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Amal I. Saba, Ammar H. Elsheikh. *Forecasting the prevalence of COVID-19 outbreak in Egypt using nonlinear autoregressive artificial neural networks*. Pages 1-8.

SARS-CoV-2 (COVID-19) is a new Coronavirus, with first reported human infections in late 2019. COVID-19 has been officially declared as a universal pandemic by the World Health Organization (WHO). The epidemiological characteristics of COVID-2019 have not been completely understood yet. More than 200,000 persons were killed during this epidemic (till 1 May 2020). Therefore, developing forecasting models to predict the spread of that epidemic is a critical issue. In this study, statistical and artificial intelligence based approaches have been proposed to model and forecast the prevalence of this epidemic in Egypt. These approaches are autoregressive integrated moving average (ARIMA) and nonlinear autoregressive artificial neural networks (NARANN). The official data reported by The Egyptian Ministry of Health and Population of COVID-19 cases in the period between 1 March and 10 May 2020 was used to train the models. The forecasted cases showed a good agreement with officially reported cases. The obtained results of this study may help the Egyptian decision-makers to put short-term future plans to face this epidemic.

- **Keywords:** COVID-19; Forecasting; Neural networks; Egypt

Nirmal Kumar Shahi, Minsoo Maeng, Donghyun Kim, Seok Dockko. *Removal behavior of microplastics using alum coagulant and its enhancement using polyamine-coated sand*. Pages 9-17.

In recent years, microplastics (MPs) smaller than 100μm have been reported to be abundant in bulk water samples from drinking water treatment plants (WTPs). In this study, the removal behavior of MPs for different sizes (10–100μm), shape and surface morphology were investigated using alum coagulant and alum combined with cationic polyamine-coated (PC) sand. For identification and quantification, MPs were stained with Nile Red dye and observed under a laser scanning fluorescent microscope. The removal of MPs increases with increasing doses of alum up to 30mgL−1 (70.7%). Further increases in the doses resulted in a sharp decrease in the removal of MPs. The analysis for different sizes showed lower removal of smaller MPs (10–30μm) for all doses of alum. PC sand (500mgL−1) combined with 20mgL−1 of alum dose showed the highest removal (92.7%) of MPs. The removal was enhanced by 26.8% when compared with alum alone. The removal of MPs followed the behavior of elongated-rough (ER)>elongated-smooth (ES) >spherical-rough (SR)>spherical-smooth (SS) and was supported by a flocculation

kinetic study. This study revealed that size, shape and surface morphology of MPs play important roles in the removal of MPs from drinking WTPs.

- **Keywords:** Microplastics; Orthokinetic flocculation; Cationic polyamine-coated sand; Physical characteristic; Fluorescent technology

Zhirong Wang, Fei Jiao, Xingyan Cao, Kewei Jiang, Shichang Ma, Zhonglin Yin. *Mechanisms of vapor cloud explosion and its chain reaction induced by an explosion venting flame*. Pages 18-27.

This experimental study focused on vapor cloud explosion and its chain reaction induced by an explosion venting flame. Two vapor clouds were installed in front of the explosion venting container along the horizontal direction. Explosion flame evolution process was recorded by a high-speed camera and a schlieren system. Pressure sensors at different locations were used to acquire the pressure data. The temperature data were collected by a high-speed infrared thermal imager and three thermocouples. The changes in flame propagation characteristics, flame temperature, and pressure distribution were determined, and the mechanisms of the vapor cloud explosion and its chain reaction induced by the venting flame were deeply analyzed. Results indicate that the venting flame could induce vapor cloud explosion and set off a chain reaction, leading to the high explosion intensity. As for the ignition condition, the venting flame directly came in contact with the vapor cloud and provided the required energy for the ignition. The pressure first increased and then decreased as the distance from the venting port increased, and the highest pressure appeared in the central region of the vapor cloud. The temperature distribution also presented a similar phenomenon.

- **Keywords:** Venting flame; Vapor cloud explosion; Chain reaction; Flame temperature; Explosion pressure

Mourad Chebila. *Generalized markovian consideration of common cause failures in the performance assessment of safety instrumented systems*. Pages 28-36.

Aiming to provide a generalized method for assessing the performance of safety instrumented systems with a flexible and accurate consideration of the common cause failures' contribution. This paper is devoted to the development of a direct way to generate the transition rate matrix associated with the continuous-time Markov model of any typical KooN architecture using any parametric model. Such a choice is considered after a detailed comparison of the ability of several dependability methods (e.g., fault trees, reliability block diagrams, Markov models, Bayesian networks, etc) to provide simple representations and genuine results in this context. To validate the developed method, the unavailability and the unconditional failure intensity of a wide range of configurations are quantified using the Binomial Failure Rate model and compared to those of the complete fault tree implementation.

- **Keywords:** Safety instrumented systems; Common cause failures; Markov process; Reliability analysis

Alireza Khataee, Mahdi Ebrahimi Farshchi, Mehrangiz Fathinia, Hassan Aghdasinia. *Photocatalytic ozonation process for degradation of an anthelmintic drug using ceramic coated TiO2 NPs: CFD simulation coupling with kinetic mechanisms*. Pages 37-48.

This paper reports numerical usage for modeling and simulation of the mebendazole (MBZ) photocatalytic ozonation in a stirred tank photoreactor by computational fluid dynamics (CFD) method, from mechanistic aspects in the presence of novel method of

TiO2 coating ceramic panels. In the first part of the study, TiO2 nanoparticles (NPs) were fixed on the exterior surface of porous ceramic panels by a new modified sol-gel method. The coated surface presented very high stability and durability for 12 runs during a year of the process implementation. The morphological characteristics of the coated and bare panels were scrutinized by SEM and AFM analysis. The evolutional impacts of input parameters such as pH, inlet ozone dosage and initial MBZ concentration on MBZ removal efficiency were experimentally investigated. More than 95% degradation was achieved only after 35min. In the second section, a numerical study of MBZ photocatalytic ozonation has been evaluated by CFD method. Assessment of this process was investigated from two viewpoints: momentum and mass balances. The experimental results revealed a high amount of MBZ elimination in the aforementioned photoreactor. Moreover, CFD modeling simulated the mechanisms of MBZ photocatalytic ozonation. The obtained results described that MBZ degradation has occurred via the two homogenous and heterogeneous pathways in the presence of OH radicals. Briefly, the CFD results confirmed the experimental results from the standpoint of hydrodynamics and various species concentrations.

- **Keywords:** Computational fluid dynamics (CFD); Photocatalytic ozonation; Immobilization; Mebendazole; TiO2 nanoparticles

Frederic Heymes, Roland Eyssette, Pierre Lauret, Pol Hoorelbeke. *An experimental study of water BLEVE*. Pages 49-60.

