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Nima Golestani, Rouzbeh Abbassi, Vikram Garaniya, Mohsen Asadnia, Faisal Khan. *Human reliability assessment for complex physical operations in harsh operating conditions*. Pages 1-13.

This paper presents a methodology for quantifying the effect of harsh environmental conditions on the reliability of human actions in performing complex physical operations. A review of current human reliability techniques confirms that there is a lack of methodology for quantifying human errors while conducting complex physical operations in extreme environments. The developed methodology is based on a hierarchical Bayesian network accounting for causal dependencies among environmental factors, human error modes, and scenario-based activities. Also, a new model is developed with three reference points (awareness of the situation, access to a system, and action) that derives human error modes (HEMs) from physiological failure mechanisms and helps an analyst identify the root causes of human errors. The proposed methodology is applied to estimate the likelihood of human error in two different scenarios in harsh operating conditions in floating offshore structures. The two scenarios are a set of different human activities in a workplace under defined operational and environmental conditions. The proposed methodology helps enhance the safety of human performance while considering effective physical factors. It will also help to reform current regulations for working in harsh environments.

- **Keywords:** Human reliability analysis (HRA); Human error modes (HEMs); Bayesian network; Physical factors; Harsh environment

Dapeng Meng, Yao Dai, Ying Xu, Yumin Wu, Peizhe Cui, Zhaoyou Zhu, Yixin Ma, Yinglong Wang. *Energy, economic and environmental evaluations for the separation of ethyl acetate/ethanol/water mixture via distillation and pervaporation unit*. Pages 14-25.

Ethyl acetate is a vital chemical raw material and is usually produced by esterification in industry. But this reaction can produce multiazeotrope mixtures of ethyl acetate/ethanol/water. In this work, triple column pressure-swing distillation process with and without heat integration and hybrid processes combining extractive distillation and pervaporation are proposed to separate a mixture of ethyl acetate/ethanol/water. Furthermore, the three processes are comprehensively compared with the triple-column extractive distillation process. Based on minimization of the total annual cost, the parameters of the all processes are optimized. The triple-column extractive distillation process has the greatest economic advantage. Additionally, the performances of the all

processes in environmental protection and energy efficiency are evaluated. The energy efficiency of the combined extractive distillation and pervaporation unit process is relatively low, but its environmental impact is the lowest among the four processes.

- **Keywords:** Energy; Economic; Environment; Pervaporation unit; Distillation

Zihao Ma, Jinhao Zhang, Haoqi Zhan, Ming Xu, Huawei Yang, Lixia Yang, Liangjiu Bai, Hou Chen, Donglei Wei, Wenxiang Wang. *Immobilization of monodisperse metal-oxo-cluster on graphene for aerobic oxidative desulfurization of fuel*. Pages 26-33.

To meet the ever-upgrading sulfur-content standard of fuel oil, aerobic oxidative desulfurization (AODS) of fuel has become a research focus for its advantages of high efficiency and low cost. Herein, monodisperse polyoxometalate (POM) clusters immobilized by poly(ionic liquid) (PIL) have been successfully supported on graphene through a one-step bottom-up strategy and used as robust catalysts for AODS with air as oxygen source. Systematical characterizations were applied to investigate the structural features and formation mechanism. The catalyst synthesized via non-covalent interactions possessed high specific surface area and large mesoporous size. POM anionic clusters were uniformly monodispersed on the surface of the material, which endowed the catalyst with excellent heterogeneous catalytic performance. Detailed experiments for desulfurization of model fuel were subsequently performed to explore the influence of crucial parameters. The optimal catalyst achieved complete conversion of sulfides under mild condition, which could be reused at least six times without noticeable decreases of the catalytic performance. Based on the obtained results, the POM/PIL/Gr composite is expected to serve as efficient, robust and recyclable catalysts for ultra-deep oxidative desulfurization.

- **Keywords:** Polyoxometalate; Graphene; Dioxygen; Aerobic oxidation; Dibenzothiophene

Muhammad Ajmal, Shi Aiping, Muhammad Awais, Muhammad Saif Ullah, Rehan Saeed, Saad Uddin, Ibrar Ahmad, Bingliang Zhou, Xu Zihao. *Optimization of pilot-scale in-vessel composting process for various agricultural wastes on elevated temperature by using Taguchi technique and compost quality assessment*. Pages 34-45.

Rapid treatment processing for agricultural waste is of the utmost importance with the boom in the agriculture sector of China. This research aimed to examine the influence and optimize the applied temperature and allowed processing time in accelerating the degradation and mineralization rates of the in-vessel composting of agricultural wastes. Under the umbrella of Taguchi technique, total 09 experiments were conducted with three levels of temperature (55°C, 65°C, 75°C) and time (15h, 18h, 22h) in a pilot-scale composter equipped with control systems for temperature, aeration, agitation, and humidity for the composting of poultry manure (PM), vegetable waste (VW), and rice straw (RS) mixed at ratio 5.5:3.5:1 respectively. Results showed that among all treatments, the combination of temperature 65°C and time 18h was an optimal treatment based on S/N ratio and experimental data analysis. Material Loss Analysis of this most stabilized compost showed final masses of mixed raw material, dry matter, moisture contents, TN, and TP were reduced by 78 %, 50 %, 93 %, 23 %, and 41 % of initial masses respectively. Elimination rates of volatile fatty acid and NH+4-N were observed at 98 % and 79 %, respectively. Little higher pH (8.3) showed slight alkane nature of the optimal compost having 26wt.% moisture content, 9.9±0.5wt. % of dm total nutrients (N+K2O+P2O5), and acceptable limits of heavy metals. All these physiochemical characteristics were within limits of the Chinese Standards of Organic

Fertilizer (2012). Overall medium size particle distribution was observed under the macroscopic analysis.

