necessarily lead to better performances.

- **Keywords:** EEG; Ensemble models; Drowsiness detection; Human reliability; DROZY

Amirreza Ebrahimi, Ehsan Houshfar. *Thermodynamic analysis and optimization of the integrated system of pyrolysis and anaerobic digestion*. Pages 582-594.

Investigating suitable waste management processes is essential nowadays. Anaerobic digestion and pyrolysis are among waste treatment processes that have demonstrated promising potentials. The objective of this study is to evaluate the integration of pyrolysis and anaerobic digestion comprehensively in terms of energy/exergy analysis and comparing the integrated energy system with bare systems. To that end, novel pyrolysis and anaerobic digestion plants are designed and proposed. MATLAB was used for developing a code that simulated the plants and meanwhile, Aspen Plus provided thermodynamic properties. Results showed that the exergy efficiency of the integrated plant is 45.71%, while this parameter is 27.60% and 88.71% for the simple pyrolysis and anaerobic digestion plants, respectively. Furthermore, to make pyrolysis plant energy-independent and maximize bio-oil production, the optimum chemical composition of biomass feedstock is obtained. Seven samples were scrutinized, of which the sample with 46.00 wt% cellulose, 29.33 wt% hemicellulose, and 24.67 wt% lignin showed the optimal conditions. This composition could raise the exergy efficiency of the pyrolysis plant to 40.03%, while more interestingly exergy efficiency of the integrated system would reach 51.15%. Taken together, the findings suggested that the integration of pyrolysis and anaerobic digestion improves both exergy efficiency and methane production.

- **Keywords:** Exergy analysis; Pyrolysis plant; Anaerobic digestion; Integrated system; Optimization

S.A. El-Agouz, Mohamed E. Zayed, Ali M. Abo Ghazala, Ayman Refat Abd Elbar, Mohammad Shahin, M.Y. Zakaria, Khaled Khodary Ismaeil. *Solar thermal feed preheating techniques integrated with membrane distillation for seawater desalination applications: Recent advances, retrofitting performance improvement strategies, and future perspectives*. Pages 595-612.

Membrane distillation (MD) is a promising technology for seawater desalination, integrating the advantages of both membrane segregation and thermal distillation. High energy consumption is one of the key barriers to the evolution of MD. The concern of utilizing solar thermal heating techniques for feed water heating in MD systems is

increasing worldwide for sustainable freshwater production and lowering of energy consumption. In this review, the recent advances and latest developments in solar-powered MD technology have been highlighted. A special focus has been considered for hybridization configurations, energy performance evaluation, and economic analyses of solar MD systems. The combination of different solar thermal units with MD systems; including, solar flat plate collectors, evacuated tube collectors, hybrid photovoltaic/thermal collectors, high concentrating solar collectors, salt-gradient solar ponds, solar distillers, …etc., has been examined. Accordingly, reviewed results and related comparisons for the different solar feed heating techniques are critically discussed and panoramically tabulated. Then the bottlenecks of the system's performance and the literature gap in previous studies are also discussed. Overall, this survey sums up the status of solar-based MD research looking at the perspective strategies to realize the next generation of solar MD systems that can address the future demands of MD and achieve a highly more cost-efficient desalination process.

- **Keywords:** Membrane distillation; Solar energy, Hybrid systems; Feed water preheating techniques; Freshwater productivity improvement, Energy consumption

Yang Yu, Shibo Wu, Jianxing Yu, Haicheng Chen, Qingze Zeng, Ya Xu, Hongyu Ding. *An integrated MCDM framework based on interval 2-tuple linguistic: A case of offshore wind farm site selection in China*. Pages 613-628.

Offshore wind farm (OWF) site selection is critical to the successful development of offshore wind energy and manifests as a complex multi-criteria decision-making (MCDM) process. To promote the further healthy development of offshore wind energy, this study developed a new integrated MCDM framework to better evaluate and rank OWF sites. The main contributions are as follows. First, the interval 2-tuple linguistic (I2TL) provides a simple, interpretable, and precise approach to linguistic information handling and effectively prevents information missing and distortion. Second, different opinions are aggregated using a modified similarity aggregation method (SAM), reducing the errors due to neglecting the effect of individual differences on consistency. Third, a new integrated weighting method combining the simplified best-worst method (SBWM) and method based on the removal effects of criteria (MEREC) is adopted to acquire evaluation criteria weights, which comprehensively reveals the relative importance of criteria. Fourth, the proximity indexed value (PIV) method is expanded with I2TL for alternative ranking to minimize the rank reversal problem. Finally, the applicability and robustness of the proposed framework are validated through a case study in China as well as sensitivity and comparative analyses. The proposed MCDM framework can provide beneficial support for managers to analyze and select the optimal OWF site.