A boiling liquid expanding vapour explosion (BLEVE) is a physical explosion caused by a sudden rupture of a vessel containing superheated liquid. A BLEVE can occur with many types of fluids and is not an exclusive phenomenon for flammable liquefied gases such as propane or butane. Other superheated liquids suffering a fast depressurization at high temperature may entail a BLEVE, such as water in steam generation systems. Several pieces in literature suggest that superheated water may produce a BLEVE, but little experimental data can be found on that topic. The aim of this work was to perform water BLEVE tests with a 14 L pressure vessel designed on purpose to produce high superheated liquid water (290 °C; 75 bar) and to trigger a BLEVE through calibrated rupture disks. Pressure sensors were set in the vessel to measure the internal phase change pressure dynamics and other aerial overpressure sensors were put around the relief rupture disk to capture the blast wave. Temperature of water was also recorded, and a fast camera (Phantom V2512) was used to see the phenomenon. Data show clearly the pressure recovery due to rapid boiling in the vessel. Explosive boiling did not add additional internal pressure force on the containment. Two main blast waves were observed, they were strongly related with outlet orifice area but little dependant on filling ratio. The two phase jet reached a 20 m range.

- **Keywords:** BLEVE; Superheat limit temperature; Explosion; Superheated water; Explosive phase change; Blast; Boiler explosion

Camilla Di Marcantonio, Agostina Chiavola, Simona Dossi, Giancarlo Cecchini, Simone Leoni, Alessandro Frugis, Massimo Spizzirri, Maria Rosaria Boni. *Occurrence, seasonal variations and removal of Organic Micropollutants in 76 Wastewater Treatment Plants*. Pages 61-72.

The present study shows the results of an experimental survey conducted over 34 months on 76 full-scale Wastewater Treatment Plants located in central Italy with the aim to determine the influent and effluent concentrations of 13 Organic Micropollutants belonging to the class of illicit drugs, pharmaceuticals and steroids. The survey focused on a large set of plants differing for the main characteristics (e.g. treatment capacity, type of lay-out). Based on the values measured in the influent and effluent, removal efficiency of each contaminant in each plant was also determined, as well as the seasonal variation of the influent concentration. Among the monitored pollutants, some illicit drugs

(i.e. Benzoylecgonine, 11-nor-carboxy-Δ9-tetrahydrocannabinol) and Ketoprofen showed the highest concentrations in the influent and were also the most frequently detected in the wastewater; nonetheless, the plants were capable of removing these pollutants at high extent (median removal value of 70 %, 65 % and 74 %, respectively). On the other side, steroid concentrations were in most cases under the detection limits. About the type of lay-out, the comparison of the efficiency obtained by the different plants showed that combination of secondary and tertiary treatment provides the best removal for most of the target Organic Micropollutants.

- **Keywords:** Endocrine disrupting compounds; Illicit drugs; Organic emerging micro-pollutants; Pharmaceuticals; Removal; Wastewater

Fatma Karray, Fathi Aloui, Meryem Jemli, Najla Mhiri, Slim Loukil, Rihab Bouhdida, Nabil Mouha, Sami Sayadi. *Pilot-scale petroleum refinery wastewaters treatment systems: Performance and microbial communities' analysis*. Pages 73-82.

This study evaluated firstly the performance of the Continuous Stirred Tank bioReactor system (CSTR) for the treatment of highly toxic petroleum refinery wastewaters at the pilot-scale. The reduction of the COD, BOD5, phenols, and the total petroleum hydrocarbon (TPH) reached 82.10%, 85.87%, 91.63%, and 81.11%, respectively at high hydraulic residence time (HRT = 10 days). Decreasing HRT to 5 and 2.5 days led to a decrease in the efficiency of the process and a decrease in biomass concentration was also observed (<1000 mg/l). We investigated to test Membrane Bioreactor (MBR) configuration inoculated with the same microbial consortium of CSTR. Therefore, the removal efficiency reached 89.14% of COD and biomass concentration increased to 2800 mg/l at HRT = 1 day. Microbial biomass showed high acclimatization to the toxic wastewater. Communities' abundance and composition in CSTR and MBR were then performed using culture-independents approaches (qPCR, Illumina Miseq sequencing, and DGGE) based on the 16S rRNA gene sequencing. Results showed that major genera affiliated with Betaproteobacteria and Gammaproteobacteria were commonly shared in both bioreactors. The MBR presented a higher bacterial abundance and diversity than the CSTR. Furthermore, dominant genera belonging to Alphaproteobacteria and Bacteroidetes were exclusively detected in CSTR and MBR, respectively. Six potential hydrocabonclastic bacteria were isolated from the CSTR. This study demonstrates the occurrence of specific acclimated bacterial communities in MBR different from those identified in CSTR, improving the petroleum hydrocarbon wastewater treatment. The results would be useful in developing an MBR system for treating toxic stripped wastewater at a larger scale.

- **Keywords:** Petroleum refinery wastewater; CSTR; MBR; Microbial diversity; Phenols; Hydrocarbon compounds

Guixin Zhang, Zhenlei Wang, Hua Mei. *Sensitivity clustering and ROC curve based alarm threshold optimization*. Pages 83-94.

In industrial practice, to reduce the variable alarm rate and ensure the safety and stability of device production, a variable alarm threshold is optimized by taking into account the receiver operating characteristic (ROC) curve that corresponds to sensitivity clustering, false alarm rate (FAR), and missed alarm rate (MAR). In this paper, the sensitivity value of the variable calculated and the grouping rule recommended by the engineering equipment and materials users association (EEMUA) are first used to cluster the variables into groups and to calculate the relevant weight ω1. In this approach, in addition to the original weights, ω1 and ω2 are the remaining weights, which correspond to the FAR and MAR, respectively. Later, the ROC functional relationship between ω1 and ω2 is obtained by the correlativity between the FAR and MAR. An optimized objective function with respect to the FAR, MAR, and original weights is then established, with the

clustering weight ω1 and ω2 added to the original weights of the FAR and MAR, respectively. Eventually, the objective function is optimized to obtain the optimal alarm threshold by using the particle swarm optimization (PSO) algorithm. The experimental results on the Tennessee Eastman (TE) industrial simulation data show that the proposed method can greatly reduce the FAR according to the variable sensitivity effect on the system, and it can decrease the number of alarms with a reduction rate of 37.8 % in comparison to the initial situation totally.

- **Keywords:** ROC curve; Sensitivity clustering; FAR; MAR; PSO; Alarm threshold optimization

Arash Esmaeili, Zhibang Liu, Yang Xiang, Jimmy Yun, Lei Shao. *Modelling and validation of carbon dioxide absorption in aqueous solution of piperazine + methyldiethanolamine by PC-SAFT and E-NRTL models in a packed bed pilot plant: Study of kinetics and thermodynamics*. Pages 95-109.