- **Keywords:** Parameters optimization; Taguchi method; In-vessel composter; Agricultural waste; Rapid composting

Giorgio Vilardi, Irene Bavasso, Marco Scarsella, Nicola Verdone, Luca Di Palma. *Fenton oxidation of primary municipal wastewater treatment plant sludge: Process modelling and reactor scale-up*. Pages 46-59.

The aim of this work was to propose a mass-transfer model and scale-up procedure of the Fenton process of organic pollutants present in sludge produced in a municipal wastewater treatment plant. The sludge was collected at the end of anaerobic stabilization, sedimentation and filter press thickening and was firstly characterized by measuring the Total Organic Carbon on the whole sludge and on the liquid phase, the Chemical Oxygen Demand on the liquid phase, the viscosity, the pH, the Cu and Fe concentration and the water content. The optimal water content for the subsequent Fenton process was assessed basing on preliminary pumpability tests, and on Fenton process performances. The analysis of Fenton process was performed by evaluating, at 24 h, the optimal Fe(II) and hydrogen peroxide concentration with respect to the initial total organic content of whole sludge and of sludge liquid phase, as well as to the chemical oxygen demand of sludge liquid phase: the optimal parameters were H2O2/total organic carbon = 1.6 g/g, added Fe(II)/H2O2 = 0.1 g/g, water content = 75 %, through which a chemical oxygen demand and total organic carbon removal efficiency of 72 and 52 %, respectively, was achieved. Kinetic tests were carried out in a batch stirred tank reactor and the results were interpreted in light of a comprehensive mass transfer model to obtain suitable kinetic parameters necessary for reactor design and scale-up. Finally, a simplified process flow diagram was also proposed. Basing on the obtained results, a first real scale-up of the lab-scale reactors could be performed adopting optimal operating parameter values found in the present study, using axial-flow impeller and maintaining constant the Re number.

- **Keywords:** Fenton-process; Viscosity; Primary-sludge

I.P. Lazzarotto, S.D. Ferreira, J. Junges, G.R. Bassanesi, C. Manera, D. Perondi, M. Godinho. *The role of CaO in the steam gasification of plastic wastes recovered from the municipal solid waste in a fluidized bed reactor*. Pages 60-67.

The worldwide solid waste composition indicates that polymeric materials account for, approximately, 10 % of municipal solid waste (MSW). After sorting, MSW still contains a fraction of plastic (Municipal Plastic Waste - MPW) which is a potential raw material for thermochemical processes. Among the thermochemical processes, combustion, pyrolysis and gasification are the most important. This study reports the steam gasification process of the MPW after the MSW sorting of the selective collection in the municipality of Garibaldi, southern Brazil. The samples were obtained after the separation of materials intended for recycling. A total of 29.8 % of the MSW after sorting was found to be made of polymeric materials incorrectly sent to landfill. The MPW was characterized by gravimetric composition, particle size distribution, ultimate and proximate analyzes. The polymeric materials with the highest participation in MPW are polypropylene (28.77 %), polystyrene (23.53 %) and polyethylene (16.67 %). The gasification experiments were carried out in a fluidized bed reactor at different temperatures (800, 850 and 900 °C), by using steam as gasification agent (0.3 kg/h). Gasification experiments were also performed with calcium oxide (CaO). The remaining ash had its morphology analyzed by Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD), while gas from steam gasification was evaluated between 0−90 min by Gas Chromatography (GC). The steam

gasification of MPW with CaO increased both dry gas yield and hydrogen yield. The maximum dry gas yield (3.12 Nm3/kgMPW) was obtained at 900 °C with CaO, as well as a high H2 yield (104 mol/kgMPW). This energy reuse can help to reduce energy demand bottlenecks, as well as the decrease of landfills.

- **Keywords:** Municipal plastic waste (MPW); Steam gasification; Calcium oxide; Fluidized bed reactor

Ahmad Sharafati, Seyed Babak Haji Seyed Asadollah, Majid Hosseinzadeh. *The potential of new ensemble machine learning models for effluent quality parameters prediction and related uncertainty*. Pages 68-78.