- **Keywords:** Multi-criteria decision making; Aggregation method; Weighting method; PIV method; Offshore wind farm

Ping Huang, Ming Chen, Kexin Chen, Hao Zhang, Longxing Yu, Chunxiang Liu. *A combined real-time intelligent fire detection and forecasting approach through cameras based on computer vision method*. Pages 629-638.

Fire is one of the most common hazards in the process industry. Until today, most fire alarms have had very limited functionality. Normally, only a simple alarm is triggered without any specific information about the fire circumstances provided, not to mention fire forecasting. In this paper, a combined real-time intelligent fire detection and forecasting approach through cameras is discussed with extracting and predicting fire development characteristics. Three parameters (fire spread position, fire spread speed

and flame width) are used to characterize the fire development. Two neural networks are established, i.e., the Region-Convolutional Neural Network (RCNN) for fire characteristic extraction through fire detection and the Residual Network (ResNet) for fire forecasting. By designing 12 sets of cable fire experiments with different fire developing conditions, the accuracies of fire parameters extraction and forecasting are evaluated. Results show that the mean relative error (MRE) of extraction by RCNN for the three parameters are around 4–13%, 6–20% and 11–37%, respectively. Meanwhile, the MRE of forecasting by ResNet for the three parameters are around 4–13%, 11–33% and 12–48%, respectively. It confirms that the proposed approach can provide a feasible solution for quantifying fire development and improve industrial fire safety, e.g., forecasting the fire development trends, assessing the severity of accidents, estimating the accident losses in real time and guiding the fire fighting and rescue tactics.

- **Keywords:** Industrial fire safety; Fire detection; Fire forecasting; Fire analysis; Artificial intelligence

Nagoor Basha Shaik, Watit Benjapolakul, Srinivasa Rao Pedapati, Kishore Bingi, Ngoc Thien Le, Widhyakorn Asdornwised, Surachai Chaitusaney. *Recurrent neural network-based model for estimating the life condition of a dry gas pipeline*. Pages 639-650.

The use of expansive pipeline networks guarantees domestic and industrial users for accessing a continuous flow of valuable liquids and gases. These pipeline systems were considered the most economical and safest pipeline of transport for oil and gas and are of great strategic importance. The risks during operating conditions need to be controlled to handle the pipeline safely and smoothly in the complex globalized economy. Accordingly, life prediction is an essential issue in the pipeline network of the maintenance systems. Recently proposed data-driven and statistical approaches for pipeline's life prediction continue to rely on previous information to create health indicators and define thresholds, which is inefficient in the significant data era. Thus, a recurrent neural network (RNN)-based method for predicting the life of equipment with corrosion dimension classes exposed to critical condition monitoring is proposed in this research. The RNN model uses the multiple condition monitoring observations at the current and previous inspection points as its inputs and the pipe life condition and corrosion type as its outputs. Further, to improve the predictability of the proposed model, a validation mechanism is introduced during the training process. The proposed RNN method is validated using the data from oil and gas fields that have been collected in real-time. A critical sensitivity analysis with missing parameters is performed to evaluate the model's effectiveness in forecasting the life situation when inputs are absent. A comparative study is also carried out between the proposed RNN method and an adapted version of the reported method. The results show the advantage of the proposed method in achieving an actual life expectancy which can reduce the annual maintenance costs and help take necessary actions for better protection and safety of a pipeline.

- **Keywords:** Oil and gas; Pipeline; Prediction; Recurrent neural networks; Safety

Mengyue Zhang, Jun Dong, Minglu Sun, Chen Sun, Yujiao Han, Yanyang Mo, Weihong Zhang. *MnO2 generation mechanisms in the presence of phase transfer catalyst enhanced trichloroethene oxidation by permanganate*. Pages 651-659.

The remediation of trichloroethylene contaminated groundwater by permanganate-based in situ chemical oxidation is limited by MnO2 formation. The application of phase transfer catalyst (PTC) is a promising alternative to enhance remediation efficiency, and the alleviation of MnO2 generation is one of crucial capacities of PTC to promote oxidation. This work has emphatically elucidated the mechanism of MnO2 alleviation by PTC, as well

as the effectiveness which was researched by conducting batch and sand column experiments. The results indicated that the contents of MnO2 suspended in aqueous phase and total manganese in the media were respectively decreased by 29.5% and 26.1% attributed to PTC addition. Although PTC could not be used as a chelator for Mn(Ⅲ) stabilization, the generation of dissolved Mn(Ⅱ) and Mn(Ⅲ) was promoted by PTC for less MnO2 generation. Further studies illustrated that redox reactions would occur between dissolved Mn(Ⅱ)/Mn(Ⅲ) and TCE, which benefited TCE degradation. Moreover, Smaller particle size and improved colloidal stabilization of formed MnO2 were achieved by PTC to minimize MnO2 precipitation. Overall, effective alleviation of the MnO2 generation and precipitation by PTC is collectively contributed from the promotion of dissolved Mn(Ⅱ) and Mn(Ⅲ) and the stabilization of MnO2 formed in situ.