A pilot plant with a closed cycle of the absorption/desorption process has been taken into account for the simulation of carbon dioxide (CO2) capture by piperazine (PZ) + methyldiethanolamine (MDEA) solution using Aspen Plus rate-based model with all design and operational parameters such as the hydraulic specifications of absorber and stripper as well as inlet flue gas conditions which are present in a commercial gas-fired burner for heating houses. Metal FLEXIPAC 250Y has been considered as the packing type to apply the model to the proposed correlations on Aspen Plus for calculation of flooding and pressure drop. In order to simulate the process, a new property package has been developed by electrolyte non-random two-liquid (E-NRTL) model and perturbed-chain statistical associating fluid theory (PC-SAFT) equation of state which are used for the calculation of activity and fugacity coefficients respectively. The model has been compared with some experimental data e.g. CO2 absorption efficiency and CO2 loading and demonstrated good agreement with them.

- **Keywords:** Absorption; Aspen plus; Carbon dioxide; PC-SAFT; Piperazine; Simulation

Raul Payri, Jaime Gimeno, Pedro Martí-Aldaraví, César Carvallo. *Parametrical study of the dispersion of an alternative fire suppression agent through a real-size extinguisher system nozzle under realistic aircraft cargo cabin conditions*. Pages 110-122.

Nearly all active fire extinguishing systems consist of injecting an agent into the space set on fire. For aircraft cargo cabins, the agent widely used up to date is Halon 1301. The FAA provides a level of safety for this fire suppression agent that needs to be used in a volumetric concentration of 6% and needs to be acting for a duration of 0.5s. On the other hand, Halon 1301 is known to contribute to the retrenchment of Earth's atmospheric ozone layer, therefore it is going to be prohibited in the incoming years. The FAA has defined an equivalent level of safety in terms of the performance of the alternative agents. In this research, two different alternative fire suppression agents and two nozzles were tested at two vessel back-pressure conditions using a new design in purpose facility and an injection system able to control the injection pressure and the injection duration (the agent injected mass) in order to satisfy the FAA performance conditions. The discharge volume is a rectangular constant volume constant pressure vessel of approximately 0.85m3 and 1.5m of length that is provided with two transparent windows of 0.75m×1.5m to ensure an optical access to study the whole agent injection and it mixing process. Liquid phase distribution of the agent injected inside the vessel is measured by means of Diffuse Back-Light Illumination (DBI) technique. Vapor phase distribution, when present, is measured through the single-pass Schlieren technique.

Results show a poor performance in terms of spatial distribution (narrow jet with little atomization) of the two alternative agents injected through the nozzle actually used in the aircraft cargo cabin fire suppression systems. However, simply replacing the nozzle and using one with a swirler showed excellent performance in terms of spray penetration and spreading angle. This results ratify that the nozzles of the fire extinguisher system currently used in the aircraft cargo cabin does not work for the alternative agents tested.

- **Keywords:** Fire suppression agent; Spray; Penetration; Spreading angle; Spatial distribution

Shengli Liu, Yi Wang, Yongtu Liang. *Environmental consequence analysis of oil spills from onshore pipelines with parametric uncertainty*. Pages 123-134.

Due to spatial heterogeneities, measurement errors and inherent errors of parameter estimation, hydrogeology parameters are not exactly known. Therefore, the accuracy of environmental consequence prediction for oil spills from onshore pipeline accidents is subject to the uncertainty of soil parameters. However, due to the time-consuming calculation of uncertainty analysis and the difficulty of modeling the cross-correlation among soil parameters, the correlativity is often overlooked in the current researches involving the impacts of uncertain soil parameters on the environmental consequence estimation. To address above concerns, this study introduces a novel methodological framework for investigating the contribution of correlated soil parameters on the environmental consequence caused by spilled oil from onshore oil pipeline accidents. The proposed methodological framework combines a polynomial chaos expansion(PCE) surrogate model and methods from Uncertainty Analysis (UA) and PAWN-based Global Sensitivity Analysis (GSA). In addition, the practical application of this framework is illustrated with a case study for estimating the contaminated range of spilled oil from onshore pipeline accidents. First of all, the correlation of soil parameters is modeled by the copula function, and a PCE surrogate model has been constructed in order to alleviate the computational burden of the following UA and PAWN-based GSA. Then, UA is performed to quantify the impacts of correlativity by means of Monte Carlo (MC) method. Results reveal the correlativity of soil parameters introduces a substantial variation in the estimation of contaminated depth of spilled oil. In addition, the UA results show that selecting different copula functions to describe the correlation of soil parameters may lead to different variations of contaminated depth. Moreover, the uncertainty of the calculation results has been reduced with the consideration of correlated soil parameters, which may make the calculation results more reliable. Finally, the PAWN-based GSA is performed to identify the most influential parameter on the variation of contaminated depth. Results of the GSA show that saturated permeability and scale parameter α are primarily responsible for the variability of the model output, while the porosity exerts a smaller influence. This finding also suggests the possibility of replacing the less influential parameters with its average value, thus appreciably reducing the computation cost of the problem. The results of GSA not only offer a better understanding of correlativity to the contaminated range of spilled oil, but also identify the parameters for which additional effort needs to be invested to reduce their uncertainty and, as a result, the uncertainty associated with environmental consequence estimation of onshore pipeline accidents.

- **Keywords:** Uncertainty analysis; Global sensitivity analysis; PAWN; Environmental consequence

Ehsan Arzaghi, Bing H. Chia, Mohammad M. Abaei, Rouzbeh Abbassi, Vikram Garaniya. *Pitting corrosion modelling of X80 steel utilized in offshore petroleum pipelines*. Pages 135-139.

High strength steels such as X80 steels have recently been used more frequently in production of offshore structures. However, they may still be subject to degradation processes such as corrosion considering the conditions in marine environment. Pitting corrosion is a destructive form of corrosion which reduces the material resistance and may result in failure accidents with severe financial, human life and environmental consequences. The process of pitting corrosion is inconsistent and largely stochastic being influenced by a number of parameters with a high level of uncertainty. This makes it very difficult to predict corrosion in terms of its initiation time and spatial behavior. Therefore, it is vital to investigate pitting corrosion phenomena in offshore structures using a probabilistic approach for the assessment of structural reliability and operational safety. In this study, an in-situ experiment has been conducted on X80 steel in an NaCl solution in a laboratory environment to observe the generation and growth of corrosion pits. A probabilistic model based on Hierarchical Bayesian Approach (HBA) is developed for predicting the pitting corrosion growth rate using experimental results. In order to model the process more realistically, the proposed methodology considers the degradation process to be consisting of the time needed for pit initiation and propagation. The results indicate that the proposed methodology is capable of predicting the time required to reach a specific pit size. The methodology developed in this study can be applied to estimate the remaining useful life of subsea structures.

- **Keywords:** Pitting Corrosion; Deterioration; Offshore Structures; Bayesian Inference; Markov Chain Monte-Carlo

Fares AlMomani, Banu Örmeci. *Assessment of algae-based wastewater treatment in hot climate region: Treatment performance and kinetics*. Pages 140-149.

