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H. Stančin, M. Šafář, J. Růžičková, H. Mikulčić, H. Raclavská, X. Wang, N. Duić. *Co-pyrolysis and synergistic effect analysis of biomass sawdust and polystyrene mixtures for production of high-quality bio-oils*. Pages 1-11.

Usage of traditional biomass raises serious concerns regarding its sustainability due to the inefficient combustion in household stoves and potential over-usage if the intention is to replace fossil fuels in power plants. Co-pyrolysis of biomass feedstock with different waste materials, especially plastics, might be a promising alternative for sustainable usage of enhanced biofuels. Even more, co-pyrolysis can help to integrate waste management schemes into the power production sector. Plastics materials have properties similar to those of fossil fuels in terms of heating value and the absence of oxygenated compounds; therefore, they could significantly improve the properties of biomass products, especially bio-oils. Especially interesting for this method is polystyrene (PS) since it yields a high share of liquid fraction, which is the most valuable pyrolytic product. In this work, co-pyrolysis was performed for a mixture of waste biomass sawdust (oak, poplar and fir wood) and waste polystyrene from dairy product packaging. Pyrolysis was carried out for sawdust and polystyrene alone, and their respective fuel blends (PS/SD 25−75%, PS/SD 50−50%, PS/SD 75−25%) from room temperature to 600°C with a retention time of half an hour. The highest yield of liquid fraction was noticed for mixtures with 75 % of PS, while the lowest one was for blends with 25 % of PS, with a yield of 83.86 % and 62.33 %, respectively. Additionally, the mass spectrometric analysis was carried out to determine the chemical composition of the obtained oil.

- **Keywords:** Co-pyrolysis; Polystyrene; Sawdust; Synergistic effect; Oil composition

Qiusheng Song, Peng Jiang, Song Zheng. *The application of cloud model combined with nonlinear fuzzy analytic hierarchy process for the safety assessment of chemical plant production process*. Pages 12-22.

According to statistics, majority of chemical accidents were caused by human factors during the production and storage of chemicals. From the perspective of human factors, a safety assessment method for chemical plant production process based on cloud model combined with nonlinear fuzzy analytic hierarchy process is proposed in this paper. The method comprehensively considers the safety influencing elements of human factors in seven aspects: organization, information, job design, human system interface, task

environment, workplace design, and operator characteristics. We use the analytic hierarchy process to establish a hierarchical structure system. Then use the triangular fuzzy numbers to quantify the indicators and the logarithmic fuzzy preference programming method to calculate the index weights. Finally, the cloud model is applied to determine the safety level of the chemical plant production process. The method is simulated and verified simultaneously. The simulation results showed that the method is reliable, practical and scientific as a safety assessment method for chemical production.

- **Keywords:** Chemical plant production process; Cloud model; Fuzzy analytic hierarchy process; Human factors; Logarithmic fuzzy preference programming; Safety assessment

Claudia Rivera Domínguez, Jovana Ivette Pozos Mares, Rosario Glendenit Zambrano Hernández. *Hazard identification and analysis in work areas within the Manufacturing Sector through the HAZID methodology*. Pages 23-38.

The article presents the situation of a company of the Manufacturing Sector located in the state of Guanajuato, Mexico, which is dedicated to the manufacture of harnesses (wiring) for heavy equipment, supplies the needs of Mexico, the United States and Canada. We proceeded to start with the bases to begin Occupational Health and Safety Management in order to comply with the regulatory framework in the country of Mexico. The study includes the application of the HAZID methodology for the identification of hazards in the workplace, carrying out a Health and Safety Diagnosis and Program to establish the preventive and corrective measures that control, eliminate or replace the hazards detected in the following order: the design intention and the normal operating conditions of the areas through the recognition of the work environment and its processes, identify possible causes and consequences of the danger, identify the existing safeguards, mitigations and control, carry out a classification of the hazards according to their safety or environmental impacts through the priority of intervention for detected danger and identify recommendations and parts of action. As a result, 28 hazards were identified in the production, warehouse and administrative areas; the risks observed were electrical, mechanical, physical, chemical, biological, ergonomic, psychosocial, surrounding, natural and locative. 43 % of the dangers are moderate, 22 % important, 21 % tolerable, 7 % trivial and 7 % intolerable, therefore, it is proposed to comply with the requirements applicable by official Mexican standards, those responsible for acting and indicators of compliance measurement. To improve the in-depth situation of the organization, it is important to conduct a study on each of the applicable Normas Oficiales Mexicanas in occupational health and safety issues issued by the Ministry of Labor and Social Welfare according to the regulatory framework of Mexico.

- **Keywords:** Occupational Health and Safety; HAZID; Harzard; Manufacturing Sector; Health and Safety Program

Jamshid Piri, Bahareh Pirzadeh, Behrooz Keshtegar, Mohammad Givehchi. *Reliability analysis of pumping station for sewage network using hybrid neural networks - genetic algorithm and method of moment*. Pages 39-51.

The reliability of pumping stations is of great importance for the robust design of wastewater networks. In order to strike a balance between safe design and energy consumption of the pumping system, a complex performance function using multiple-failure mode under various uncertainties is required. In the present research to evaluate the failure probability of wastewater pumping station, a hybrid reliability analysis framework using artificial neural network (ANN) coupled by moment methods is proposed. Drawing upon genetic algorithm (GA), ANN model is trained to approximate

the failure domain of the pump. The ANN is approximated input variables captured by the optimal condition of the rotational speed of the pump in turn it is obtained by GA. The main strength of the reliability method is to diminish the computational burden with accurate predictions of safety margin in the pumping systems of Zabol. The machine learning-based backpropagation (BP) for training feedforward neural networks using GA and gradient methods are compared for the regressed process of ANN models. This hybrid reliability framework involves three main levels including i) the pump rotational speed is minimized using GA as optimal hydraulic parameters such as inlet flow, static head, pumping head and outlet flow rate, ii) the limit sate function is approximated using ANN for optimal rotating speed pumps and iii) reliability analysis is disused using MCS and method of the moment for sewage pumping stations located at Zabol (Iran) station. Given the results, the machine learning-based GA for training ANN model provides accurate predictions compared to the ANN-based gradient method. Three moments of reliability method is an efficient and accurate approach to evaluate the reliable conditions of the pumping system.

- **Keywords:** Reliability analysis; Neural network; Multi-failure performance function; Zabol; Genetic algorithm; Sewage pumping stations

Enara Fernandez, Maider Amutio, Maite Artetxe, Aitor Arregi, Laura Santamaria, Gartzen Lopez, Javier Bilbao, Martin Olazar. *Assessment of product yields and catalyst deactivation in fixed and fluidized bed reactors in the steam reforming of biomass pyrolysis volatiles*. Pages 52-62.

The performance of fixed and fluidized bed reactors in the steam reforming of biomass fast pyrolysis volatiles was compared, with especial attention paying to the differences observed in catalysts deactivation. The experiments were carried out in continuous regime in a bench scale unit provided with a conical spouted bed for the pyrolysis step. They were carried out on a Ni-Ca/Al2O3 commercial catalyst and under optimum conditions determined in previous studies, i.e., pyrolysis temperature 500 °C, reforming temperature 600 °C and a steam/biomass ratio of 4. Moreover, the influence of space time was analysed in both reforming reactors. The fixed bed reactor showed higher initial conversion and H2 yield, as it allowed attaining a H2 yield higher than 90 % with a space time of 10 gcat min gvolatiles−1. However, a space time of 15 gcat min gvolatiles−1 was required in the fluidized bed to obtain a similar H2 yield. Moreover, the fixed bed also led to lower catalyst deactivation. Catalyst deactivation was mainly related to coke deposition, and higher coke contents were observed in the catalysts used in the fluidized bed reactor (1.2 mgcoke gcat−1 gbiomass−1) than those in the fixed bed one (0.6 mgcoke gcat−1 gbiomass−1). Therefore, the differences in the performance of the two reactors were analysed and their practical interest was discussed.