- **Keywords:** In situ chemical oxidation (ISCO); Phase transfer catalyst (PTC); Permanganate; MnO2 formation alleviation; Trichloroethene (TCE)

Jinghan Yu, Xuting You, Yedong Gao, Liang Guo, Xiaoman Yang, Mengchun Gao, Yangguo Zhao, Chunji Jin, Junyuan Ji, Zonglian She. *The impact of auxin analogues on microalgal intracellular component accumulation and nutrient removal for mariculture wastewater treatment basing on bacterial-algal coupling technology*. Pages 660-668.

Acidogenic fermentation coupled with microalgae cultivation is a promising approach for mariculture wastewater (MW) treatment. However, the low biomass and lipid production of microalgae restrict its practical application. In this study, auxin analogues including α-naphthylacetic acid (NAA), 2,4-dichlorophenoxyacetic acid (2,4-D) and indomethacin were applied to the cultivation of Chlorella pyrenoidosa under mixotrophic condition. The effects of auxin analogues on microalgal growth, intracellular component accumulation and nutrient removal were evaluated. The optimal growth and intracellular composition accumulation of Chlorella pyrenoidosa were obtained at 2 mg L−1 NAA, 1 mg L−1 indomethacin, and 1 mg L−1 2,4-D. NAA was more efficient than indomethacin and 2,4-D for lipid production, and the maximum lipid accumulation reached 52% with 2 mg L−1 NAA. Auxin analogues enhanced the uptake of volatile fatty acids, ammonium and phosphate from acidogenic fermentation effluent, attributed to the improvement of microalgal growth. This study provided a new insight for enhancing mariculture wastewater treatment with mixotrophic microalgae.

- **Keywords:** Microalgae; Mariculture wastewater; Auxin analogue; Nutrient removal; Intracellular component

Chia-Yen Liang, Pei-Ting Hsu, Min-Hao Yuan, Yi-Hung Chen, Chun-Ming Chang, Ching-Ying Chang, Shih-Chi Chou, Chia-Jung Liang. *Removal of fine particulate matter from cooking-oil fume using an intensified mobile chemical scrubber based on a rotating packed bed with green surfactants*. Pages 669-677.

Cooking-oil fumes (COFs) from street-food stalls in night markets have adverse effects on air quality and workers. This study proposes a floor-mounted, cylindrical, movable, small-sized rotating packed bed (RPB) coupled with green surfactants in a Span and Tween mixture as an intensified chemical scrubber for COF purification. Moreover, it is used for an on-site performance evaluation of PM2.5 removal efficiency (ηPM2.5) in a fried-food stall. With a hydrophilic–lipophilic balance of 6 (H6) from the Span and Tween mixture, an optimal dose of 8.2 g/L is achieved for an ηPM2.5 of 88.8 %. Except for direct interception and inertial impaction, the RPB with H6 stimulates the emulsification of COFs, which is a dominant mechanism for the range of PM1–2.5. By comparing the effects of scrubbing solutions of water, traditional detergent, and H6, it is found that H6 exhibits the highest emulsification effect for ηPM2.5 with low scent and manageable

foaming level. A 7-day performance evaluation for commercial operation suggests that a promising ηPM2.5 can be reached by maintaining the concentration of H6 in the scrubbing solution. Therefore, the effectiveness of the RPB with the bio-based H6 surfactant is clearly demonstrated by the removal of PM2.5 in commercial fried-food stalls. The findings shed light on the development and application of RPB with bio-based and eco-friendly surfactants for wet scrubbing of COFs in terms of particulate-matter removal in commercial fried-food stalls.

- **Keywords:** Cooking oil fume (COF); Fried-food stall; High-gravity rotating packed bed (RPB); Span and Tween surfactants; Fine particulate matter (PM2.5)

Peijun Liu, Zhenggen Liu, Mansheng Chu, Ruijun Yan, Feng Li, Jue Tang, Jinge Feng. *Detoxification and comprehensive recovery of stainless steel dust and chromium containing slag: Synergistic reduction mechanism and process parameter optimization*. Pages 678-695.

Stainless steel dust and chromium containing slag are representative harmful solid wastes produced in modern iron and steel metallurgy industry. Based on the study of stainless steel dust reduction, the direct reduction process with low energy consumption and high efficiency was obtained by changing the addition amount of chromium containing slag and the conditions of reduction process system. The results show that with the addition of chromium containing slag, the basicity of raw materials decreases, the recovery of metal is improved, and the self-pulverization effect of reducing slag is improved. The optimum process conditions are as follows: the mixing ratio of stainless steel dust to chromium containing slag is 94%: 6%, the reduction temperature is 1400 °C, the reduction time is 25 min, the FC/O is 0.9, the recoveries of Fe, Cr and Ni in the reduction products are 90.5%, 90.6% and 91.2%, respectively, the grades of Fe, Cr and Ni in Fe-Cr-Ni-C alloy are 61.3%, 19.9% and 3.7%, respectively, and the contents of harmful components such as S and P are very low. The self-pulverization rate of reduction slag can reach 92.8%, and the residues of metal Fe, Cr and Ni in reduction slag are 134 ppm, 96 ppm and 129 ppm, respectively.