This study evaluated the use of microalgae for wastewater treatment in hot climate regions. The growth rates of C. vulgaris (C.v.) and N. oleoabundans (N.o.) at 36 °C were studied in primary effluent (PE), secondary effluent (SE) and centrate (CEN) and their performance in removing soluble chemical oxygen demand (CODs), inorganic nitrogen and total dissolved phosphorus were determined. A comprehensive kinetics model was developed to predict algae growth and treatment efficiencies under the studied conditions. Significant differences between the growth patterns and rates of C.v. and N.o. were observed in different wastewater samples. C.v. showed the highest growth rate in CEN followed by PE and SE. N.o. showed the highest growth rate in PE followed by SE and CEN. The percentage CODs removals (%CODs) for C.v. were 51%, 55% and 80%, and for N.o. were 63%, 47% and 72% in PE, SE, and CEN, respectively. Ammonia removal efficiencies (70%–84%) were very similar for C.v. and N.o. in different wastewaters. Phosphorus removal by C.v. and N.o. was high in PE (> 84%), moderate in CEN (>22%) and limited in SE (<15%). Growth rates of C.v. and N.o and percent removals of CODs, ammonia, nitrate and total dissolved phosphorus at 36 °C were compared to those at 20 °C. The kinetics of algal strains, validated using experimental data, accurately reproduced the growth profile and evolution of organic matter and nutrients, permitting process optimization and scale-up. The results of the study showed that microalgae can be successfully cultivated in a wide range of wastewaters at 36 °C and can achieve natural treatment of wastewaters in hot climate regions by removing organic carbon, nitrogen, and phosphorus.

- **Keywords:** Micro algae; Wastewater; Growth; Carbon; Nitrogen; Phosphorus

Haitao Li, Jun Deng, Xiaokun Chen, Chi-Min Shu, Chia-Ho Kuo, Xiaowei Zhai, Qiuhong Wang, Xiangyu Hu. *Qualitative and quantitative characterisation for explosion severity and gaseous–solid residues during methane–coal particle hybrid explosions: An approach to*

***estimating the safety degree for underground coal mines*. Pages 150-166.**

Methane–coal dust explosions can damage coal mining equipment and the working environment by overpressure, particulate release, and gas emissions. In this study, we investigated the influence of fuel concentration and coal particle size on multiple explosion parameters for methane–coal particle mixtures within a 20-L sphere. Next, we analysed the effects of fuel concentration and coal particle size on the oxygen consumption index (OCI). Then, we determined the quantitative and qualitative data pertaining to oxycarbides and hydrocarbons. The surface microstructures, pore structure properties, chemical composition, particle size distribution, and thermal hazard of solid residues and raw samples were systematically evaluated. Results revealed that fuel concentration and particle size exert large influences on the explosibility of methane–coal dust mixtures. Oxycarbides and hydrocarbons were analysed because they are useful for predicting explosions and monitoring air quality. We investigated the effects of microstructure, pore structure, and particle size. We proposed a mechanism by which methane–coal particle hybrid mixtures induce explosions, including the formation pathway of gaseous and solid products. This study aids strategic decision-making pertaining to the prevention of methane–coal dust explosions.

- **Keywords:** Methane–coal dust explosion; Particulate release; Explosion parameter; Thermal hazard; Gaseous and solid products

Hui Liu, Rui Hong, Chenglang Xiang, Haining Wang, Yanqiang Li, Guang Xu, Ping Chang, Kai Zhu. *Thermal decomposition kinetics analysis of the oil sludge using model-based method and model-free method*. Pages 167-177.

Oil sludge (OS) is one of the main waste in the petrochemical industry, and serious consequences can result from the improper disposal of this waste. Pyrolysis is an effective method to dispose of OS and to recover the high heating value combustibles from it. The pyrolysis of three OS samples was carried out in a nitrogen atmosphere at heating rates of 5°C/min, 10°C/min, and 20°C/min, respectively. The TG-DTG/DSC-DDSC curves show that the thermal decomposition of OS has been divided into 5 stages, and each stage has unique thermal decomposition characteristics. Two model-free methods were used to calculate the apparent activation energy at a conversion rate from 0.05 to 0.95, and based on 10 solid-state mechanisms of thermal decomposition, the model-based method was used to fit the thermal decomposition mechanisms exposed to the three heating rates. The results show that the high heating rate is beneficial for the pyrolysis of OS. The apparent activation energy varies irregularly with the conversion rate, and the apparent activation energy error calculated by the FWO method is smaller. For the three samples, OS-1, OS-2 and OS-3, the average apparent activation energies calculated by the FWO method are 40.39kJ/mol, 38.01kJ/mol, and 85.53kJ/mol, respectively. The mechanism function of OS thermal decomposition changed, and the process of thermal decomposition should be described by a three-step thermal decomposition model. During 140.48–331.88°C, the fitting correlation coefficients of the two-dimensional phase interfacial reaction mechanism under the three heating rates were all above 0.99. During 400.00–556.57°C, the fitting result of the three-dimensional nucleation and growth mechanism is better than fitting results of other models. During 583.82–676.60°C, the two-dimensional diffusion mechanism has a good fitting regression. Significantly, model-based method and model-free method provide effective and reliable thermal decomposition kinetics parameters and models as a theoretical support for optimization of OS industrial pyrolysis and treatment of OS.

- **Keywords:** Oil sludge; Pyrolysis; Model-based method; Model-free method; Thermal decomposition kinetics

Jui-Yuan Lee, Ya-Chu Lu, Ying-Chen Chen. *A sizing-validation approach to hybrid power system design and planning*. Pages 178-189.

Renewable energy (RE) is an important emissions reduction technology for climate change mitigation. Hybrid power systems (HPSs) are designed to facilitate the deployment of RE. This paper addresses HPS design under RE resource uncertainties and presents a two-step mathematical approach. The method involves the use of an optimisation model for HPS sizing and Monte Carlo simulation for results validation. The superstructure-based model considers all feasible power allocation options in an HPS and allows the selection of energy storage technologies. To account for resource uncertainty, chance-constrained programming is applied in the optimisation model and the effective power output of renewable sources can be computed according to the specified system reliability. The optimised HPS configuration is then simulated and its reliability estimated to ensure that the specified system reliability level is achieved. Two case studies of isolated and on-grid HPSs are used to demonstrate the proposed approach. The results show that for higher system reliability, the isolated system requires larger generator and energy storage capacities, whilst the on-grid system requires more grid electricity instead of intermittent RE. Further analyses are performed to explore the trade-off between cost and carbon emissions as well as to assess the effects of electricity price and emission factors on HPS design.

- **Keywords:** Renewable energy; Microgrid; Resource uncertainty; System reliability; Mathematical programming; Monte Carlo simulation

Fida Tibi, Amine Charfi, Jinwoo Cho, Jeonghwan Kim. *Fabrication of polymeric membranes for membrane distillation process and application for wastewater treatment: Critical review*. Pages 190-201.