- **Keywords:** Hydrogen; Pyrolysis; Reforming; Biomass; Deactivation; Fixed bed; Fluidized bed

Lluís Godo-Pla, Jose Javier Rodríguez, Jordi Suquet, Pere Emiliano, Fernando Valero, Manel Poch, Hèctor Monclús. *Control of primary disinfection in a drinking water treatment plant based on a fuzzy inference system*. Pages 63-70.

Drinking water treatment plants (DWTPs) have to be efficiently managed to produce safe water at all times, independently from variations of influent water quality. Artificial Intelligence techniques like fuzzy inference systems (FIS) can help in consolidating process knowledge accumulated through years of experience and improve the consistency and resiliency of decision-making in these facilities. The objective of this study was to develop an advanced control system for choosing the combined dose of

sodium hypochlorite and chlorine dioxide at the primary disinfection step of a full-scale DWTP. To accomplish this, two FISs consisting of a feed-forward and feed-back control elements were developed. The models were integrated in an environmental decision support system (EDSS) that evaluates the disinfection by-products (DBPs) formation risk and proposes actions which can be verified and applied by treatment managers. Implementation of the EDSS at a full-scale DWTP of Barcelona was positively validated 85.5 % of the times, maintaining acceptable DBPs concentrations at the effluent. The presented methodology can be used at similar surface water DWTPs for developing control strategies to manage DBPs formation.

- **Keywords:** Drinking water; Disinfection; Modelling; Fuzzy inference systems; Environmental decision support system

Feiran Chen, Bin Chen, Zhengqiu Zhu, Laobing Zhang, Xiaogang Qiu, Yiduo Wang, Yong Zhao. *A cost-beneficial area-partition-involved collaborative patrolling game in a large-scale chemical cluster*. Pages 71-82.

Terrorists often take the chemical clusters as the attacking target because of the adverse impacts of a chemical accident on society and the environment. In addition to some fixed countermeasures, previous studies have verified the feasibility of a patrol in addressing adversarial attacks. However, the previous patrolling practices fail to tackle the terrorist attacking problems in a large-scale area cost-effectively. To further tackle the protection issue with cost-beneficial solutions in a large-scale scenario, i.e., in a chemical cluster, we propose an area-partition-involved collaborative patrolling (APCP) game. We first leverage the proposed greedy deployment algorithm to determine the initial deployment of defenders (patrollers), including the quantity and position of patrol vehicles. Then, the large-scale area is partitioned into multiple smaller areas by using the collaborative idea of static partitioning. In the meantime, corresponding patrolling graphs are constructed based on graphic modeling methods. Finally, the APCP game is built between patrol vehicles (namely defender) and potential terrorists (namely attacker), in which patrol vehicles aim at detecting attack behaviors of terrorists by intelligently scheduling the patrolling routes. After formalizing the problem into a sequential game, we compute the Stackelberg equilibrium through the MultiLPs algorithm. Through case studies of three practical chemical cluster scenarios, the results explicitly show the superiority of our proposed APCP game by saving up to 25.48 % patrolling costs in a one-shot game compared to the results before partition. As for the collaborative patrolling problem in a large-scale area, the methods and models proposed in this paper can facilitate the management department of chemical clusters with intelligently scheduled patrolling routes, which can effectively reduce the cost of patrollers, and better protect the chemical cluster.

- **Keywords:** Collaborative patrolling game; Area partition; Game theory

Gengyuan Tian, Yuan Zhou, Yanping Huang, Junfeng Wang, Yangle Wang, Chengtian Zeng, Jiajian Huang. *Experimental study of accidental release behavior of high-pressurized CO2 vessel*. Pages 83-93.

The accidental release is one of the main risks of carbon capture and storage (CCS) and supercritical carbon dioxide (S-CO2) power cycle system. The release of mass CO2 will present severe risks to pipeline, vessel and surrounding population. The study of CO2 release characteristics is helpful to understand the crack propagation and the diffusion behavior outside the crack. In this paper, to investigate release characteristics in vessel and diffusion phenomenon outside rupture, high pressure CO2 release experiments from pressurized vessel were carried out for different initial states (liquid and gaseous phase), temperature (20.0℃ to 50.0℃) and rupture sizes (1.0 mm, 2.0 mm, 3.0 mm). The

transient pressure, mass flow rate, wall temperature, external jet structure and phase transition were studied following vessel release. The results show that different initial states will undergo different decompression process. As initial state is in liquid phase, fluid temperature is lower and circumferential wall temperature shows large gradient. Effects of initial temperature and nozzle sizes under different initial states on CO2 release characteristics were obtained. The experimental results show lower temperature will not damage material in experiment and results are of great significance for early leakage detection and model development.

- **Keywords:** Carbon capture and storage (CCS); Supercritical carbon dioxide power cycle system; Accidental release; Decompression; Phase transition

Jingde Li, Hong Hao. *Numerical simulation of medium to large scale BLEVE and the prediction of BLEVE's blast wave in obstructed environment*. Pages 94-109.

After the numerical study of medium-to-large-scale Boiling Liquid Expanding Vapour Explosion's (BLEVE) in open space (Li and Hao, 2020), this second article focuses on the investigation of the interaction of blast wave with structures in obstructed environment. Currently, pressurized tanks are commonly used as the storage vessels in the oil and gas industry. Pressurized tanks contain high-energy liquid/vapour which, if accidentally released, originates a BLEVE. Although there are already a series of approaches available in literature to estimate blast waves generated from these pressurized tanks, most of these approaches are suitable to predict blast load in the open space only. In this paper, the authors intend to utilize their previously validated numerical approach to predict BLEVE's peak pressure in different obstructed environments. By carrying out over 200 different simulations of BLEVE, the separation distance effect, obstacle geometry effect and BLEVE's scale effect on blast wave generation and propagation are studied. A number of simulation-based correlations for pressure prediction are proposed. The Bologna BLEVE that occurred in 2018 is further modelled to investigate the accuracy of the proposed correlations in predicting the peak pressure in the event. The outcome of this study can be used to predict explosion loads for better assessment of their effects on structures.

- **Keywords:** Medium-large-scale gas explosion; BLEVE; Blast wave; Interaction with structures; CFD; Separation distance

Arbab Tufail, Sultan Alharbi, Jawad Alrifai, Ashley Ansari, William E. Price, Faisal I. Hai. *Combining enzymatic membrane bioreactor and ultraviolet photolysis for enhanced removal of trace organic contaminants: Degradation efficiency and by-products formation*. Pages 110-119.