- **Keywords:** Stainless steel dust; Chromium containing slag; Synergistic reduction; Fe-Cr-Ni-C alloy; Detoxification and comprehensive recovery

Amina, Qumber Abbas, Awais Shakoor, Mu Naushad, Balal Yousaf. *In-situ oxidative degradation of sulfamethoxazole by calcium peroxide/persulfate dual oxidant system in water and soil*. Pages 696-705.

Calcium peroxide (CaO_2) and persulfate (PS) dual oxidant system is an innovative in-situ chemical oxidation (ISCO) technique for the restoration of contaminated groundwater. Several field applications also confirm its efficacy in remediating the groundwater, however, published articles are rarely present. In this work, the performance of the CaO_2/PS system was examined for the degradation of sulfamethoxazole (SMX) in the SMX polluted soil and water. Results indicated that SMX could be efficiently degraded with CaO_2 and PS (2 g/L dosages for each oxidant) around neutral pH (7), and 95.8% pollutant removed after 36 h of reaction time. The removal efficiency of SMX improved as the concentrations of CaO_2 and PS were increased. Moreover, SMX removal was significantly decreased with the increase of initial solution pH. This dual oxidant system at 30 °C was also used for the remediation of SMX (10 mg/kg) spiked soil. Soil degradation experiment was performed at 150 rpm of shaking speed using soil slurry (soil/water; 1/1 ratio) at pH 7. Dual oxidant dosage was kept at 2 g/L CaO_2 and 2 g/L PS. The results showed that this dual oxidant system is also very efficient for the antibiotics SMX degradation in the soil system. Overall, an insight knowledge and

practical information gained from this work will help in the treatment of SMX contaminated soil and water as well as wastewater with CaO_2/PS dual oxidant system.

- **Keywords:** Calcium peroxide (CaO2); Persulfate (PS); Sulfamethoxazole (SMX); Catalytic oxidation; Dual oxidant System; Free radical species

Xijian Guo, Jianqiang Deng, Zheng Cao. *Study on the propagation characteristics of pressure wave generated by mechanical shock in leaking pipelines*. Pages 706-714.

This paper focuses on the characteristics of pressure wave generated by an active mechanical shock in leaking pipelines. A piston type pressure wave generator was designed and applied to the pipeline experimental system and a three-dimensional (3D) numerical simulation model was developed based on the k-ε turbulence model and dynamic mesh. The experimental results showed that the maximum amplitude of pressure wave was about 104.71 kPa, and the leakage intensified the attenuation of pressure wave in space and time through quantitative analysis. Based on the 3D simulations, the processes of the pressure wave generation and propagation were revealed. The amplitude of pressure wave increased linearly with the increase of the maximum velocity of mechanical shock, and the effects of leakage on the waveforms of pressure wave were observed under the dimensionless analysis. In addition, a shorter duration of mechanical shock can increase the amplitude of the pressure wave generated. The results presented in this paper will contribute to the development and application of the transient leak detection method for pipeline systems.

- **Keywords:** Pressure wave; Mechanical shock; Dynamic mesh; Pipeline leakage; Hydraulic experiments

Valentine Chikaodili Anadebe, Vitalis Ikenna Chukwuike, Vinoth Selvaraj, Alagarsamy Pandikumar, Rakesh Chandra Barik. *Sulfur-doped graphitic carbon nitride (S-g-C3N4) as an efficient corrosion inhibitor for X65 pipeline steel in CO2- saturated 3.5% NaCl solution: Electrochemical, XPS and Nanoindentation Studies*. Pages 715-728.

The present study reports the role of sulfur-doped graphitic carbon nitrides (S-g-C3N4) as a self- assembly corrosion inhibitor for X-65 steel in 3.5% NaCl solution enriched with CO2. The S-g-C3N4 was synthesized via simple pyrolysis and polymerization route. Detailed physiochemical characterization was carried out using XRD, Raman, FTIR, UV, and XPS analysis. Surface analysis such as FE-SEM and AFM studies reveals a uniform coating of S-g-C3N4 over the steel surface. Electrochemical techniques were adopted to investigate the efficiency of S-g-C3N4 on steel corrosion mitigation. Maximum inhibition efficiency of 98% and 94% at concentration of S-g-C3N4 (0.3 wt%) for polarization and impedance methods were achieved. Also, the DFT and MD simulation studies evidenced that S-g-C3N4 forms a protective layer over the steel surface. The excellent inhibition efficiency of the S-g-C3N4 is due to the presence of sulfur heteroatom thus has more affinity towards steel surface. This sulfur doped g-C3N4 could open up new opportunities in corrosion and materials protection area.