Membrane distillation (MD) is a thermally driven membrane separation process in which only vapor molecules can be transferred through hydrophobic membrane. Significant efforts have been made with MD membrane especially for seawater desalination, but its application is expanded quickly for wastewater treatment and reuse. Membrane performance in MD process varies strongly depending upon the intrinsic properties of membrane materials. This paper provides critical reviews on MD membrane focusing on fabrication methods and membrane materials as well as its applications for wastewater treatment and reuse. To achieve high effluent quality for wastewater reuse purposes, the MD process is integrated with membrane bioreactor (MBR) although both organic and inorganic fouling are the main issues to be resolved in hybrid MD system.

- **Keywords:** Membrane distillation; Wastewater; Membrane materials; Membrane bioreactor; Fouling

Ting Liu, Baiquan Lin, Xuehai Fu, Chuanjie Zhu. *Modelling air leakage around gas extraction boreholes in mining-disturbed coal seams*. Pages 202-214.

Air leakage is one of the most important factors that affect the underground gas extraction in mining-disturbed coal seams. It was demonstrated that the gas concentration in most in-seam boreholes decreased to a very low level in a short time. Such a low concentration may lead to secondary disasters such as coal spontaneous combustion, gas explosion and gas combustion. Aiming at this problem, a fully coupled mechanical- composite gas flow (MCF) model was developed to reveal the mechanism of air leakage around the borehole. The reliability of the model was verified by matching the calculating results with gas extraction data monitored in the field. Then, with the MCF model, factors affecting the gas extraction effect were systematically investigated. It was found that the mining-disturbed zone led to an increase of both the gas and air flow rate,

but a decrease of the gas concentration in the borehole. Both the gas and air flow rate reduced with an increase of the sealing length of the borehole, while the gas concentration showed an increase trend. The optimal sealing length of the in-seam borehole in Pingmei 8th Mine was identified as 10−14 m. In addition, the attributes of the coal seam itself also have obvious influence on the quality of the gas extracted. The results indicate that both the borehole and the mining-induced fractures around the borehole should be appropriately treated to improve the quality of gas extracted. Therefore, we propose a new sealing method which integrates cement grouting and gel injection. In this method, after the sealing of the gas extraction boreholes, the sodium silicate and ammonium bicarbonate aqueous solutions were mixed and injected into the coal seam. The produced silicone gel could block the mining-induced fractures and the crescent-shaped gap between the sealing material and borehole wall, thus preventing the air leakage. The research results could help to optimize borehole sealing and improve the quality of gas extracted, thus prevent disasters such as coal spontaneous combustion and gas explosion, so as to guarantee the safety of mining and reduce the greenhouse gas emission.

- **Keywords:** Safe extraction; Air leakage; Binary gas system; Multifield coupling; Mining disturbed coal seam

Vicent Hernández-Chover, Lledó Castellet-Viciano, Francesc Hernández-Sancho. *Preventive maintenance versus cost of repairs in asset management: An efficiency analysis in wastewater treatment plants*. Pages 215-221.

The operation and management of Wastewater Treatment Plants (WWTPs) is of paramount importance to guarantee the sustainability of water resources. Just like any other production process, wastewater treatment process involves different costs, such as: energy, personnel, maintenance and reagents. Regarding maintenance costs, they have become an issue of great concern to many operators in the last years. Maintaining the facilities in good condition ensures the proper performance of these infrastructures and reduces the risk of failures. It should be known that equipment breakdowns imply an increase in operating costs, with a high risk of generating an environmental damage due to the malfunction or the stoppage of the process. To address this situation, preventive maintenance polices are portrayed as the best strategies to reduce equipment breakdowns and repairs. Although maintenance costs are a relevant issue for wastewater treatment plant operators, there are not many studies that assess the influence of maintenance on the efficiency of the facilities. In order to fill this gap an empirical study is proposed for a sample of wastewater treatment plants facilities.

- **Keywords:** Infrastructure management; Preventive maintenance; Repairs; Efficiency; Risk management; Operating costs; Energy consumption

Vinita Khum-in, Jirapon Suk-in, Papop In-ai, Kitsanateen Piaowan, Yanapat Phaimisap, Wisa Supanpaiboon, Tanapon Phenrat. *Combining biochar and zerovalent iron (BZVI) as a paddy field soil amendment for heavy cadmium (Cd) contamination decreases Cd but increases zinc and iron concentrations in rice grains: a field-scale evaluation*. Pages 222-233.

Consuming rice grown in contaminated soil that has an elevated level of cadmium (Cd) is a health risk. This study revealed that using a combination of biochar and zerovalent iron (BZVI) reduces the concentration of Cd and enhances that of the essential elements zinc (Zn) and iron (Fe) in rice. The Cd concentration in brown rice grain cultivated in an untreated paddy was 0.84 ± 0.20 mg kg−1, double the acceptable level (0.4 mg kg−1). Soil amendment with BZVI successfully decreased Cd in brown rice by 83 % compared to

the untreated field presumably due to the Cd sorption on biochar (BC) and enhanced ZVI corrosion by-products while ZVI and BC alone achieved only 40 % and 74 % reduction, respectively. Moreover, while using ZVI or BC alone decreased Fe in rice grain by 8–14 %, BZVI enhanced the Fe concentrations in rice grain by 11 % because of Fe2+/Fe3+ release from BC-enhanced ZVI corrosion. Similarly, the presence of BC in BZVI enhanced Zn accumulation in rice grain by 8% due to competitive sorption of Cd2+ on BZVI, which may desorb Zn2+, promoting Zn translocation to rice. Using ZVI alone decreased Zn in rice by 19 %.

- **Keywords:** Cadmium; Essential metals; Rice; Soil amendment; Biochar; Zerovalent iron

Pengfei Wang, Runze Gao, Ronghua Liu, Fuqiang Yang. *CFD-based optimization of the installation location of the wall-mounted air duct in a fully mechanized excavation face*. Pages 234-245.

As a novel ventilation method for fully mechanized excavation face, i.e., wall-mounted air duct, has outstanding advantages in solving the problems of dust pollution and gas overrun. In order to decide the best installation location of the wall-mounted air duct, a physical model was developed proportional to the dimensions of C103 fully mechanized excavation face of the Nahe Coal Mine of the Bai Coal Group in Baise, Guangxi Province. The CFD numerical method was used to analyze the air flow field, dust concentration distribution and gas diffusion of the excavation face when the wall-mounted air duct was installed at different positions. The results showed that the dust and gas control effect in the fully mechanized excavation face was highly dependent on the installation location of the wall-mounted air duct. When the wall-mounted air duct was installed farther away from the working face, on the one hand, the wind curtain moved backward and the dust control effect was poorer; on the other hand, the gas was diffused to a larger distance and the concentration of gas in front of the working face was lower. For the investigated fully mechanized excavation face, the reasonable installation distance of the wall-mounted air duct should be 9.6 m. At this installation distance, the concentration of gas on the working face roof was 0.65%, and the concentration of dusts around the roadheader's driver was 59 mg/m3.

- **Keywords:** fully mechanized excavation face; wall-mounted air duct; installation location; numerical model; dust; gas

Pramoth R., Sudha S., Kalaiselvam S. *Resilience-based Integrated Process System Hazard Analysis (RIPSHA) approach: Application to a chemical storage area in an edible oil refinery*. Pages 246-258.