Coupling of membrane distillation with bioreactors containing enzymes such as 'laccase' forms an enzymatic membrane bioreactor resulting in complete retention of both trace organic contaminants and enzyme, facilitating simultaneous trace organic contaminants degradation. Integration of enzymatic membrane bioreactor and ultraviolet photolysis may result in further improved degradation of trace organic contaminants in membrane-concentrate. We studied the degradation as well as by-products formation of five selected trace organic contaminants, namely, sulfamethoxazole, diclofenac, bisphenol A, oxybenzone, and carbamazepine by 'membrane distillation — ultraviolet photolysis' system and 'enzymatic membrane bioreactor — ultraviolet photolysis' system. In the former, the membrane effectively retained the trace organic contaminants and then ultraviolet photolysis of membrane-concentrate resulted in trace organic contaminant degradation in the following order: diclofenac (88 %) > sulfamethoxazole (71 %) > oxybenzone (35 %) > bisphenol A (33 %) > carbamazepine (27 %). By contrast, the

enzymatic membrane bioreactor — ultraviolet photolysis system resulted in 100 % degradation of diclofenac, sulfamethoxazole, and bisphenol A and around 70 % degradation of oxybenzone and carbamazepine. This system also resulted in more than 50 % reduction in number of degradation products with 60–70 % lower abundance. Our results indicate that laccase degradation led to products that were more amenable to the post-treatment by ultraviolet photolysis. Overall, it can be concluded that for enzymatic membrane bioreactor — ultraviolet photolysis system, enzymatic pre-treatment not only helped in better degradation of the parent trace organic contaminants but also led to the formation of fewer by-products with lower abundance (i.e., more complete degradation).

- **Keywords:** Trace organic contaminants; UV photolysis; Laccase; Enzymatic membrane bioreactor; Degradation products

Bamidele Victor Ayodele, May Ali Alsaffar, Siti Indati Mustapa, Chin Kui Cheng, Thongthai Witoon. *Modeling the effect of process parameters on the photocatalytic degradation of organic pollutants using artificial neural networks*. Pages 120-132.

The need for pollutant-free wastewater has necessitated a huge volume of research on the photocatalytic degradation of organic pollutants. The data obtained from various photocatalytic degradation experimental runs can be employed in data-driven machine learning modelling techniques such as artificial neural networks. In this study, the use of Levenberg-Marquardt-trained artificial neural network for modelling the photocatalytic degradation of chloramphenicol, phenol, azo dye, gaseous styrene, and methylene blue is presented. For each of the photocatalytic degradation processes, 20 neural network architectures were investigated by optimizing their hidden neurons. Optimized ANN configurations of 3−20-1, 3−5-1, 3−2-1, 4−17-1, 4−6-1, and 3−10-1 were obtained for modelling the photodegradation of chloramphenicol, phenol, phenol, azo dye, gaseous styrene, and methylene blue, respectively. The optimized ANN architectures were robust in predicting the degradation of the organic pollutants with R2 > 0.9 at a 95 % confidence level with very low mean absolute errors. The sensitivity analysis using the modified Garson algorithm revealed that all the process parameters significantly influenced the photodegradation of the organic pollutants. The photocatalyst concentration, phenol concentration, pH of the solution, hydrothermal temperature, and methylene blue initial concentration were however found to have the most significant influence on the photodegradation processes. The ANN algorithm can be implemented in a photocatalytic degradation process for making vital decisions regarding the operation of the process.

- **Keywords:** Artificial neural networks; Photocatalytic degradation; Titanium oxide; Organic pollutant; Wastewater

Leila Heidari, Mahdi Jalili Ghazizade. *Recycling of spent industrial soil in manufacturing process of clay brick*. Pages 133-140.

The present study aimed to investigate the feasibility of using Spent Industrial Soil (SIS) generated in the process of Aromatics production in manufacturing clay brick. The physicochemical properties of raw clay and SIS were analyzed using different lab tests such as X-ray Fluorescence (XRF) and X-ray diffraction (XRD). Six different amounts of SIS (i.e. 0, 5, 10, 15, 20 and 25 % by weight) were mixed with clay soil and fired by electric furnaces at 950 °C for 8 h to make fired brick samples. Magnified images were taken using Scanning Electron Microscope (SEM) for all samples to indicate the significant changes in pores size due to adding SIS. The results showed that SIS increases the water absorption and water suction and reduces the density of brick samples due to increasing porosity in the structure of brick. Also the linear shrinkage is reduced in samples containing SIS and this finding is justified by the lower amounts of hydrophilic elements (i.e. Ca, Mn, and Mg) in SIS, compared with raw clay soil. On the other hand, the

compressive strength of brick samples which is affected by both porosity and SiO2 amount has been increased by mixing SIS content of 20 %. Thus using SIS in clay brick construction is an effective way to make a porous and lighter brick which meets the required standards of structural and environmental issues.

- **Keywords:** Spent industrial soil; Clay brick; Compressive strength; Waste recycling

Farah Naaz, Arghya Bhattacharya, Kamal Kishore Pant, Anushree Malik. *Impact of heavy metal laden algal biomass on hydrothermal liquefaction and biorefinery approach*. Pages 141-149.

Disposal of metal contaminated biomass after bioremediation poses challenges due to non-availability of suitable techniques. In the present study, an attached algal biofilm reactor (ABR) of 3 L capacity was used for remediating six heavy metals (Zn, Cu, Cr, Ni, Pb and Cd) from a metal mix and subsequently the biomass after bioremediation was hydrothermally liquefied to see the fate of the heavy metals. The algal biofilm was a consortium of Phormidium and Chlorella which was able to remove between 50–90 % of the heavy metals after 6 d. The metal removal trend followed the order Zn > Cu > Cr > Ni > Pb > Cd. Hydrothermal liquefaction of the metal contaminated biomass was done at 230 °C of temperature, 27 bar of pressure, water to biomass ratio of 4, K2CO3 as catalyst and holding time of 20 min under N2 environment in a high temperature pressure reactor. The biocrude obtained in presence of metals had a HHV of 20 MJ kg−1 compared with 19.32 MJ kg−1 in control (without metal). The heavy metal analysis of the solid and aqueous fraction showed that >70 % of the metals had partitioned into the solid fraction whereas <1 % were in the aqueous fraction. The aqueous fraction was also rich in nitrate and phosphate which could be reused for algal cultivation. Hence, hydrothermal liquefaction could be a very useful technique for valorisation of metal contaminated biomass for a sustainable biorefinery.

- **Keywords:** Attached biofilm reactor; Heavy metals; Hydrothermal liquefaction; Biocrude; Biorefinery

I. Bradley, G.E. Scarponi, F. Otremba, A.M. Birk. *An overview of test standards and regulations relevant to the fire testing of pressure vessels*. Pages 150-156.

Fire exposure of storage and transportation vessels of hazardous materials (including pressure liquefied gases) can result in BLEVEs and other high-consequence incidents with large societal and economic impacts. To reduce risk most countries have numerous regulations, codes of practice and guidance notes covering the design, operation and maintenance of vessels and thermal protection systems. Yet despite such regulations there remains no internationally accepted fire test procedure for pressure vessel and accompanying thermal protection systems that is capable of meeting a range of regulatory requirements. This paper considers some of the regulations in place in the western world and considers the origin of these based on large and medium-scale testing conducted to date. It examines conditions found in these tests to propose a set of recommendations on which to base a standard method of test. These recommendations are proposed as being representative of a credible large pool fire scenario that may occur.

- **Keywords:** LPG; Pressure vessel; Test; BLEVE; Fire

Hamdy Hassan, Mohamed S. Yousef. *An assessment of energy, exergy and CO2 emissions of a solar desalination system under hot climate conditions*. Pages 157-171.

In this study, the performance of single slope solar still combined with enhanced condenser and integrated with parabolic trough solar collector (PTC), is assessed based on productivity, energy, exergy, exergoeconomic, and enviroeconomic methodologies. Experiments are conducted using various saline water media inside a basin exposed to the hot weather conditions of Sohag city in Upper Egypt. Several solar still configurations are tested: conventional solar still (CSS), modified solar still (MSS) using aluminum heat sink as enhanced condenser (HSC), modified solar still incorporated with PTC (MSS + PTC), modified solar still comprising sand as a porous media inside the basin (MSS + SD), and modified solar still comprising sand inside the basin and incorporated with PTC (MSS + SD + PTC). The experimental findings revealed that the MSS + SD + PTC achieved the highest freshwater productivity of 4.65 L/m2 in winter and 9.75 L/m2 in summer, leading to an improvement of around 113 % in winter and 146 % in summer compared with the CSS system. The highest increase in energy and exergy output per year is obtained in the case of MSS + SD + PTC at 139 % and 245 %, respectively. Incorporation of PTC into the MSS system for all studied water media is found promising in terms of energy payback time, cost, and freshwater yield compared with MSS without PTC. The exergoeconomic and environmental parameters of the active systems are found more effective compared with those of the passive systems.