- **Keywords:** CO2 corrosion; API 5 L X-65 steel; Inhibitor; Electrochemical tests; FE-SEM; XPS

Prince Chapman Agyeman, Kingsley JOHN, Ndiye Michael Kebonye, Solomon Ofori, Luboš Borůvka, Radim Vašát, Martin Kočárek. *Ecological risk source distribution, uncertainty analysis, and application of geographically weighted regression cokriging for prediction of potentially toxic elements in agricultural soils*. Pages 729-746.

A resilient environment is essential for society's long-term viability. Receptor models have evolved into an excellent tool for detecting pollution sources and evaluating each source's empirical contributions based on ecological datasets. One hundred and fifteen soil sample were collected from the district of Frydek Mistek in the Czech Republic and the concentration of arsenic (As), cadmium (Cd), copper (Cu), chromium (Cr), manganese (Mn), nickel (Ni), lead (Pb)and zinc (Zn) measured inductively coupled plasma–optical emission spectrometry. The results suggested that the hybridized receptor models ER-PMF and PMF identified the following geogenic, steel industries, vehicular traffic, and agro-based activities such as pesticide and fertilizer applications as the primary sources in the source distribution. The ER-PMF source pollution identification efficiency ranged from R2 0.872–0.970, RMSE 0.128–17.344 and MAE 0.085–10.388, whereas the PMF R2 ranged from 0.883 to 0.960, RMSE 0.246–79.003 and MAE 0.145–49.925. The overall assessment of the efficiency of the receptor models suggests that the ER-PMF appears to yield more efficient results in pollution source identification compared to PMF. The PTEs mapping using geographical weighted regression (GWR) and a hybridized regression approach, geographical weighted regression cokriging (GWRCoK), revealed that GWRCoK had a higher goodness of fit in the spatial prediction maps than GWR. According to Hakanson's risk index classification, the ecological risk level in the study area was moderate to high (risk level = 51 observed locations out of 115, or 44.35%); however, Chen's risk index reclassification indicated that the toxicity level in the study area was moderate to extremely high (risk level = 113 observed locations out of 115, or 98.26%). However, the uncertainty assessment results indicated that the DISP interval ratio of the hybridized ER-PMF model was lower than that of the parent PMF model. However, it was clear that the random error that could occur in the DISP based on the DISP interval ratio was likely to be lower in the ER-PMF receptor model than in the parent model. The assessment of PTEs in soil has been widely published, but this study recommends using a pollution assessment-based receptor model (ER-PMF), which has been shown to be reliable and practical in estimating distribution sources.

- **Keywords:** Source distribution; Ecological risk-positive matrix factorization; Geographically weighted regression cokriging; Random forest; Uncertainty assessment

Negin Entezami, Mehrdad Farhadian, Ali Reza Solaimany Nazar, Shahram Tangestaninejad. *Synthesis and characterization of Bi2O3/ZIF-67 nanocomposite integration with capacitive deionization system in the degradation tetracycline*. Pages 747-760.

A Bi2O3/ZIF-67 heterostructure was synthesized as a novel and highly active photocatalyst by the hydrothermal method. The as-synthesized catalysts were identified by XRD, SEM, EDX, FTIR, TEM, UV–Vis DRS, BET, and PL analyses. The two-component composite showed a significant improvement in photoactivity compared to Bi2O3 and pristine ZIF-67 due to its unique characteristics such as increased specific surface area and visible light adsorption, as well as reduced bandgap and recombination rate of electron-hole. The optimum values of the processing variables for the contaminant degradation efficiency were determined for photocatalytic process (catalyst concentration= 0.4 g/L, pH= 9, tetracycline (TC) initial concentration= 20 mg/L, and time= 120 min) and capacitive deionization system (CDI) (L=5 mm, voltage=1.8 V, and TC concentration=20 mg/l) and the maximum pollutant removal efficiency under optimal conditions for catalyst adsorption, photocatalytic process, and CDI systems were

obtained 12%, 84% and 69%, respectively. The identification of a kinetic study confirmed that the TC removal followed the pseudo-first-order model. According to kinetic studies, the combination of photocatalysis and CDI system (PCS) has a significant effect on the efficiency of the contaminant removal, and the reaction rate constant is increased by about 1.5 and 2.4 times compared to the photodegradation process and the CDI system, respectively. As the results show, the PCS system is a promising way of removing contaminants and dramatically increasing the removal efficiency. Experimental results showed a great chemical stability and reusability of the photocatalyst and the graphite electrode after five cyclic usage.

- **Keywords:** Bi2O3/ZIF-67 composite; Photocatalyst; Tetracycline; MOF; Capacitive deionization

Ahmed A. Hassan, Ahmed E. Elwardany, Shinichi Ookawara, Hidetoshi Sekiguchi, Hamdy Hassan. *Energy, exergy, economic and environmental (4E) assessment of hybrid solar system powering adsorption-parallel/series ORC multigeneration system*. Pages 761-780.