The hazard that prevails in the chemical storage area of a process industry is exceptionally high in contrast to other different areas. In the present scenario, upcoming process industries handle different hazardous chemicals for processing, due to which the chemical storage area draws more attention with regard to safety. It is very hard to repair the damages brought about unintentionally in a chemical warehouse. Resilience-based Integrated Process System Hazard Analysis (RIPSHA) approach is a recently developed methodology to examine the varied nature of an accident. In this study, storage areas of chemicals, namely sulfuric acid, phosphoric acid, hydrochloric acid, caustic (sodium hydroxide), ammonia in an edible oil refinery in South India were considered for resilient analysis. The results of the study were made in RIPSHA worksheet and represented graphically. The existing risk has been adequately investigated in both plant system layers and managerial system layers, and it has been found that the safety precautions and structural design of the chemical storage area needed development.

- **Keywords:** Chemical storage area; Edible oil refinery; RIPSHA approach; Risk analysis; Resilient nature

Xule Zhou, Jiaqian Yang, Shuning Xu, Jiade Wang, Qingqing Zhou, Yiren Li, Xinyi Tong. *Rapid in-situ composting of household food waste*. Pages 259-266.

Composting can be used to reduce the volume of perishable food waste and increase soil fertility. In this study, an innovative composting device was developed to rapidly crush food waste at home. A special thermophilic microbial agent (Consists of four different functioning microorganisms) was prepared from the local food waste and rotted wood to facilitate degradation. After composting for four days with our device and microbial agent, the water-soluble organic carbon to total organic nitrogen ratio (WSOC/TON) in the mature compost was less than 0.55, the germination index (GI) reached 89.7 %, the pH value was 5.57 and the electrical conductivity (EC) was 1984 μS cm−1. The mature compost met the soil quality standards and was qualified as planting soil. This techno-economic evaluation shows that our domestic composting model saves labor, transport and classification costs compared with the centralized composting system, and presents new disposal and management model of domestic waste. The total cost of our device was only $0.033 per kg for food waste. Taking the disposal fee saved into account, the net profit of the mature compost was $89.06 per year.

- **Keywords:** Thermophilic microorganisms; Domestic composter; High-temperature composting; Plug-flow composting bin; Food waste

Jing Yuan, Xianghong Wang, Mohammadtaghi Vakili, Giwa Abdulmoseen Segun, Lexuan Zhong. *Volatile organic compounds (VOCs) releasing model from tailings solvent recovery unit (TSRU) tailings and its sensitivity analysis in environment management*. Pages 267-277.

During froth treatment and environmental management processing, a small number of hydrocarbons are lost to tailings, especially from a Tailings Solvent Recovery Unit (TSRU), known as TSRU tailings. And some of the residual volatile organic compounds (VOCs) in the tailings are discharged into the atmosphere, which pollutes the air, soil, and groundwater. Besides, understanding the factors that affect the release of VOCs from tailings would promote oil sands design and environmental management. The fate of VOCs in TSRU tailings is studied by employing detailed kinetics models. A new batch experimental setup verified the release model of VOCs and the model predicts the experimental results appropriately. Furthermore, the feasibility of reducing the emission of the VOCs in the tailings was discussed by optimizing the performance of TSRU, and the sensitivity is analyzed. The simulation results also show that the temperature and pressure during the VOCs release process of tailing have a significant influence on the solvent recovery. The results showed that the higher the tailings pressure, the greater the pentane volatilization and the higher the temperature, and the less pentane residue in TSRU tailings. For example, the solvent release rate at 80 °C is about five times higher that at 50 °C.

- **Keywords:** Volatile organic compounds; Tailings; Solvent recovery unit (TSRU); Oil sands; Kinetics model

Lulit Habte, Natnael Shiferaw, Thenepalli Thriveni, Dure Mulatu, Mee-hye Lee, Seok-ho Jung, Ji Whan Ahn. *Removal of Cd(II) and Pb(II) from wastewater via carbonation of aqueous Ca(OH)2 derived from eggshell*. Pages 278-287.

Accelerated carbonation is an effective and attractive method for the utilization of captured and stored CO2. It has versatile applications in different fields. One of the applications presented in this study was investigation of the efficiency of carbonation of Ca(OH)2 derived from waste eggshell to remove heavy metals from wastewater. Cadmium (Cd(II)) and lead (Pb(II)) were the target heavy metals for this study. Three parameters were studied: Ca(OH)2 dosage, initial Cd(II) and Pb(II) concentration, and CO2 flow rate. The optimum conditions were 3g/L of Ca(OH)2, 100mg/L of initial metal concentration and 1L/min of CO2 flow rate where the removal efficiencies were found to be 99.99% and 99.63% for Cd(II) and Pb(II) respectively. The phase transformation has also been detected by XRD, FTIR and TGA/DTA analysis. All the results showed a transformation of Ca(OH)2 to CaCO3 (calcite) due to complete carbonation. The transfer of CO2 during calcite formation in the presence of Pb(II) and Cd(II) was slightly retarded by a retarding factor of 0.06 and 0.09 respectively. The carbonation process was also applied to real wastewater and the performance was effective although it had very low concentrations of cadmium and lead. Precipitation of metal carbonate was the dominant mechanism for the removal of heavy metals.

- **Keywords:** Carbonation; Cadmium; Lead; Waste eggshell; Removal efficiency; Final concentration

Jinyang Fan, Peng Liu, Jiajun Li, Deyi Jiang. *A coupled methane/air flow model for coal gas drainage: Model development and finite-difference solution*. Pages 288-304.

Gas drainage through underground boreholes is intensively associated to safety mining and clean energy capture. The key factor restricting the improvement of underground gas drainage is air leakage around borehole, which always leads to the rapid decay of drained gas concentration and methane production rate. Although tremendous work has been implemented on coal-gas interactions, few studies address the air leakage phenomenon in underground gas drainage operations. This work first presents a coupled compositional flow model by integrating the methane-air mixture flow in fracture, methane flow within the matrix, mass transfer between fractures and matrixes, and permeability evolution induced by gas depletion. Then, a numerical model and a simulator are developed using the finite difference method (FDM) to solve the compositional model and are successfully validated against two sets of in situ gas drainage data. Subsequently, the effect of parametric variations on gas drainage performance is quantified through a series of simulations. The simulated results reveal that: (1) A higher drainage pressure corresponds to a higher drained gas concentration and a longer time for air leakage into the borehole; at the beginning of drainage, the methane flow rate increases linearly with the decrease of drainage pressure. (2)The efficiency of lowering the drainage pressure to enhance methane production is getting weaker with the drainage pressure decreasing. Lowering drainage pressure will transfer more air to the drainage borehole, decrease the concentration of drained gas and pure methane production. Therefore the drainage pressure should be optimized by comprehensively balancing methane production, gas concentration and costs; (3) Increasing the sealing area on the coal wall around the borehole will prevent air from flowing into coal, and linearly promote the concentration of drained gas and methane production; (4) A longer borehole sealing length corresponds to a higher concentration of drained gas and a slower decay of methane production rate, while the increase of drained methane flowrate results from increasing borehole sealing length is non-linear, and an optimal borehole sealing length could be evaluated using the proposed model and simulator to promote the gas extraction efficiency. This coupled model and the numerical results improve the understanding of the methane-air flow behaviors and air leakage phenomenon in coal during underground gas drainage, and suggest a powerful tool for evaluating the drainage gas production objectively and optimizing the gas extraction system scientifically.