Accurate simulation of wastewater effluent parameters is a vital concern to reduce the operational costs of a wastewater treatment plant. In this way, a reliable predictive model is a necessity to achieve an acceptable performance. This study represents a novel approach to predict the effluent quality parameters for an industrial wastewater treatment plant in Qom province, Iran. Three new ensemble machine learning models called Ada Boost Regression (ABR), Gradient Boost Regression (GBR) and Random Forest Regression (RFR) are used to predict the effluent quality parameters including Total Dissolved Solids (TDS), five-day Biochemical Oxygen Demand (BOD5), and Chemical Oxygen Demand (COD) in daily scale. The gamma test technique is used to obtain the optimistic predictive variables. The performance accuracy of the predictive models is assessed based on several metrics indices and visual performance indicators. Results show that the ABR model provides the most performance for predicting the TDS (CC=0.962, RMSE=30.3 mgl) while the GBR offers a better accuracy to simulate the BOD5 (CC=0.9, RMSE=4.6mgl) and COD (CC=0.75, RMSE=9.6mgl) parameters. The findings obtained from uncertainty analysis indicate that the prediction results are more sensitive to model structure (R-factorTDS=0.52, R-factorBOD=0.89 and R-factorCOD=1.06) than the input variables (R-factorTDS=0.21, R-factorBOD=0.67 and R-factorCOD=0.62).

- **Keywords:** Ensemble machine learning model; Effluent quality parameter; Prediction; Gamma test; Uncertainty

Cheng-lin Miao, Meng-meng Duan, Xin-xiu Sun, Xin-yu Wu. *Safety management efficiency of China's coal enterprises and its influencing factors—Based on the DEA-Tobit two-stage model*. Pages 79-85.

In order to accurately analyze the safety management efficiency of China's coal enterprises, based on the panel data of 14 coal listed enterprises in 2012–2018, this paper analyzes the overall technical efficiency (TE), pure technical efficiency (PTE) and scale efficiency (SE) of safety management of sample enterprises by the Data Envelopment Analysis (DEA) model, and builds Tobit model of random panel effect to evaluate the impact of business management and safety investment on safety management efficiency. The results show that: in 2012–2018, the average values of TE, PTE and SE of sample enterprises are respectively 0.674, 0.777 and 0.864; all have great room for improvement. The development of PTE and SE in most sample enterprises is unbalanced; TE of sample enterprises does not significantly improve, and shows a trend of rising-decreasing-rising; safety investment, enterprise scale and labor productivity are significantly positively related to safety management technical efficiency, while safety training person time and employees quality are negatively correlated. This paper identified the positive and negative effects of various influencing factors on the safety management efficiency of coal enterprises, and analyzed the main reasons that hinder the improvement of safety efficiency, and puts forward corresponding countermeasures

and suggestions, which are helpful for coal enterprises to effectively improve their safety management efficiency and economic efficiency.

- **Keywords:** Safety management efficiency; Coal enterprise; Technical efficiency; DEA-Tobit

Zainab Al Ani, Mohammed Thafseer, Ashish M. Gujarathi, G. Reza Vakili-Nezhaad. *Towards process, energy and safety based criteria for multi-objective optimization of industrial acid gas removal process*. Pages 86-99.

Acid gas removal processes find significance in industries because of the need to meet government regulations regarding the concentration of sweet gas. Also, the fact that the removed H2S can be converted to sulfur by the Claus process and the rising importance of carbon capture increases its importance. Optimization of the process with regards to energy consumption and damage index is among the many cases carried out in this study using evolutionary algorithm, NSGA-II. The process is simulated using ProMax 4.0 which was linked to Excel to conduct the multi-objective optimization cases (EMOO). Hydrocarbon recovery and sulfur removal have also been optimized. Detailed analysis of the two-objective optimization cases is carried out in the study followed by a three-objective case which is then compared with the two-objective cases and the results are reported. With industries operating under more than two objectives, the three-objective case would provide more practical results. A four-objective case optimization study, which combines all the studied objectives, is also carried out for more industrial practical solutions. The decision makers will be able to analyze the Pareto-optimal solutions to determine the preferred operating point.

- **Keywords:** Acid gas removal; DEPG; Multi-objective optimization; Energy considerations; Hydrocarbon recovery; Safety indices

Shuhao Zhang, Hongtao Ma, Xiaomei Huang, Shini Peng. *Numerical simulation on methane-hydrogen explosion in gas compartment in utility tunnel*. Pages 100-110.

To explore the sustainability of urban utility tunnel and the possibility for methane/hydrogen mixture transportation, FLACS, the gas explosion simulation software, was used to study the explosion in gas compartment in utility tunnel, and the fuel are 100%CH4, 90%CH4+10% H2, 80%CH4+20% H2 respectively. The results show that with the increase of proportion of H2, vapour cloud with same volume leads to higher overpressure, which increase 16% averagely in 10% H2 and 32% in 20% H2; but in long-narrow structure confined space, the length and the height of vapour cloud affect more than the total mass of fuel; the ventilation opening and door can prevent the fire transfer but can prevent the shock wave and control overpressure; for the situation that ignition position is closed the firefighting wall, if the fuel is enough, the peak overpressure shows at the wall rather than other closed position form the ignition position, so the firefighting wall should be reinforced; for people in utility tunnel, they will not be hurt by shock wave but by fire because of the board range, so the risk of burn exists that people must leave compartment immediately.

- **Keywords:** utility tunnel; gas compartment; gas explosion; FLACS; methane-hydrogen mixture; burn risk

R. Vinoth Kumar, Marta O. Barbosa, Ana R. Ribeiro, Sergio Morales-Torres, M. Fernando R. Pereira, Adrián M.T. Silva. *Advanced oxidation technologies combined with direct contact membrane distillation for treatment of secondary municipal wastewater*. Pages 111-123.