- **Keywords:** Solar still; Parabolic trough collector; Exergy; Environmental; Condenser

Maryam Takht Ravanchi, Saeed Sahebdelfar. *Catalytic conversions of CO2 to help mitigate climate change: Recent process developments*. Pages 172-194.

Despite its bad reputation as a greenhouse gas and pollutant, carbon dioxide can be viewed as a renewable, non-toxic and cheap feedstock for chemical synthesis. The chemical utilization of CO2 not only could reduce greenhouse gas emissions, but also saves the fossil fuels resources. In this work, the chemical conversions relevant to large-scale utilization of CO2 including use of CO2 as an oxidant, conversion of CO2 to energy materials and synthesis of CO2-based polymers are reviewed with emphasis on catalysis and reaction engineering as well as technology readiness and processes. Environmental metrics such as atom economy, life cycle analysis and exergy efficiency are also considered. A circular economy based on CO2 is possible if renewable energies, catalyst development and separation technologies are integrated and further developed.

- **Keywords:** Carbon dioxide; Catalytic conversion; Renewable sources; Sustainable development; Circular economy; CO2 value chain

Alba Pedrouso, Angeles Val del Rio, Nicolas Morales, Jose R. Vazquez-Padin, Jose Luis Campos, Anuska Mosquera-Corral. *Mainstream anammox reactor performance treating municipal wastewater and batch study of temperature, pH and organic matter concentration cross-effects*. Pages 195-202.

The anammox process is an energy efficient promising alternative to biologically remove the nitrogen. Thus, a 5-L anammox granular reactor was inoculated with sludge coming from a sidestream partial nitritation and anammox reactor (>200 mg TN/L and 30 °C) and it was directly subjected to 15 ± 1 °C treating mimicked municipal wastewater (50 mg TN/L). Results indicated that an acclimation period (commonly used) to progressive reach the mainstream conditions is not needed, shortening the start-up periods. The

long-term anammox process stability was proved to treat synthetic wastewater with decreasing alkalinities and nitritified primary settled municipal wastewater. The low pH values (6.2 ± 0.1) of the municipal wastewater fed did not affect the process stability. Residual organic matter concentrations augmented the nitrogen removal efficiency from 80 % (with the synthetic medium) to 92 % achieving effluent concentrations below 10 mg TN/L. Finally, the effect of pH (6–8), temperature (15–30 °C) and organic matter concentration (0–75 mg TOC/L) over the specific anammox activity (SAAMX) was evaluated at short-term. pH and temperature and their interactions exerted significant influence on the SAAMX value while the TOC concentrations itself did not significantly change the SAAMX.

- **Keywords:** Alkalinity; Autotrophic nitrogen removal; Inorganic carbon; Mainstream; Low temperature; Specific anammox activity

Saumitra Mishra, Pushpendra Kumar Vishwakarma, Ankit Sharma, Kirti Bhushan Mishra. *Experimental investigation of small-scale CS2 (carbon disulphide) pool fires*. Pages 203-210.

This work reports the characteristics of CS2 pool fires such as Mass Burning Rate (MBR), flame length, flame temperature, concentration of combustion products (CO2 and SO2) measured for two pool diameters (d =0.05 m and 0.1 m) in the laboratory scale test setup and with well calibrated instruments. Measurements indicate that the MBR of CS2 pool fires (d ≤ 0.1 m) is governed mainly by conduction and convection like hydrocarbons and decrease with an increase in diameter. For d =0.05 m the MBR of CS2 pool fires are 1.5 times higher than gasoline. Due to convection, at d =0.1 m, the MBR of CS2 pool fire was similar to gasoline but 1.5 times higher than diesel and ethanol. Depending on the background CS2 flames are invisible (in daylight) and whitish blue (in dark environment) having shorter flames with negligible thermal radiation in comparison to diesel, gasoline and ethanol. Emission measurements revealed that even for a very short duration (60–120 s) burning of CS2 pool fire produced higher concentration (>200 ppm) of SO2 as prescribed by the National Institute for Occupational Safety and Health (NIOSH) for Immediate Dangerous to Life and Health (IDLH). A correlation among pool diameter, time of burning and concentration of SO2 is developed, which can be used to assess the fire risks associated with the processing, storage and transportation of CS2.

- **Keywords:** Carbon disulphide; Pool fire; Mass burning rate; Thermal radiation; SO2 exposure

Jun Zhang, Ying-Ying Ma, Li-Ping Chen, Wang-Hua Chen. *Experimental and numerical simulation to identify the thermal hazards and hazardous scenarios of N-Nitrodihydroxyethyl dinitrate*. Pages 211-221.

As a major high-energy plasticizer in the production of propellant, the destructive nature and thermal hazards of DINA are enormous. To evaluate the potential thermal hazards for its decomposition, the non-isothermal DSC and ARC experiments were performed to determine the decomposition kinetic model and parameters. It can be seen from the DSC results that DINA underwent a melting process before thermal decomposition, the endothermic peak and exothermic peak are identified at about 49−52℃ and 153−162℃, respectively. Combined with the results of DSC and ARC tests, the reliable kinetic model of DINA consists of four consecutive autocatalytic reaction has been created and verified. Subsequently, kinetic-based numerical simulations were executed to evaluate the thermal explosion hazards of DINA under the different scenarios. Process safety parameters under adiabatic conditions including time to maximum rate as well as induction period were consequently retrieved. Furthermore, inherent safety recommendations were proposed to forestall the process accidents in storage and the applications of DINA.

- **Keywords:** N-Nitrodihydroxyethyl dinitrate; Multi-stage kinetic model; Thermal hazards; Quantitative risk analysis; Hazardous scenario

Hao Wang, Zhanyou Sa, Weimin Cheng, Ran Zhang, Shuai Yang. *Effects of forced-air volume and suction region on the migration and dust suppression of air curtain during fully mechanized tunneling process*. Pages 222-235.

To grasp the effects of forced-air volume and suction region on the migration and dust suppression of air curtain during fully mechanized tunneling process, the 1:1 proportional physical models of the 2-5082 fully mechanized tunnel were constructed, the CFD-DPM based numerical simulations were conducted. The results showed that during the migration process of the air curtain, the decrease of the forced-air volume and the arrangement of the suction region near the side wall opposite to the forced-air duct were conducive to the formation of a uniformly distributed axial airflow region. At the same time, the dust pollution area satisfied the rule of reducing with the decrease of the forced-air volume as well. When the forced-air volume was 350 m3/min and the suction region was near the side wall opposite to the forced-air duct, the diffusion distance of high concentration dust reached to the minimum, the dust concentration at the place that the tunneling driver located had fallen below 50 mg/m3, the best dust suppression performance could be achieved. The model effectiveness was finally validated by comparing the simulation results with the field measured values. This study could provide new insights into the environmental sustainability of tunneling process. The achievements could meet the requirements of process safety and environmental protection in fully mechanized tunnels.