- **Keywords:** Underground gas drainage; Air leakage; Coupled flow through coal; Finite difference method; Numerical modeling

Shahin Shahsavari, Seyed Mojtaba Sadrameli. *Production of renewable aromatics and heterocycles by catalytic pyrolysis of biomass resources using rhenium and tin promoted ZSM-5 zeolite catalysts*. Pages 305-320.

The purpose of this study is to investigate the effects of rhenium and tin loading (between 0 and 5% by impregnation method) on a ZSM-5 zeolite catalyst as well as the product distribution and aromatic yield under different catalytic conditions. A biomass to catalyst ratio of 5–20 is also considered. Due to its feed characteristics, beechwood was selected as the biomass resource, and the catalytic pyrolysis process was chosen, for it is an economic process. For a better analysis of the product distribution, all product samples were identified using gas chromatography coupled with mass spectrometry. Responses then were analyzed utilizing the full factorial method. The models obtained for high-economic-value produced aromatic and heterocyclic production had R-Sq. of 92.89 and 96.81 %, respectively, indicating the validity of the proposed models. The results clearly show that by changing the parameters, valuable heterocyclic compounds can be synthesized with acceptable yields. According to the study, the highest aromatic selectivity belongs to catalytic loadings of 1.58 % rhenium and 3% tin resulted in selectivity of 51.27 for aromatic compounds. Moreover, the catalytic loading of 3% rhenium and 3% tin resulted in the highest selectivity with a rate of 24.62 for heterocyclic compounds.

- **Keywords:** Pyrolysis; Biomass; Zeolite; Renewable fuel; Aromatic; Heterocycle

Amin Sokhansanj, S. Majid Abdoli, Mohammad Zabihi. *Insight into simultaneous catalytic oxidation of benzene and toluene in air over the nano-catalyst: Experimental and modeling via CFD-ANN hybrid method*. Pages 321-332.

This study reveals the simultaneous deep oxidation of benzene and toluene over the novel supported cobalt oxide catalyst derived from metal organic framework (MOF) over the almond shell based activated carbon. The performance of the fabricated catalyst was evaluated under the various operating conditions including oxidation temperature, initial concentration of benzene and toluene. The maximum conversion of benzene and toluene were also measured to be 89.74 % and 82.37 %, respectively. The sample morphology was studied by applying XRD, FESEM, BET and TGA analysis. The characterization tests indicated that the well dispersed spherical nano-supported catalyst was synthesized with size of less than 40 nm. To the best of our knowledge, the computational fluid dynamics (CFD) analysis incorporated with artificial neural network (ANN) was also studied for modeling the deep catalytic oxidation over the prepared sample. The modeling involved with the three dimensional analysis of polluted air flow through of a tubular micro-reactor axial inlet and outlet. The computational fluid dynamics was coded by adopting COMSOL Multiphysics to model the catalytic conversion of volatile organic compounds (VOCs) inside the porous media. The kinetic modeling was also conducted by using three-layer ANN to determine the reaction rates while the reaction temperature, initial concentration of benzene and toluene were considered as the input variables of network. The reaction rates were calculated by a non-linear feed-forward network with 5 neurons and log-sigmoid function in the hidden layer while the correlation coefficient was achieved to be 0.99. The validation of CFD model was accomplished which showed the appropriate matching between the experimental data and model achievements. Therefore, the developed intelligent hybrid model (CFD-ANN) in the offered investigation can be a useful tool for studying the fluid dynamics of VOCs oxidation over the nano-catalyst under the different operating conditions.

- **Keywords:** Oxidation; Metal organic framework; Computational fluid dynamic; Neural network

Yunshan Wang, Gang Yang, Jun He, Guangzhi Sun, Zhi Sun, Yong Sun. *Preparation of biochar catalyst from black liquor by spray drying and fluidized bed carbonation for biodiesel synthesis*. Pages 333-343.

Lab-scale experiments were carried out to investigate a new approach of preparing biochar-based catalyst for transesterification reaction. Black liquor (BL) from cotton pulping process was used as a precursor for preparing the catalyst via spray drying followed by fast carbonization in a fluidized bed reactor. Response surface methodology (RSM) was employed to statistically analyze and optimize the entire process of catalytic synthesis of biodiesel from a waste frying oil, consisted of the catalyst preparation and transesterification steps. Several major operation parameters of the biodiesel synthesis process, including alkaline loading in biochar, methanol to oil ratio, catalyst loading, and the carbonization temperature of catalyst, were studied for their effects on biodiesel conversion. The optimal condition for achieving the maximum biodiesel conversion (i.e. 91.5 %) was found to be: 27wt% alkaline loading in biochar, 600°C carbonization temperature, 7.7 methanol to oil ratio, and 6.5wt% catalyst loading. Overall, the spry drying fluidized bed carbonization demonstrated its viability for significantly reducing duration of high temperature carbonization, opening up the prospects of manufacturing the catalyst in a much less energy consumption manor.

- **Keywords:** Biodiesel; Catalyst; Cotton black liquor; Fluidized bed

Yangpeng Liu, Xishi Wang, Tong Liu, Jing Ma, Guochun Li, Zihao Zhao. *Preliminary study on extinguishing shielded fire with water mist*. Pages 344-354.

Fires in commercial and industrial areas, such as large warehouses containing goods on shelves, are inevitably shielded by nearby objects that act as obstacles, making such fires difficult to extinguish. Water mists, as an alternative to the halon fire-extinguishing agent, are capable of bypassing obstacles owing to the small size of the water particles. Therefore, by varying the distance between a plate obstacle and the nozzlefire source, half-scale experiments were performed under different working pressures to determine the critical condition of shielded sand-burner fire extinguishment. The flame temperature and radiant heat flux were measured using thermocouples and a radiometer. The interaction between a water mist spray and a shielded fire was visualized via laser light sheet illumination. The fire-extinguishing capability was analyzed based on the plate obstacle block ratio and the plume–spray thrust ratio. The results indicate that an empirical linear correlation can be adopted to predict the critical plume–spray thrust ratio required for fire extinguishment under different block ratios. In addition, Fire Dynamics Simulator was used to simulate the spray–plume interaction under the shielding conditions employed. The experimental and numerical results show a similar suppression tendency in cases with a low block ratio and fire size. This preliminary study may provide some raw data on shielded fire suppression with a water mist, in addition to serving as a reference for the optimal design of water mist systems.