In this work, the combination of advanced oxidation technologies (AOTs) and direct contact membrane distillation (DCMD) was investigated for the treatment of municipal wastewater collected from the secondary clarifier of a municipal wastewater treatment plant (MWWTP). Average removal efficiencies of the 12 micropollutants present in the wastewater samples were higher than 95 % with ozonation (O3) and photolytic ozonation (UV/O3), whereas only near 50 % of removal efficiency was achieved with UV-peroxidation (UV/H2O2). When the ozone-based processes were combined with DCMD, the concentration of these micropollutants were below the detection limits in the respective permeate, increasing the quality of the treated water. However, the permeate fluxes in DCMD were remarkably higher when the wastewater was pre-treated with UV/H2O2 instead of O3, most probably due to the better disinfection achieved by UV/H2O2. It was also confirmed that the dissolved organic carbon (DOC) of the wastewater strongly affects the permeate fluxes achieved by DCMD. In this regard, the combination of the oxidation and membrane separation processes is more appropriate for wastewaters with low DOC contents (< 15 mg L−1).

- **Keywords:** Advanced oxidation processes (AOPs); Membrane; Urban wastewater; Microcontaminants

Yong Xiang, Chicheng Song, Chen Li, Erdong Yao, Wei Yan. *Characterization of 13Cr steel corrosion in simulated EOR-CCUS environment with flue gas impurities*. Pages 124-136.

For a better understanding of the pitting corrosion mechanism of 13Cr steel in a supercritical (SC) CO2–H2O environment with flue gas impurities, experiments were conducted with different exposure time with and without rotation and Cl–. The results show that the corrosion products formed in CO2 phase and water phase varied in morphologies and compositions. The corrosion scale in CO2 phase mainly consisted of amorphous FeCO3 while the corrosion scale in water phase was mainly made up of crystalline FeCO3. Pitting corrosion was the predominant corrosion type in supercritical CO2 with flue gas impurities and it was more severe in CO2 phase than that in water phase. No pitting corrosion occurred in both CO2 and water phase with the presence of flow. Cl– enhanced uniform corrosion in both phases and had ability to break down corrosion products. Secondary localized corrosion could be observed at the boundary of pit holes.

- **Keywords:** Stainless steel; Flue gas; Chloride; Pitting corrosion; Supercritical CO2; Water phase

Changgeng Gui, Fan Geng, Junhua Tang, Hongwei Niu, Fubao Zhou, Chun Liu, Shuda Hu, Haixu Teng. *Gas–solid two-phase flow in an underground mine with an optimized air-curtain system: A numerical study*. Pages 137-150.

Dust control in underground coal mines has long been of great concern to mine operators, and the use of an auxiliary ventilation system is essential to address dust pollution. The present study focuses on analyzing gas–solid two-phase flow in a typical coal roadway with a fully mechanized heading face in the presence of an auxiliary ventilation system with an air curtain. The two-phase flow was simulated by the Euler–Lagrange method. The dust particles were simulated via the discrete phase model (DPM) based on certain sample particles in the form of parcels. To control dust more effectively, the air curtain generator was optimized based on a recently proposed structure. It was found that the air curtain and the improved form have obvious effects on the air flow field, the dust distribution and the amount of particulate matter (PM2.5) in the front part of the roadway (within approximately 15 m of the heading face). PM2.5 around the driver is substantially reduced after the improvement but is limited when the initial supply air

velocity is increased. Selected simulation results were verified by relative field measurements. The results obtained in this study provide useful information on auxiliary ventilation design for use in mining activities.

- **Keywords:** Gas–solid two-phase flow; Underground mines; Ventilation; Air curtain; Numerical simulation; Euler–Lagrange method

Peng-Yi Cui, Jin-Hao Zhang, Yi-Ping Wu, Yan Zhang, Jia-Zheng Zhou, Yang Luo, Yuan-Dong Huang. *Wind-tunnel measurements and LES simulations of air pollutant dispersion caused by fire-induced buoyancy plume inside two parallel street canyons*. Pages 151-169.

A physical model consisting of two parallel street canyons with the fire room located in the windward side of the first street canyon was established. Large eddy simulation (LES) was employed to investigate the effects of air pollutant dispersion caused by the fire-induced buoyancy plume on the indoor and outdoor air quality. The effect of thermal buoyancy was firstly taken into account by burning the smoke cakes in wind-tunnel experiments under different Fr (Froude number) cases. Results show that the diffusion characteristics of smoke plume, temperature and velocity distributions by wind-tunnel measurements agreed well with the numerical models. According to the smoke soot's effects on two street canyons, the dispersion of fire pollutants can be divided into three regimes. There exist two critical Fr, Frcrit,1=0.313 and Frcrit,2=0.389, at which the smoke plume begins to influence the 1st and 2nd street canyons, respectively. Moreover, the region areas of $w < 0$ (vertical velocity) can indirectly represent the concentration distribution of pollutants, and the temperature distribution is closely proportional to the distribution of pollutant (smoke plume, CO2 and CO) concentration, that is, where the plume concentration is high, the temperature is high. The quantitative formulas between Ucrit (Ucrit,1 and Ucrit,2) and the reference height (Zref) of the fire source at different floors were further confirmed. This study provides a new idea for visualizing the diffusion characteristics of fire pollutants, and is helpful for dealing with the building fire, personnel evacuation and emergency escape.