Energy, exergy, economic and environmental assessment is performed for an integrated hybrid solar system powering a multigeneration system. The proposed multigeneration system is integrated parallel/series configurations of organic Rankine cycle (ORC) unit and adsorption chiller under weather conditions of Alexandria-Egypt. The solar subsystem comprises photovoltaic/thermal collectors (PVT) connected in parallel arrangement with evacuated tube solar collectors (ET). The system output aims to provide annual electricity requirements via PVT collectors and the ORC unit and supply cooling requirements during summer via an adsorption chiller for a small building. The hot water output of the solar system is used to drive the ORC unit and adsorption chiller in four configurations; (Conf-1) hot water drives the adsorption chiller, then its output hot water runs the ORC unit (series), (Conf-2) it drives the ORC first, then the adsorption chiller (series), (Conf-3) hot water is divided between adsorption and ORC (parallel), and (Conf-4) hot water drives only adsorption without using ORC unit. Moreover, the impact of the area ratio of the PVT to ET collector and the ORC working fluid and its flow rate on the system performance is investigated. A complete mathematical model is developed for the system components and solved using MATLAB software. The results show that Conf-4 has the best cooling production performance with an average value of 9.6 kW during the summer months and energy efficiency with an average value of 0.3 during August. Conf-1 is the best performing configuration in cooling production of about 5.6 kW average cooling capacity compared to Conf-2 and Conf-3. In contrast, Conf-2 has the best ORC unit performance with a maximum output of 1.2 kW on a typical day in July. Increasing the PVT collector area in the solar configuration negatively affects cooling production but increases electricity production, which augments the system's overall exergy and energy efficiencies. R600 is the best ORC working fluid compared to R290 and R134a in terms of average ORC power production of about 0.72 kW compared to 0.63 kW for R290 and 0.39 kW for R134a. Conf-1 is found to have the best energy savings of about 50.8 MWh/year and thus the best emissions of approximately 10.06 equivalent tonCO2 per year. The system Payback period is about 9.8, 9.95, 9.9, and 8.45 years for Conf-1 to Conf-4, respectively, proving the system's economic feasibility.

- **Keywords:** Multigeneration system; Adsorption chiller/ORC; 4E assessment; Evacuated tube collectors; PVT collectors; Series/parallel

A.C. Silva, P. Rocha, J. Antelo, P. Valderrama, R. López, D. Geraldo, M.F. Proença, J.P. Pinheiro, S. Fiol, F. Bento. *Comparison of a variety of physico-chemical techniques in the chronological characterization of a compost from municipal wastes*. Pages 781-793.

The degree of stability and maturity of the organic matter are fundamental features of the chemical characterization of compost. These characteristics are related to the extensive formation of aromatic structures and of oxygen-containing functional groups. The increase of the amount of these chemical moieties can be assessed by different analytical methodologies, based on thermal, spectrophotometric, and electrochemical techniques. In order to compare the ability of the most used methodologies to differentiate compost at different composting stages, results from the direct characterization of solid samples and their extracts are reported. A total of 108 parameters from the characterization of a compost at four composting stages were treated by a ComDim analysis. The relevance of the analytical techniques for monitoring composting was established by considering the absolute value of the loadings and that results vary in a single way along the process.

- **Keywords:** Compost; Humic-like substances; Stabilization; Circular Economy; Common Dimensions Analysis

Hamed Mirzavand, Alireza Aslani, Rahim Zahedi. *Environmental impact and damage assessment of the natural gas pipeline: Case study of Iran*. Pages 794-806.

Today, oil and gas trunklines from production to consumption have become one of the challenges for governments. Due to the need to install energy-intensive equipment such as compressors, turbines and pumps along the trunkline route, a systematic study of the environmental impact of this trunkline has received less attention from researchers. However, from a social and environmental point of view, the benefits of this transfer in the face of its environmental effects have always been criticized by indigenous groups and environmentalists in the region. The purpose of this study is to evaluate and systematically analyze the environmental effects of the natural gas trunkline process in part of the sixth national gas trunkline of Iran, which is done for export to neighboring countries. The research method is life cycle assessment. After defining the goal and scope, in the second step, the flow data of the inlet and outlet gas, the amount of gas rivet, the amount of turbine emissions, the amount of electricity consumption, the amount of gas consumed and the amount of black powder entering the collection station and energy consumption calculations were performed. In the third step, the environmental effects of the system were examined from two perspectives: (1) the effects that can lead to environmental problems and (2) the damage that can be done to human health, ecosystem, and resource. These analyses were reviewed at two general levels of the system and each station and equipment. The results showed that the total annual carbon dioxide emissions of this pipeline in Ahvaz station emit 70,149 kg CO2 eq per day, which is the highest amount of emissions among all stations. This is equivalent to 30,499 liters of car fuel per year. On the other hand, Bidboland station emits 7443 kg CO2 eq per day of carbon dioxide, which is the lowest emission among all stations. Due to the environmental effect of water consumption, Ahvaz station with 39 m3 per day has the highest amount among stations and Bidboland station with 6 m3 per day has the lowest consumption.