- **Keywords:** Water mist; Fire extinguishment; Shielded fire; Sand-burner fire; Fire Dynamics Simulator

Siti Suhailah Rosli, Chung Yiin Wong, Normawati Mohd Yunus, Man Kee Lam, Pau Loke Show, Chin Kui Cheng, David K. Wang, Wen Da Oh, Jun Wei Lim. *Optimum interaction of light intensity and CO2 concentration in bioremediating N-rich real wastewater via assimilation into attached*

***microalgal biomass as the feedstock for biodiesel production*. Pages 355-365.**

Impoverishing nutrients from wastewater via assimilation into microalgal biomass has gained footprint in bioremediation technologies. To ease the harvesting of mature microalgal biomass from effluent, this study proposed the employment of fluidized bed bioreactor to grow attached microalgal biomass onto polyurethane foam support material while bioremediating the N-rich real wastewater from chemical fertilizer manufacturing industry. The complete removals of all nitrogen species (NH4+-N, NO2−-N and NO3−-N) together with COD and total phosphorus were achieved at the optimum light intensity and CO2 concentration of 216μmol/m2 s and 9.1 %, respectively, giving rise to the attached microalgal biomass productivity of 0.094g/L/day. These performances were also found maintaining for at least 4 cycles of reiterative uses of spent polyurethane foam support material in similar fluidized bed bioreactor setup condition with every cycle being introduced with fresh N-rich real wastewater. The mechanism of attachment formations study predicted that the polysaccharides and proteins from microalgal extracellular polymeric substances had bridged the cells onto polyurethane foam support material during the initial colonization prior to populating and growing to cover the surfaces of support material. For biodiesel production, the extracted neutral lipid content of attached microalgal biomass was found to be four times higher than the suspended growth culture. From the transesterification process, about 97 %–98 % of attached microalgal lipid could be converted into fatty acid methyl esters (FAMEs) mixture. Interestingly, the degree of saturated fatty acids (SFA) in FAMEs was recorded increasing with the increase of cycles of reusing spent polyurethane foam support material. The presence of more SFA in FAMEs could overall enhance the oxidative stability and contribute to higher cetane number of produced biodiesel from facilely harvested attached microalgal biomass.

- **Keywords:** Bioremediation; Attached microalgal biomass; Fluidized bed bioreactor; Light intensity; CO2 concentration; Biodiesel

Shams Anwar, Faisal Khan, Yahui Zhang. *Corrosion behaviour of Zn-Ni alloy and Zn-Ni-nano-TiO2 composite coatings electrodeposited from ammonium citrate baths*. Pages 366-379.

Electrochemical and corrosion behaviour analysis of Zn-Ni alloy and Zn-Ni-nanoTiO2 composite coatings electrodeposited on steel from ammonium citrate containing bath was performed. The complexation of zinc and nickel ions in citrate stabilized the electroplating bath. The electrochemical behaviour of samples showed that Zn-Ni alloy with the incorporation of 0.003 mol/l of titania (TiO2) nanoparticles exhibited noble corrosion potential (Ecorr) and decreasing corrosion current (Icorr). This leads to increase impedance modulus with a more compact and durable uniform coating of 25.84 nm grain size. The surface characterization and crystalline phase texture of the coatings were investigated by scanning electron microscopy (SEM) integrated with energy dispersive spectroscopy (EDS) and X-ray diffraction (XRD). The topographical structure of the coating was analyzed by atomic force microscopy (AFM). The chemical composition result showed that the Zn-Ni+0.003TiO2 coating electrodeposited from a citrate bath in various immersion tests reduced dezincification in the coating. The presence of higher intensity of the γ-phases (γ-NiZn3) (815) and γ-Ni2Zn11 (330) (631) plane orientation and β-Ti phase provide better corrosion resistance performance of the coating. The most significant corrosion products for Zn-Ni alloy electroplating are simonkolleite, hydrozincite, zincite, and wulfingite.

- **Keywords:** Electrodeposition; Zn-Ni-nanoTiO2; Corrosion prevention; Process safety; Loss prevention; Impedance spectroscopy

Xiaotong Ma, Yingjie Li, Chunxiao Zhang, Zeyan Wang. *Development of Mn/Mg-copromoted carbide slag for efficient CO2 capture under realistic calcium looping conditions.* Pages 380-389.

Loss-in-capacity of carbide slag in CO2 capture restricts the development of industrial wastes in calcium looping technology. In this work, a novel Mn/Mg-copromoted carbide slag was prepared using carbide slag, dolomite and trace Mn(NO3)2 additive. Experimental tests were carried out in the fixed-bed reactor to evaluate how the preparation and the reaction conditions influenced the CO2 capture performance of Mn/Mg-copromoted carbide slag during calcination/carbonation cycles. Results show that MgO diminishes the sintering of synthetic sorbents. The optimal Mn/Mg-copromoted carbide slag (mass ratio of CaO:MgO:MnO2=89:10:1) exhibits the highest CO2 capture capacity of 0.52g/g after 10 cycles under the severe calcination condition (100 % CO2, 950°C) and the wet carbonation condition (15 % CO2/20 % steam/N2), which is 1.7 times as high as that of untreated carbide slag. MnO2 positively affects the slow carbonation stage by enhancing the electron transfer between CaO and CO2. Observations of the morphology of Mn/Mg-copromoted carbide slag indicate that the stabilized CO2 capture performance is mainly attributed to porous structure, MgO as the skeleton and MnO2 as an electron-transfer promoter.

- **Keywords:** MgO promoter; Mn doping; Carbide slag; Calcium looping; CO2 capture

Juanxia He, Liliang Yang, Ye Ma, Daping Yang, Angang Li, Liwen Huang, Yongzhong Zhan. *Simulation and application of a detecting rapid response model for the leakage of flammable liquid storage tank*. Pages 390-401.

The oil terminal is a facility for oil transportation and storage. Flammable gas detectors (FGDs) are able to reliably detect the release of hazardous liquid chemical materials in the tank area, but it cannot accurately obtain the key detecting parameters at the alarm time. This work analyzes the three stages of storage tank leakages under a static storage state. Firstly, the key elements affecting the leakage and detection are analyzed after considering the relative–position relationship of the horizontal distance from the jet point on ground level to the leak hole (Xjet), which denoted by the FGD's coordinate and the wind direction. Secondly, the denser–than–air dispersion is calculated by the SLAB model based on the liquid–pool radius determined by the bisection method (r), the liquid pool area corresponding to the alarm–response time can be ascertained, and then the detecting rapid response model (DRRM) for the leakage of the flammable liquid storage tank is established. Finally, the model was verified by a small–scale tank leakage and some crucial parameters such as Xjet, r and area of liquid pool, mass accumulating during the continuous leakage period (M) and total leaking time that corresponds to the time to alarm (Ttotal) are obtained. These findings provide scientific data for providing early warning and emergency response.

- **Keywords:** Flammable gas detector (FGD); Storage tank leakage; Denser–than–air dispersion; SLAB model; Bisection method; Detecting rapid response model (DRRM)