- **Keywords:** Wind-tunnel measurement; Large eddy simulation; Fire pollutant; Critical Froude number; Urban street canyon

Hongyang Ren, Yan Wang, Zijing Wei, Puzhen Liu, Bing Wang. *Excess sludge conditioning with ultrasound/ozone and its effect on the anaerobic anoxic oxic process in a municipal wastewater treatment plant*. Pages 170-177.

Impact of ultrasonication and ozonation pre-treatment on the sewage sludge and ultrasonication–ozonation integrated with anaerobic anoxic oxic system were investigated. According to response surface methodology, the optimal conditions were determined for an ozone dosage of 0.14g·O3/g·SS and an ultrasonic intensity of 1.61W/mL, which corresponded to a maximum sludge reduction ratio of 68.1%. When the residence time of broken sludge was 30min and the reflux ratio was 60%, the broken sludge returned to the anaerobic or anoxic zone had little effect on chemical oxygen demand and improved total phosphorus removal rate of the anaerobic anoxic oxic system effluent. The broken sludge was returned to the anoxic zone, the removal rate of total nitrogen in the effluent of the anaerobic anoxic oxic system could be increased by 13.2%. The broken sludge backflow improved the sedimentation performance of the anaerobic anoxic oxic system sludge, which had little to do with reflow methods. The broken sludge reflowed to the anaerobic zone reduced the sludge production of the anaerobic anoxic oxic system by 51.3%.

- **Keywords:** Ultrasound; Ozone; Sludge reduction; Effluent quality; Sludge production

Tao Wang, You Zhou, Zhenmin Luo, Hu Wen, Jingyu Zhao, Bin Su, Fangming Cheng, Jun Deng. *Flammability limit behavior of methane with the addition of gaseous fuel at various relative humidities*. Pages 178-189.

The lower flammability limit (LFL) of methane is 5 % in volume. Usually, in the relevant industry, the methane leakage monitoring threshold is set on the basis of the LFL from the perspective of safety precautions. When small amounts of other combustible gases coexist with methane, setting the monitoring threshold according to 5% vol may cause a large deviation and lead to a potential explosion accident. To investigate the effects of flammable gases and the relative humidity (RH) on the methane flammability limit behavior, the flammability limits of methane-air mixtures with the addition of gaseous fuels were experimentally measured in a standard cylindrical setup at various relative humidities. A theoretical model based on the adiabatic flame temperature method was employed to obtain reasonable estimates of the flammability limits of binary mixtures of methane and vapor. The combustion hazards of methane-air mixtures were evaluated. The results showed that both the LFL and the upper flammability limit (UFL) of methane were diminished with the addition of gaseous fuel at the same RH, while these parameters increased with an increase in the RH. The flammable range of methane-air mixtures was slightly narrowed by increasing the RH but was extended by the addition of gaseous fuel. The combustion hazard of methane increases as the volume fraction of added gases increases but drops with an increase in the RH. These phenomena were ascribed to the dual roles of water vapor and the influence of the added gaseous fuel on the initial stage of the methane-air chain reactions. The obtained data could supplement the flammability limits database and help to prevent potential explosion hazards.

- **Keywords:** Flammability limits; Gaseous binary fuel; Water vapor; Sensitivity analysis; Combustion hazard

Xian Xi, Quanlin Shi, Shuguang Jiang, Weiqing Zhang, Kai Wang, Wu Zhengyan. *Study on the effect of ionic liquids on coal spontaneous combustion characteristic by microstructure and thermodynamic*. Pages 190-198.

Ionic liquids (ILs) including [BMIm][NTf2], [BMIm][BF4] and [HOEtMIm][NTf2] were used to inhibit coal spontaneous combustion (CSC) in this study. The effects of three Ionic liquids (ILs) on the physical and chemical structure of coal including surface morphology, pore structure and functional groups were analyzed by Scanning electron microscope, N2 adsorption, Fourier transform infrared spectroscopy (FTIR). Subsequently, thermodynamic analysis and oxidation kinetics experiment were utilized to investigate the influence of ILs on the oxidation process. Pore structure analyses indicated that ILs could dissolve the minerals in coal, causing the collapse and blocking of pore structure and resulting in lower specific surface area and pore volume of the treated coals by ILs compared to the raw coal (RC). FTIR results showed the enhanced apparent aromaticity and more stable chemical structure of the treated coals, and this increased the difficult of chemical functional group on the coal surface reacting with oxygen. The thermodynamic and oxidation kinetics experiments revealed that ILs delayed the oxidation process of the treated coals obviously, and the treated coals demonstrated less mass loss ratio and oxygen consumption, as well as lower heat release and carbon monoxide products than the RC. Moreover, [HOEtMIm][NTf2] showed the best inhibition effect on coal spontaneous combustion as verified by minimum heat release and highest activation energy Ea for the treated coal sample.