- **Keywords:** Numerical simulation; Forced-air volume; Suction region; Swirling air curtain; Dust suppression

Yuexing Wei, Min Song, Lei Yu, Fanyue Meng. *CO2 reforming of methane over carbon fiber-lanthanum oxide supported bimetallic nickel-cobalt catalysts: Kinetic and mechanistic studies*. Pages 236-246.

With high surface area (1393m2/g) and fibrous structure, carbon fiber (CF) was used to prepare a composite of CF-lanthanum oxide (La2O3), which was applied as support to synthesize nickel-cobalt based bimetallic catalyst. The as-prepared catalysts were utilized in CO2 reforming of methane and it performed well at the metal ratio (nickel to cobalt) of 4:1 with an ideal syngas (H2/CO reached to 1.1) produced. The characterization results showed that La2O3 uniformly grew on the surface of carbon fiber in wrinkled like. Moreover, nickel-cobalt alloy structures were formed on the surface of 4Ni-1Co/CF-La2O3 catalyst, thus improving the resistance to Ni-sintering, then promoting the stability of syngas production. Except for the promotion effect of cobalt, the role of La2O3 addition was also demonstrated by model calculation. It was found that the lanthanum carbonate (La2O2CO3) formed during CO2 adsorption process. The formation of the intermediate could facilitate to the CO2 dissociation by decreasing the CO2 activation energy, thus promoting the CO2 conversion to produce more CO. Combined with the kinetic experimental results, the reaction mechanism over 4Ni-1Co/CF-La2O3 was proposed with the reactants of CH4 and CO2 dissociated both on the surface of the support and the metal active sites. It was corresponded to the Langmuir-Hinshewood mechanism type.

- **Keywords:** Reforming; Syngas production; Model calculation; Sintering resistance; Reaction mechanism

Na Yuan, Ling Ren, Bozhong Wang, Deliang Teng, Peng Li, Zhiyong Xu, Yanjie Li, Haiyan Chen, Longyuan Lin. *Experimental study on the effects of diversion device on pulse-jet cleaning of horizontal filter cartridge*. Pages 247-254.

In recent years, horizontal cartridge filters have developed rapidly and been gradually used in the industrial production. However, most existing studies are focused on the vertical dust collectors, and there are few studies on the effect of diversion device type on the cleaning performance of horizontal filter cartridge. Therefore, in order to investigate the influence of this important factor on the peak static pressure of this filter cartridge, three typical diversion nozzles were used to the experiment. This study examined the peak static pressure distribution along the surface of the filter cartridge during the pulse-jet cleaning process. The results showed as follows: among these three types of diversion nozzles, the rotating nozzle has the smallest size and the best uniformity of peak static pressure, but the peak static pressure was too low due to the energy consumption by rotation. For venturi, although the cleaning requirements can be guaranteed, the excessive pressure of the filter cartridge bottom can easily cause partial damage. Compared with these two, the diffuser nozzle can ensure excellent cleaning performance and make a smaller space occupation of horizontal cartridge filters. In general, it is suggested to select the diffuser nozzle for horizontal cartridge filter.

- **Keywords:** Horizontal cartridge filter; Diversion device; Pulse-jet cleaning; Peak static pressure; Dust cleaning effect

José Gilmar da Silva do Nascimento, Maria Helena Peres de Araújo, André Bezerra dos Santos, Marcos Erick Rodrigues da Silva, Paulo Igor Milen Firmino. *Can microaeration boost the biotransformation of parabens in high-rate anaerobic systems?* Pages 255-261.

The main objective of the present study was to demonstrate microaeration as an effective strategy to boost the biotransformation of four parabens (methylparaben, ethylparaben, propylparaben, and butylparaben) in an upflow anaerobic sludge blanket reactor operated at a short hydraulic retention time (8 h). Moreover, the effect of different airflow rates (1−4 mL min−1) was also assessed from an engineering and microbiological perspective. Low mean removal efficiencies (REs) (14–20 %) were achieved under anaerobic conditions. However, the addition of only 1mL air min−1 (0.027L O2L−1 feed) remarkably boosted the biotransformation of parabens, ensuring mean REs above 85 % for all compounds. In contrast, the increase in the airflow rate had a minor impact on the process, and an apparent saturation in the removal capacity was observed, noticeably from 2 to 4 mL air min−1. The reactor presented high stability throughout the experiment, and microaeration did not impair the organic matter removal and methanogenesis. However, high airflow rates can dilute biogas, compromising its use as a fuel in combined heat and power units. The microaerobic conditions increased both richness and diversity of the reactor's microbiota, likely favoring the growth of oxygenase-producing microorganisms, which may have played a role in the biotransformation of parabens. Finally, the high REs of parabens reached in the microaerated reactor, a more cost-effective technology, are comparable to those found in high-cost wastewater treatment systems, such as activated sludge and its variants.

- **Keywords:** Parabens; Organic micropollutants; Endocrine-disrupting chemicals; Microaerobic conditions; Wastewater treatment

Letiane Thomas Hendges, Tamires Cristina Costa, Bruna Temochko, Sergio Yesid Gómez González, Luciana Prazeres Mazur, Belisa Alcantara Marinho, Adriano da Silva, Silvio Edegar Weschenfelder, Antônio Augusto Ulson de Souza, Selene M.A. Guelli Ulson de Souza. *Adsorption and desorption of water-soluble naphthenic acid in simulated offshore oilfield produced water*. Pages 262-272.

The removal of water-soluble organics compounds in oilfield produced water (OPW) is currently one of the biggest challenges to meet the environmental legislation, as conventional remediation focuses mainly on removing solids and the dispersed oil fraction. Naphthenic acids (NAs) are present in significant amounts in water-soluble organics compounds; therefore, this work milestone is to properly understand the adsorption process by using an acutely recalcitrant O2-NA as WSO model. For this, a comprehensive screening of commercial adsorbents and waste was tested for NAs remediation, assessing also the influence of adsorbent properties and functionalities. Afterwards, there were selected the resins MN 202 and L 493 as adsorbents to further evaluate the regeneration and other variables such as temperature, pH and salt content, focusing on on-site offshore conditions. The initial screening and the equilibrium data suggest that characteristics such as surface area, pore diameter, and ionic form have a great influence on the adsorption process. Furthermore, the adsorption mechanisms involve anion exchange and hydrophobic interactions, showing a transition between multilayer to monolayer adsorption with the increase of the adsorbent dosage and the kinetics, while increasing NA encourages pore diffusion, resulting in irreversible adsorption. The use of eluents, while avoiding irreversible adsorption, allows recovering the adsorbent, improving the process feasibility at the targeted conditions.

- **Keywords:** Produced water; Water-soluble organics; Naphthenic acid; Adsorption-desorption

Mariana Fronja Carosia, Cristiane Marques dos Reis, Camila Aparecida de Menezes, Isabel Kimiko. Sakamoto, Maria Bernadete Amâncio Varesche, Edson Luiz Silva. *Homoacetogenesis: New insights into controlling this unsolved challenge by selecting the optimal C/N ratio, C/P ratio and hydraulic retention time*. Pages 273-284.

The objective of the present study was to evaluate the influence of the carbon/phosphorus (C/P) ratio (300–1100) on hydrogen production and the control of homoacetogenesis in four anaerobic fluidized bed reactors with fixed carbon/nitrogen ratios of 100, 150, 200, and 250. The reactors were fed glucose (5000mgL−1) at the hydraulic retention time (HRT) of 8h. Low production of acetic acid attributed to homoacetogenesis was observed in all reactors (<29 % of total metabolite production) at C/P ratios between 500 and 1100, with no occurrence at the C/P ratio of 300. Thus, the effect of HRT (8 to 1h) on hydrogen production was evaluated at a C/P ratio of 300. The highest values of hydrogen yield (1.76mol H2mol−1 hexose) and hydrogen production rate (13.8l H2 day−1 L−1) were observed for a C/N/P ratio of 100/0.5/0.3 at HRTs of 8 and 1h, respectively. The maximum hydrogen production was attributed to butyric acid production. The decrease in the HRT caused an increase in acetic acid and ethanol production. Molecular analysis identified the presence of Ethanoligenens sp. and Clostridium sp., which were related to the production of hydrogen, ethanol, butyric acid, and acetic acid.