- **Keywords:** Life cycle assessment; Natural gas; Sixth global gas pipeline

Cong Ma, Yaoyao Tian, Xinying Liu, Yajing Li, Pengda Zhang, Xiuru Chu, Liang Wang, Bin Zhao, Zhaohui Zhang. *Preparation and characterization of double-skinned FO membranes: Comparative performance between nanofiber and phase conversion membranes as supporting layers*. Pages 807-817.

To address the internal concentration polarization (ICP) effect and membrane fouling problems of forward osmosis technology in pressure retarded osmosis (PRO) mode, another highly selective polyamide (PA) layer was introduced on the other side of the single-skinned forward osmosis (FO) membrane. Recently, a new symmetrical nanofiber support layer has shown excellent performance. For better proof, the nanofiber support layer and the phase inversion support layer were prepared separately in this study, respectively, and two double-skinned FO membranes were obtained via interfacial polymerization. By comparing various surface physicochemical properties of the nanofiber support layer and the phase inversion support layer, it can be seen that the double-skinned PA layer formed on the surface of the nanofiber support layer had better performance. The nanofiber double-skinned FO membrane showed water flux of 19.99 LMH when using 2 M NaCl and DI water as the draw and feed solution, much higher than that of the phase inversion double-skinned FO membrane. Furthermore, the anti-fouling performance of the nanofiber double-skinned FO membrane was also better than that of the phase inversion double-skinned FO membrane. This study pointed out a new direction for a double-skinned FO membrane with high permeability selectivity and provided a promising method for anti-membrane fouling.

- **Keywords:** Double-skinned; Forward osmosis; Nanofiber support layer; Phase conversion support layer

Jie Cheng, Hong-Yi Li, Xin-Mian Chen, Dong Hai, Jiang Diao, Bing Xie. *Eco-friendly chromium recovery from hazardous chromium-containing vanadium extraction tailings via low-dosage roasting*. Pages 818-826.

The Cr recovery from the Cr-containing tailings of vanadium extraction always generates large amounts of hazardous wastewater sludge and solid waste. This work proposed an eco-friendly Cr recovery method based on low-dosage soda roasting for a new kind of Cr-containing tailing, the Mg-based tailing. The low dosage of soda ensures the targeted conversion of Cr-bearing phases in the Mg-based tailing during roasting and minimizes the soda roasting of accompanying phases other than Cr-bearing phases, leading to the minimization of waste discharge. In the optimal condition of low-dosage soda roasting-water leaching, the Cr extraction efficiency is as high as 93.25 %; from the leach liquor, the Cr2O3 product is obtained by Na2S reduction, precipitation, and calcination with total Cr recovery of 92.93 %. For Cr extraction, the soda dosage has been reduced by 20 % while the production rates of hazardous sludge, leach residue, and CO2 have been reduced by 30 %, 18 %, and 20 %, respectively. This work exemplifies the control of targeted phase conversion to minimize hazardous wastes, which provides a novel strategy for eco-friendly resource utilization of hazardous tailings.

- **Keywords:** Cr-containing tailing; Low dosage; Soda roasting; Water leaching; Cr recovery

Xiaobin Li, Xiaobing Gao, Yilin Wang, Qiusheng Zhou, Guihua Liu, Zhihong Peng, Tiangui Qi. *Coal fly ash cleaner utilization by ferric oxide assisted roasting – leaching silica: Recycling lixiviant by seeded precipitation of leachate*. Pages 827-835.

Recycling lixiviant from sodium silicate solution is a key to the cleaner utilization of aluminosilicate solid wastes such as coal fly ash and coal gangue via ferric oxide assisted

roasting - alkali leaching silica process. This work focuses on seeded precipitation of higher-modulus sodium silicate solution to obtain recyclable spent solution with lower-modulus. The results show that adding silica hydrate seeds can induce the decomposition of sodium silicate solution to obtain amorphous silicate hydrate and low-modulus spent solution. The SiO2 precipitation yield, precipitation rate and the spent solution modulus can respectively reach up to 108.26 g/L, 72.17 % and 0.86, under the appropriate conditions: initial modulus 3.09, total Na2O concentration 50 g/L, seed amount 350 g/L-liquor, temperature 50 ℃, and duration 6 h. Meanwhile, the average particle size of precipitation product is ~ 56.20 μm. Moreover, the structural evolution of silicates during the precipitation implies that silica hydrate mainly precipitates from high-polymerized silicates. The precipitation product was further characterized as opal-A by XRD, chemical composition, TG-DSC and FT-IR analyses. This work may be beneficial either to improving the ferric oxide assisted roasting - alkali leaching silica process for treating aluminosilicate solid wastes or to developing a new technology for preparing opaline silica hydrate.