- **Keywords:** Ionic liquids; Coal spontaneous combustion; Microstructure; Oxidation characteristic; Heat release

Donghui Li, Weiguang Li, Kailei Zhang, Guanglin Zhang, Houqiang Zhang, Duoying Zhang, Pengfei Lv, Jiao Wu. *Nutrient removal by full-scale Bi-Bio-Selector for nitrogen and phosphorus removal process treating urban domestic sewage at low C/N ratio and low temperature conditions*. Pages 199-210.

For solving the nutrient removal from urban domestic sewage at low temperature and low C/N ratio, the full-scale Bi-Bio-Selector for Nitrogen and Phosphorus removal (BBSNP) process was set in Shanghai, China and run continuously at C/N about 3.6. It was run for 133 days along with the temperature dropping from 22±2℃ to 10±2℃. After 27 days' operation, the performance of BBSNP process reached to stable. Chemical oxygen demand (COD), NH4+-N, total nitrogen (TN) and total phosphorus (TP) in effluent were lower than 40, 0.5, 8 and 0.1mg/L, respectively. The NH4+-N and TN removal efficiency were influenced and decreased at low temperature (10±2℃). After improving mixed liquor suspended solids (MLSS) from 4000mg/L to 6000mg/L, the nitrogen removal efficiency lifted to previous level because of the increasing NH4+-N and NO2−-N oxidation rate of suspended sludge. Denitrifying phosphorus accumulating organisms (DPAOs) were the dominant bacteria responsible for phosphorous removal in this study. The Denitrifying phosphorus removal (DPR) efficiency was as high as 74.16±4.40%. Dechloromonas was in higher amount than other DPAOs in the BBSNP process. The results of this study provided a convincing evident that BBSNP could be a practical and cost-effective process for removing nutrient from urban domestic sewage.

- **Keywords:** BBSNP process; Urban domestic sewage; Nutrient removal; Denitrifying phosphorus removal; Low temperature; Low C/N ratio

Mengxin Ji, Liang Chen, Jiajun Que, Lianlian Zheng, Zizhao Chen, Zhengshun Wu. *Effects of transition metal oxides on pyrolysis properties of PVC*. Pages 211-220.

Polyvinyl chloride (PVC) produces a large amount of solid wastes because of its wide use. How to dispose quickly and harmlessly of the PVC solid wastes and turn into a resource is currently a major problem. In this paper, the experimental material was PVC. Thermogravimetric analyzer (TG) and pyrolysis-gas chromatography-mass spectrometer (Py-GC–MS) were used to study the pyrolysis characteristics of PVC with transition metal oxide. The effect of in-situ pyrolysis of PVC in N2 on transition metal oxides was studied in a SX3−4-10A muffle furnace. The composition of tars captured by the cold trap was analyzed by GC–MS. The residual carbon after pyrolysis was analyed by scanning electron microscope (SEM) and XRD. The results of PY-GC–MS and GC–MS showed that the two stages of PVC pyrolysis were advanced with the transition metal oxide.The decomposition peak temperature increased to make PVC pyrolysis more complete. The transition metal oxide reduced significantly the production of benzene, toluene, indene, naphthalene, anthracene and other compounds during the pyrolysis of PVC. The results of SEM and XRD showed that transition metal oxides absorbed HCl produced by pyrolysis and increased the amount of residual carbon in the system. These studies provided a theoretical basis for the pyrolysis rapidly of PVC.

- **Keywords:** Polyvinyl chloride (PVC); Pyrolysis; Transition metal oxide; Polycyclic aromatic hydrocarbons (PAHS); Product distribution

Ziyue Jia, Wei Zeng, Huanhuan Xu, Shuaishuai Li, Yongzhen Peng. *Adsorption removal and reuse of phosphate from wastewater using a*

***novel adsorbent of lanthanum-modified platanus biochar*. Pages 221-232.**

In this study, a novel adsorbent of lanthanum-modified platanus ball fiber biochar (La-TC) was developed for efficient adsorption and reuse of phosphate from actual wastewater. La-TC adsorbing phosphate could be used as agricultural fertilizer. The saturated adsorption capacity of phosphate on La-TC was 148.11 mg/g at dosage of 0.4 g/L, initial solution pH of 6.0, contact time of 20 min, and temperature of 35 ℃, which was much higher than most phosphate biochar adsorbents. Simultaneously, La-TC had a wide pH (3–9) adsorption stability, a strong ability to resist interference of anti-competitive anion (SO_4^{2-} and NO_3^-), and an outstanding regeneration ability. Fourier transform infrared spectroscopy (FTIR), and X-ray photoelectron spectroscopy (XPS) were used to reveal the adsorption mechanism of La-TC to phosphate, including electrostatic adsorption, ligand exchange, and complexation mechanisms. In the fixed bed column experiment of phosphorus removal from real wastewater, the maximum treated bed volume was 420, 440 and 480 (BV) under the bed flow of 1 mL/min and La-TC of 0.5, 0.75 and 1.0 g, respectively. Outcomes suggested that La-TC had a broad prospect of engineering application for removal and reuse of phosphate from wastewater, also realizing the resource utilization of wasted platanus ball.