- **Keywords:** Ethanol-type fermentation; Nitrogen; Phosphorus; Microbial diversity; Anaerobic fluidized bed reactor; Ethanoligenens sp

Regilene de Sousa Silva, Carolina D' Ávila Kramer Cavalcanti, Rita de Cassia Siqueira Curto Valle, Ricardo Antonio Francisco Machado, Cintia Marangoni. *Understanding the effects of operational conditions on the membrane distillation process applied to the recovery of water from textile effluents*. Pages 285-292.

This study analyzed the influence of operational conditions on the Direct Contact Membrane Distillation for synthetic effluents containing reactive and disperse dyes. Results of the permeate flux demonstrated different behavior of the process according to the class of dye. It was found a higher dependence of feed temperature to reactive dye and the analysis of temperature gradient between feed and permeate demonstrated the possibility of operation with higher temperatures in both streams to increase the permeate flux for both dyes. Feed flow rate influenced more the process with reactive dye, while the permeate flow rate determined this behavior for disperse dye. Energy factors showed that the gain output rate and energy efficiency enhanced with the increase of feed temperature, and the energy efficiency increased only with the permeate flow rate (and not with feed flow rate). The water distillation recovery rate was 97.3 % for reactive and 98.7 % for disperse dye; the color rejection of the dyes was over 98 %. These results indicated the adequate functionality of the process for water recovery of textile wastewater, providing an adequate permeate for possible reuse.

- **Keywords:** Dye; Energy factors; Feed temperature; Feed flow rate; Permeate flow rate; Water recovery

Rongchen Zhu, Xiaofeng Hu, Jiaqi Hou, Xin Li. *Application of machine learning techniques for predicting the consequences of construction accidents in China*. Pages 293-302.

Construction accidents can easily cause massive casualties and property losses. This research uses machine learning technique to analyze 16 critical factors and assess the impact of diverse combinations of factors on the performance of predicting the severity of construction accidents. The prediction is carried out with eight algorithms: Logistic regression, Decision tree, Support vector machine, Naive Bayes, K-nearest neighbor, Random forest, Multi-Layer Perceptron and AutoML. The results show that (1) Based on 16 accident factors, Naive Bayes and Logistics regression achieve the best F1-Score of 78.3 % on raw data set. (2) With AutoML method, severity classification can achieve an average F1-Score of 84 %. (3) The analysis of the confusion matrix shows that the subjective classification of the original data and specific unusual accidents are the sources of misprediction. (4) The "Type of accident" and "Accident reporting and handling" are the most critical factors and "Emergency management" and "Safety training" are important subsystems, both of which greatly affect the severity of the accident. (5) Based on the Decision tree, a set of assessment rules for the severity of construction accidents can be extracted. The prediction models and conclusions obtained from this study can be used to enhance the experience of safety professionals in urban construction and to make the safety intervention measures more efficient.

- **Keywords:** Construction accidents; Safety management; Machine learning; Prediction

Yifan Song, Qi Zhang. *Explosion effect of vapor-liquid two-phase n-heptane at various initial temperatures*. Pages 303-311.

Abstract: The explosion characteristics of vapor-liquid two-phase n-heptane inside and outside (the boundary is the junction of premixed fuel and air) the original premixed zone studied, and the effects of concentration and initial temperature on the explosion development have been analyzed using a numerical method. The explosion overpressure

increases with distance in a certain range outside the premixed zone with the change of premixed vapor-liquid two-phase n-heptane concentrations. The peak overpressure of rich fuel is larger than that of lean and stoichiometric fuel. The fuel rich explosion outside the premixed zone results in a so-called "secondary explosion", and the explosion overpressure has two peaks with similar values. The initial temperature has a significant effect on the flame length (characterization by combustion rate) of two-phase n-heptane explosion. The flame length of a lean fuel explosion decreases with the increase of initial temperature. At an initial temperature of 253K, the flame length is 4.15 times that of the premixed zone. With stoichiometric and rich fuel, the flame length increases with the initial temperature in the range of 273−333K, and at 333K the flame length is 5.26 and 5.99 times that of the premixed zone, respectively.

- **Keywords:** Vapor-liquid two-phase n-heptane; Initial temperature; Droplet diffusion; Flame length

Appala Naidu Uttaravalli, Srikanta Dinda, Bhanu Radhika Gidla, Girija Kasturi, Padma Kasala, Gayathri Penta. *Studies on development of adhesive material from post-consumer (waste) expanded polystyrene: a two-edged sword approach*. Pages 312-320.

In the present study, low-cost adhesive materials are prepared by valorizing a post-consumer (waste) expanded polystyrene (EPS). The adhesives are prepared by dissolving the waste EPS in six different solvents namely n-butyl acetate (n-BA), tetrahydrofuran (THF), methyl ethyl ketone (MEK), m-xylene, carbon tetrachloride (CTC) and gasoline, and the corresponding additives are designated as AD-B, AD-T, AD-M, AD-X, AD-C, and AD-G, respectively. Various physico-chemical properties such as solubility, moisture content, viscosity, adhesive (shear) strength, shear modulus, etc. of the adhesives are characterized in detail. Among the chosen solvents, the solvent MEK offered maximum solubility of the EPS. Paper and wood-based substrates were used to quantify the adhesive strength of the in-house developed adhesives. The study revealed that the in-house prepared adhesives are appropriate to stick paper and wood-based substrates. The adhesive strength of the adhesives is also compared with commercial adhesives namely fevistick and fevicol. The order of shear strength of the studied adhesives for wood as a substrate is AD-X < AD-B < AD-T < AD-M < fevicol. The obtained value of shear strength of AD-X, AD-B, AD-T, AD-M, and fevicol is 1081, 1372, 3791, 4407, and 4722 kPa, respectively. The investigation shows that the shear strength of AD-M is comparable (around 7 % lower) with the shear strength of the commercial fevicol. The in-house developed adhesives show more elastic in nature compared to the fevicol adhesive. The study further revealed that the in-house developed adhesives are also suitable to bind clay and ceramic-based substrates. From the investigation, it can be concluded that the EPS derived additives can be used as a suitable substitute for commercial adhesives to bind various materials.

- **Keywords:** Recycling and reuse; Expanded polystyrene; Adhesive; Shear strength

Ting Liang, Khaled Elmaadawy, Bingchuan Liu, Jingping Hu, Huijie Hou, Jiakuan Yang. *Anaerobic fermentation of waste activated sludge for volatile fatty acid production: Recent updates of pretreatment methods and the potential effect of humic and nutrients substances*. Pages 321-339.