- **Keywords:** Sodium silicate solution; Seeded precipitation; Silica hydrate; Precipitation mechanism

Fanhui Guo, Yang Guo, Guofeng Qiu, Jie Xu, Yanjie Niu, Yixin Zhang, Lixiang Jiang, Xianghong Hu, Jianjun Wu, Haijun Zhang. *A new separation flowsheet for resources recovery from waste coal gasification fine slag black water and its benefits analysis*. Pages 836-845.

The gasification fine slag black water (GFSBW) is a kind of slurry including fine gasification fine slag particles produced in the coal gasification process and ineffective disposal process causes environmental pollution and resources waste. The aim of this study is to recover combustible matters, high silica-aluminum minerals and water resources via reprocessing GFSBW by innovative separation process of "flotation-agitator-ceramic membrane vacuum (CMV) dewatering". The physicochemical properties of samples are characterized and at least 6 kinds of carbon-ash occurrence modes of gasification fine slag were found. The flotation process could be a useful method to separate residual carbon and tailing ash. The dewatering processes of flotation slurries are then achieved by the ceramic membrane vacuum filtration, followed by dewatering combustible matters, high silica-aluminum minerals and industrial-water-grade filtrate will be recovered. It is worth noting that the components separation of GFS eliminates their synergistic water holding effect and the average dewatering effect after flotation is improved by 11.67%, and the fixed carbon content of combustible matters is elevated from 22.74% to 44.64%, while the tailing ash including high silica-aluminum minerals is purified to 97.25%. A novel flotation-agitator-ceramic membrane vacuum (CMV) dewatering flowsheet is developed, and useful resources could be recovered to realize waste comprehensive utilization. The proposed GFSBW processing flowsheet could bring 9.82 million US$ per year which is benefit.

- **Keywords:** Gasification fine slag black water; Waste management; Slag characterization; Efficient separation; Benefits analysis

Shanshan Wei, Yan Chen, Xiaoqin Wei, Chunying Dong, Meiqiang Cai, Zhijun Song, Yuejing Shi, Micong Jin, Ting Xu. *Understanding mechanism of improved-dewatering of waste activated sludge by multi-stage pressurized vertical electro-osmotic*. Pages 846-856.

A multi-stage pressurized vertical electro-osmotic dewatering (MS-PVEOD) were designed to break through the dewaterability limit of pressurized vertical electro-osmotic dewatering (PVEOD) process and reduce energy consumption (EC). The effects of mechanical pressure and voltage on sludge moisture content (MC) are studied. The

sludge MC can be reduced to 44.6 % and 54.7 % respectively after MS-PVEOD (0–2–3.5 MPa) and PVEOD (2–2–2 MPa) process dewatering under 40 V, and the total EC of the former is 33 % lower than that of the latter. The sludge morphology, electric current, protein (PN) and polysaccharide (PS) content and fluorescence spectrum of extracellular polymeric substances (EPS) were analyzed. The PN/PS of the sludge treated by the MS-PVEOD process is 16.3 % higher than that of the PVEOD process, and 20.0 % higher than that of the raw sludge (RS). The three-dimensional fluorescence spectrum (3D-EEM) showed that the fluorescence of hydrophilic fulvic acid and humus decreased more than that of hydrophobic tryptophan protein and tyrosine protein. The present work may be helpful to understand the dewatering mechanism of MS-PVEOD and provides some useful technical guidance for the industrial application of efficient deep dewatering of sludge.

- **Keywords:** Electro-dewatering; Multi-stage pressurization; Extracellular polymeric substances; Hydrophilicity; Electro-osmotic

Jingyi Lu, Yunqiu Fu, Jikang Yue, Lijuan Zhu, Dongmei Wang, Zhongrui Hu. *Natural gas pipeline leak diagnosis based on improved variational modal decomposition and locally linear embedding feature extraction method*. Pages 857-867.

Natural gas pipeline leaks can cause serious hazards to natural gas transportation and pose considerable risks to the environment and the safety of residents. Therefore, feature extraction of pipeline signals is crucial in natural gas pipeline leak detection. However, the quality of feature extraction directly affects the effectiveness of pipeline leak detection. Therefore, this paper proposes a pipeline leakage feature extraction method based on variable mode decomposition (VMD) and local linear embedding (LLE). First, the pipeline signal is decomposed into several modal components by VMD; then, the dispersion entropy is used to select the feature modes. Secondly, the time-frequency domain features of different components are extracted to construct a high-dimensional feature matrix, which LLE reduces to obtain the classified low-dimensional feature vectors. Finally, the extracted feature vectors are used to train and test the support vector machine (SVM). By analyzing the experimental results, it can be seen that the proposed method can classify pipeline signals with an accuracy of up to 95%, which effectively solves the problem of false alarms and missed alarms in pipeline leakage detection.

- **Keywords:** Variational mode decomposition; Locally linear embedding; Characteristic modes; Feature extraction; Leak detection