- **Keywords:** Phosphate; Biochar; Lanthanum-modified; Adsorbents; Fixed-bed column

Wei Yang, Minghua Lin, Gabriel Walton, Baiquan Lin, Sankhaneel Sinha, Changzheng Lu, Guangtao Li. *Blasting-enhanced water injection for coal and gas out-burst control*. Pages 233-243.

Coal and gas out-bursts are a major risk in deep gassy coal mines. In order to minimize the out-burst potential during the mining process, we propose a novel blast-injection integrated (BII) technology. In this technology, a group of de-stress blasts are first used to de-stress the area near the active mining face and push the stress peak further away from the mining face. The cracks generated by the blasting improve the connectivity between the pre-existing fractures and promote gradual release of gas at the mining face. This is followed by water injection directly into the coal seam through the blast holes. The injection of water can greatly improve coal plasticity and reduce the initial speed of gas diffusion, ultimately reducing the potential for violent out-bursts. To implement this technology, a set of devices were developed that include hole packers and transport and safety accessories. The BII technology was subsequently tested at an active mine. It was found that the stress relief zone in front of the coal face increased longitudinally by ~5m, and the rate of gas emission at the mining face doubled within 30min after the de-stress blasting. The injection water volume after the de-stress blasting also increased by 25 times compared to the un-blasted condition, and the monthly gas concentration in the return airway decreased from 0.58% to 0.36%. Additionally, the concentration of dust in the return airway was found to decrease. Based on the field test results, it was concluded that BII technology is an effective measure to limit coal and gas out-burst potential.

- **Keywords:** Coal and gas out-burst; Blasting; Water injection; Stress relief zone

Jing Tao, Fuqiang Yang, Dongyang Qiu, Genserik Reniers. *Analysis of safety leadership using a science mapping approach*. Pages 244-257.

It has been increasingly recognized that safety leadership can effectively contribute to organizational safety, so a lot of attention is paid to safety leadership studies in recent years. In order to understand the current status and development trends of research in safety leadership field around the world, a science mapping analysis of scientific

publications on safety leadership was conducted via the Web of Science Core Collection database. Overall, a total of 238 documents on safety leadership were collected, involving 622 authors, 140 journals, 40 countries, and 388 institutes between 1999 and 2018. The studies associated with safety leadership have been growing from 3 in 1999 to 126 in 2018. The USA, UK, and Canada play important roles in safety leadership research, while further international cooperation should be strengthened in the future. Kelloway, Conchie, and Flin are the most active researchers in this field. With respect to the main sources of safety leadership publications, the Safety Science journal ranks first with 23 articles, followed by the International Journal of Psychology, and the Journal of Nursing Management. In addition, the University of Aberdeen (UK) is the most productive research institute with respect to safety leadership research. In terms of the frequency of keywords, safety performance, transformational leadership, member exchange, transactional leadership, and safety climate are the hottest topics in safety leadership research. The primary themes in safety leadership research concentrate on empiric supports of leadership on safety performance, various leadership styles applied in safety, specific applications of safety leadership in health care, and the correlation between safety leadership and safety climate. Additionally, there are new research topics appearing in recent three years, associated with psychological safety, authentic leadership, ethical leadership, charismatic leadership, empowering leadership.

- **Keywords:** Safety leadership; Safety performance; Bibliometric mapping; Scientific knowledge

Yongjiang Zhang, Quanle Zou, Lindong Guo. *Air-leakage Model and Sealing Technique With Sealing–Isolation Integration for Gas-drainage Boreholes in Coal Mines*. Pages 258-272.

Sealing of boreholes for gas drainage is crucial for ensuring efficient gas drainage in coal seams. In this paper, the damage to coal masses where roadways were excavated and boreholes were drilled was separately simulated to determine the distribution ranges of pressure-relief plastic and elastic zones. Furthermore, the factors influencing air leakage of boreholes were analyzed to determine three patterns of air leakages-air leakage, air leakage, borehole fissure due to roadway fissure zones, borehole fissure zones and materials in borehole-sealing sections, respectively. In addition, a model for the air leakage of boreholes was established, and the principle underlying the sealing of boreholes with sealing–isolation integration was illustrated to separately determine the reasonable borehole-sealing depth, the position and depth of slots, and the grouting parameters. The borehole-sealing techniques for different parameters were compared to verify the applicability of the borehole-sealing technique with sealing–isolation integration. The gas-drainage concentrations after drilling for 30 days showed that, compared with the test borehole sealed using the traditional technique, the initial gas-drainage concentration in the boreholes sealed with sealing–isolation integration increased by 1.5–2 times, and the average gas-drainage concentration increased by approximately 2–3.5 times.

- **Keywords:** air-leakage model; gas drainage; stress distribution; sealing–isolation integration

Yasir A. Elsheikh, Fawzi Elfghi, Qazi Nasir, Nawshad Muhammad. *Effect of pyrazolium ionic liquid halide content on in-situ transesterification of Castor Bean (Ricinus Communis L.) seeds*. Pages 273-282.