Owing to the development of urbanization, the amount of sewage sludge generated through biological activated sludge process has increased dramatically. Anaerobic fermentation of sludge is recognized as an expedient and efficient treatment process, widely applied for biogas generation, resource recovery, and volatile fatty acid

production. Volatile fatty acids are one of the most widely used carbon sources and have great use in biological nutrient removals. Volatile fatty acids production in anaerobic sludge fermentation is affected by sludge properties, metabolic pathways, and operating parameters. This paper aims to present an overview of the recent advancement in volatile fatty acids production from waste activated sludge. Standalone and hybrid pretreatment methods prior to the sludge fermentation were introduced and assessed based on VFAs accumulation rate and system performance. In addition, different metabolic steps involved in anaerobic fermentation (i.e. hydrolysis, acidification, and methanogenesis) were deeply evaluated. More importantly, the effects of humic substances were evaluated, among which, the electron transfer, the enzyme activity of microbial species, and the interaction between exogenous electron transporters and humic substances were illustrated. Furthermore, the influence of nitrogen and phosphorus ingredients in sludge fermentation and volatile fatty acids production was introduced. It was found that the additives and pretreatment of waste activated sludge are energetically preferred for the hydrolysis improvement and accelerating the volatile fatty acids accumulation. It was concluded that different structures of humic substances may have different effect on the fermentation process and volatile fatty acids production. The synergistic addition of hydrolytic enzymes assisted to reverse the negative effect of humic acids in some cases, and mitigated the adverse effect of humic substances on the inhibition of bacterial growth. The composition and properties of waste activated sludge may limit its biodegradability and hamper the volatile fatty acids production.

- **Keywords:** Waste activated sludge; Anaerobic fermentation; Volatile fatty acids; Humic acids; Interspecies electron transfer

Tom Matko, John Chew, Jannis Wenk, Jian Chang, Jan Hofman. *Computational fluid dynamics simulation of two-phase flow and dissolved oxygen in a wastewater treatment oxidation ditch*. Pages 340-353.

This study presents a computational fluid dynamics (CFD) model of an aerated wastewater treatment oxidation ditch, taking into account gas-liquid flow, oxygen mass transfer and dissolved oxygen. Especially, the effect of the bubble size distribution (BSD) and the biochemical oxygen demand (BOD) distribution on the dissolved oxygen (DO) distribution has been considered. Species transport modelling predicts the DO and BOD distribution. De-oxygenation of local dissolved oxygen by BOD is modelled by an oxygen sink that depends on the local BOD concentration. Bubble coalescence and breakup models predict the BSD. The behaviour of the ditch is non-ideal, which is indicated by the residence time distribution (RTD), heterogeneous flow pattern and DO distribution. The parameters with the greatest influence on the dissolved oxygen are the BOD and bubble size. There is good agreement between the numerical simulation and the observations of flow pattern and measurements of mean DO. This study identifies that the BOD distribution and the BSD are important parameters for accurately predicting the DO distribution and which have been mostly neglected in the public research.

- **Keywords:** Aeration; Oxidation ditch; Computational fluid dynamics; Dissolved oxygen; Multiphase flow; Wastewater treatment

Fabricia Araújo Sales, Ascendino Pereira de Araújo Neto, Gilvan Wanderley Farias Neto, Romildo Pereira Brito. *Intensified heat transfer applied to a zinc roasting process: Economic and environmental factors.* Pages 354-363.

The zinc roasting process has been the subject of several studies regarding the roaster and its feed characteristics. However, to identify the most sustainable operating scenario, it is necessary to consider the behavior of the whole plant. In this work, a zinc roasting

process model was developed, validated with plant data, and then used to evaluate heat transfer throughout the entire plant. Through simultaneous manipulation of decision variables and changes in values of the heat transfer area at different points of the plant, a sensitivity analysis was performed, generating hundreds of operating scenarios in terms of zinc oxide production and green steam generation (steam generated without burning any fuel), which were investigated to determine conditions that yield savings, from an economic and environmental point of view. Without capital investment, zinc oxide production could be increased by 10.6 %, although the green steam generation decreased by 8.6 %. With capital investment to intensify heat transfer, results showed that it is possible to promote an increase in both zinc oxide production and green steam generation by up to 14.2 % and 10.6 %, respectively, and a reduction of up to 14,000 t/year in CO2 emissions.

- **Keywords:** Zinc oxide; Green steam; Process intensification; Process sustainability

Xin Chen, Jiabin Zhou, Yi Chen, Ying Zhou, Lidan Ding, Hong Liang, Xi Li. *Degradation of tetracycline hydrochloride by coupling of photocatalysis and peroxymonosulfate oxidation processes using CuO-BiVO4 heterogeneous catalyst*. Pages 364-377.

In this study, we synthesized CuO modified BiVO4 composite (CuO-BiVO4) and used it to construct a novel coupling system, in which two processes of photocatalysis and peroxymonosulfate (PMS) oxidation processes were integrated together to synergistic remove tetracycline hydrochloride (TC−HCl). XRD, XPS, FESEM, EDS, PL and UV–vis DRS techniques were applied for characterization of the catalyst features. CASTEP procedure of MS software was employed to calculate the electronic structure of the catalyst. The catalytic performance of CuO-BiVO4+ Vis + PMS system was investigated under impact of different variables such as CuO loading amount, pH, PMS dosage, catalyst dosage, temperature and co-existing ions. Compared with the individual photocatalysis or peroxymonosulfate oxidation process, the catalytic performance of the coupling system was significantly improved. Under visible light irradiation, 100 mL of 80 mg/L TC−HCl solution was completely degraded using 2 mM PMS activated by a CuO-BiVO4 composite in 50 min without adjust pH, and the system synergistic index reached 3.04. The improved catalytic activity is due to the effective separation of photogenerated electrons-holes and the availability of more activation PMS sites. After five cycling experiments, the degradation rates of TC−HCl were reduced slightly to 94 %, which indicated the catalysts exhibited excellent reusability and stability for its practical applications. Active species trapping experiments and ESR tests confirmed that SO4·−,·OH, hVB+, O2·− and 1O2 worked together for the TC−HCl degradation. Furthermore, the possible reaction mechanism of the coupling system was proposed, and the degradation intermediates of TC−HCl were identified by LCMS. In conclusion, integration of CuO-BiVO4, Vis and PMS exhibited an excellent performance for TC−HCl degradation within 50 min reaction, which could be introduced as an effective and promising method for the wastewater treatment.

- **Keywords:** Photocatalysis; Peroxymonosulfate oxidation processes; CuO-BiVO4; Tetracycline hydrochloride

Mengdi Gao, Mingshu Bi, Lili Ye, Yanchao Li, Haipeng Jiang, Mingrui Yang, Caicai Yan, Wei Gao. *Suppression of hydrogen-air explosions by hydrofluorocarbons*. Pages 378-387.

This study examines the suppression effectiveness of fluorinated species CHF3 and C2HF5 on the premixed hydrogen-air explosions experimentally and numerically. The results demonstrate that as for stoichiometric and rich hydrogen-air mixtures, both CHF3 and C2HF5 can effectively reduce thermal expansion ratio and increase flame thickness,

and then reduce the influence of hydrodynamic instability on the flame acceleration. Laminar burning velocity, the maximum of explosion pressure, the maximum rate of pressure rise and the absolute value of pressure impulse all decrease with increasing suppressant concentration at various equivalent ratios. The maximum of explosion pressures for stoichiometric flames is decreased by 11.54 % with 2 % CHF3 added, and decreased rapidly by 40.39 % with 2 % C2HF5 added. The hydrogen-rich mixtures cannot be ignited when C2HF5 content reaches 10 %. Numerical simulations have confirmed that both CHF3 and C2HF5 can effectively reduce the concentration of active radicals with the decrease order of H > OH > O. C2HF5 is more effective in suppressing explosions than CHF3 by converting more H atoms to HF formation through the elementary reactions CHF2 + H <=> CHF + HF, CF2:O + H <=> CF:O + HF, and CF2 + H = CF + HF.

- **Keywords:** Hydrofluorocarbons; Explosion suppression; Flame morphology; Explosion pressure; Laminar burning velocity

Cong Li, Ying Chen, Diao Qin, Yao Chen. *Cultivation of phagotrophic algae with microbial cells released from waste activated sludge: An evaluation of different pretreatment methods to enhance release of microbial cells from sludge flocs*. Pages 388-394.

The application of phagotrophic algae in waste activate sludge (WAS) treatment can largely accelerate WAS organics reclamation rate, because the phagotrophic capability of phagotrophic algae on intact microbial cells provides an efficient and fast way to digest microbial cells, which eliminate the need of the time-consuming hydrolysis of WAS solid organics. In this research work, different pretreatment methods of anoxia, alkali, and ultrasound were compared in terms of efficiency in releasing microbial cells from WAS flocs and subsequent growth of phagotrophic algae. Results show that ultrasonic pretreatment was the most efficient method since it yielded the highest microbial cell release and subsequent algae growth, while requiring the shortest pretreatment time. Mathematical modelling shows that the release of microbial cells in anoxic and ultrasonic pretreatment was achieved mainly through breaking physical forces of attraction, while the release of microbial cells in alkali pretreatment was achieved through breaking ionic bonds. Re-floc of released microbial cells was observed during algae growth, and the microbial cells released through breaking ionic bonds were less liable to reform floc. The electricity consumption of ultrasonic pretreatment was the highest, which was 6.9 times and 17.9 times of that of alkali and anoxic pretreatment. The electricity consumption of ultrasonic pretreatment can be reduced by performing alkali pretreatment prior to ultrasonic pretreatment.

- **Keywords:** Waste sludge treatment; Phagotrophic algae; Organics reclamation; Sludge pretreatment

Parvathy G, Sethulekshmi AS, Jitha S Jayan, Akhila Raman, Appukuttan Saritha. *Lignin based nano-composites: Synthesis and applications*. Pages 395-410.

The development of bio-based nanocomposites is of extreme significance in the current environmental situation and hence the progression as well as modification of lignin based nanocomposites is gaining potential research interest. Often treated as a wood waste, lignin is generated as an unwanted component during the production of ethanol and paper. Being a biopolymer with cross-linked structure and an imperative renewable material with antioxidant property, high thermal stability, biodegradability and UV absorption characteristics, lignin could be effectively employed in numerous prospective applications. Introducing various functionalities into lignin transforms it into a valuable material in the composite arena. The key aim of this review is to summarize the

synthesis methods and functionalization of lignin nano particles along with the applications of lignin based nanocomposites thereby creating awareness towards the sustainable utilization of waste lignin in the environment.

- **Keywords:** Lignin; Biopolymer; Nanocomposites; Applications

Limin Geng, Shijie Li, Yonggang Xiao, Hao Chen, Xubo Chen, Yanlei Ma. *Influence of the addition of titanium oxide nanoparticles to Fischer-Tropsch diesel synthesised from coal on the combustion characteristics and particulate emission of a diesel engine*. Pages 411-424.

The use of Fischer–Tropsch (F–T) diesel synthesised from coal in automobiles can alleviate petroleum shortages and promote clean utilisation of coal. Because F–T diesel does not contain oxygen, in this study, we added TiO2 nanoparticles and n-octanol to the F–T diesel to serve as oxygenated enhancers to increase the oxygen content and reduce the particulate matter emission of F–T diesel. To achieve better combustion characteristics and emission performance, TiO2 nanoparticles with different concentrations (20, 50, and 100 ppm) were dispersed to the fuel blends of F–T diesel and n-octanol to determine the optimum amount of TiO2 nanoparticles. The brake thermal efficiency (BTE), combustion stability, number concentration, and size distribution of the ultrafine particulate (UFP) emission of the three nano-emulsion fuels were investigated on a turbocharged heavy-duty diesel engine. The experimental results indicated that the BTE of the F–T diesel and that of the nano-emulsion fuel T50 increased by 0.75 % and 2.26 %, respectively, compared with petro-diesel. The nano-emulsion fuels had higher peak cylinder pressure and peak heat release rate owing to the faster combustion rate caused by the micro-explosion of fuel droplets and higher thermal conductivity caused by the high surface-to-volume ratio of TiO2 nanoparticles. Moreover, the nano-emulsion fuels exhibited higher cyclic variations of peak cylinder pressures and more dispersed corresponding crank angles with the increase in the concentration of TiO2 nanoparticles. Compared with petro-diesel, the soot emission of the F–T diesel was reduced by an average of 27.32 % at various loads, whereas that of the optimal T50 decreased by an average of 43.61 %. Additionally, the number concentration of UFPs of T50 was reduced by an average of 21.2 % compared to the F–T diesel. At low loads, the three nano-emulsion fuels exhibited greater geometric mean diameters (GMDs) of UFPs and lower ratios of nucleation mode particulates (NMPs) owing to the higher fuel viscosity in the pre-injection stage at a lower in-cylinder temperature. At medium and high loads, the nano-emulsion fuels exhibited smaller GMDs of UFPs and higher ratios of NMPs owing to micro-explosion and secondary atomisation at higher temperatures.

- **Keywords:** Fischer-Tropsch diesel; Titanium oxide nanoparticles; Combustion characteristics; Particulate emission; Number concentration; Size distribution

Yang Li, Hao Wang, Ke Bai, Simeng Chen. *Dynamic intelligent risk assessment of hazardous chemical warehouse fire based on electrostatic discharge method and improved support vector machine*. Pages 425-434.

Chemical accidents occur frequently in China owing to inadequate process safety risk management and control in warehouses. Real-time dynamic risk assessment can identify stored process risks and reduce the accident probability. The support vector machine (SVM) is an effective dynamic risk assessment method. To improve the dynamic risk assessment performance of the SVM model, the electrostatic discharge method (ESDA), which has a strong optimization ability, was used to optimize the model parameters. An improved mixed kernel (NP mixed kernel) that was a linear combination of the novel radial basis function and polynomial kernel was constructed, and an intelligent assessment model of the warehouse fire dynamic risk based on the ESDA and improved

SVM (ESDA-NPSVM) was proposed. The experimental results indicated that the proposed model had excellent performance for the dynamic risk assessment of fire accidents in Class A hazardous chemical warehouses, suggesting that it is useful for practical applications.

- **Keywords:** Process safety; Risk assessment; Electrostatic discharge algorithm; NP mixed kernel; Support vector machine; Hazardous chemical warehouse

Nan Pang, Peng Jia, Liquan Wang, Feihong Yun, Gang Wang, Xiangyu Wang, Lei Shi. *Dynamic Bayesian network-based reliability and safety assessment of the subsea Christmas tree*. Pages 435-446.

The major functions of the subsea Christmas tree include production management, wellhead pressure control, chemical reagent injection, and oil/gas production safety control. It is necessary to investigate the reliability and safety of the tree for safe and stable operation of subsea production systems. A fault tree and a dynamic Bayesian model are used to assess reliability and safety and to consider the time slice-based characteristics of the reliability. Using the control variable method, impact analysis is performed to quantify the impact of each failure rate on the system and sort the impacts of failure modes on reliability and safety. Finally, failure prediction is performed. The results show that the annulus loop has the lowest reliability and is the most likely to fail. The failure rate of the tubing hanger has the biggest impact on system reliability, while the failure rate of the choke valve has the biggest impact on system safety. When the tree fails, the failure probabilities of the tubing hanger and the valve group of the production loop are relatively high. On the basis of the above results, corresponding control measures are proposed that can significantly reduce the failure risk of the tree.

- **Keywords:** Reliability analysis; Safety analysis; Subsea Christmas tree; Fault tree model; Dynamic Bayesian model