Currently, ionic liquids (ILs) have apprehended considerable attention as greener substitutions to volatile organic compounds. In this work, duplicate 1-methyl-2-(butyl-4-sulfonate) pyrazolium hydrogensulfate (MSBPHSO4) were synthesized by two different methods. It is observed that IL2 is significantly less stable and more viscous than IL1. To assess their catalytic actions, each IL was explored individually for in-situ transesterifying

of Ricinus Communis seeds. Under similar reaction conditions, the percentage of methyl esters obtained from in-situ transesterification catalyzed by IL1 and IL2 were 88.5 and 76%, respectively. Hence, the use of IL free halide has the opportunity to achieve high esters content. At investigated optimal conditions with increasing the temperatures beyond 120 °C, in contrast to IL1, IL2 led to significant drop in the product yields. This phenomenon means that higher temperatures offer greater affinity to chemisorb chloride impurities on IL2 surfaces that are sufficient to block the active site and hinder the progress of the reaction. Too, IL1 revealed an excellent catalytic reusability after ten successive running cycles. These results further prove that the halide pathway should be avoided during synthesizing such ILs for biodiesel preparation. In this study we have established a new way for separating IL from the biodiesel as well as glycerol by salting-out assisted liquid-liquid extraction with aqueous MgSO4.

- **Keywords:** Ionic liquid; MSBPHSO4; In-situ transesterification; SALLE; Recyclability

Debasish Tikadar, Ashish M. Gujarathi, Chandan Guria. *Multi-objective optimization of industrial gas-sweetening operations using economic and environmental criteria*. Pages 283-298.

Multi-objective optimization of industrial natural gas sweetening process using elitist non-dominated sorting genetic algorithm is carried out for methyl di-ethanol amine absorbent to tune the process parameters to improve absorption as well as regeneration performance. This study includes several operating parameters such as lean amine temperature and pressure, feed gas temperature and pressure, regenerator feed temperature and pressure, feed flow rate, etc. Environmental and economic optimization criteria are considered using four cases comprising of several conflicting objectives like net profit, global warming potential, and acidification potential under two-objective and three-objective optimization scenarios. Constraints are imposed on H2S content and CO2 content as per the maximum permissible limit. Pareto optimal fronts are found for different cases and trade-offs between different objectives are illustrated. Simultaneous effects of different variables together on the conflicting objectives are considered to analyze the sweetening process to get a more economical and environmentally friendly process.

- **Keywords:** Natural gas sweetening; Methyl di-ethanol amine; Aspen Hysys; Genetic algorithm; Multi-objective optimization; Global warming and acidification potential

Tatiana Flechas, Delphine M. Laboureur, Charles J. Glover. *A 2-D CFD model for the decompression of carbon dioxide pipelines using the Peng-Robinson and the Span-Wagner equation of state*. Pages 299-313.

Pressurized liquefied gases such as carbon dioxide are transported at a pressure above their saturation pressure. Therefore, if a pipeline transporting this substance ruptures, an abrupt expansion occurs, causing the flashing of the fluid. Computational tools that predict how fast a depressurization develops, help to assess the consequences of potential pipeline rupture scenarios. This paper describes the development of a 2-D full-bore rupture decompression model to simulate the transient depressurization of a pipeline transporting pure liquefied CO2, using ANSYS Fluent as CFD software. The scope of work focuses on incorporating non-equilibrium phase transition, while addressing the calculation of properties for metastable liquid. Additionally, it includes the comparison of model predictions when implementing two thermodynamic approaches: the Peng-Robinson Equation of State (EoS), and correlations developed in this work based on the Span-Wagner EoS. It was found that the thermodynamic approach is deemed to have a predominant effect on the arrival time of the decompression wave front at different locations along the computational domain, while the mass transfer coefficient in the

source terms (C) governs the phase transition and the pressure plateau representing this phenomenon.

- **Keywords:** CO2 pipelines; CFD modeling; Decompression; Multiphase flow; Metastable properties

Hesham Khalil, Hamdy Hassan. *Enhancement of waste heat recovery from vertical chimney via thermoelectric generators by heat spreader*. Pages 314-329.

This paper presents three-dimensional study on the enhancement of waste heat recovery from vertical chimney via thermoelectric generators (TEG) by using heat spreader. The physical model composes of aligned TEGs mounted on the chimney wall where each TEG is cooled at its cold side by rectangular finned heat sink. The spreaders are installed on the generators' cold sides between the generators and the heat sinks' bases. The studied model represents three of the TEGs installed on the chimney wall. Three-dimensional model is presented for the physical model coupling the governing equations of thermal, fluid flow and electrical models and is solved by using ANSYS software. Results indicate that using spreader increases total output generators power by 17% and 42% at spreader length 40 and 140mm, respectively and pitch 140mm. The increase of the TEGs power is about 17% and 21% due to using spreader length of 40 and 80mm, respectively at 80mm pitch. Using heat spreader with maximum length of 140mm, increases the conversion efficiency of the lower, middle generator and upper TEGs by 22.2%, 18.8%, and 19.7%, respectively, while the overall efficiency of the system rises by 20.4%. Using spreader with 140mm reduces the used generators and heat sinks numbers to approximately the half.

- **Keywords:** Waste heat recovery; Thermoelectric generators; Chimney; Heat spreader; Enhancement; Heat sink

Qin Xu, Shengqiang Yang, Wenming Yang, Zongqing Tang, Xincheng Hu, Wanxin Song, Buzhuang Zhou. *Micro-structure of crushed coal with different metamorphic degrees and its low-temperature oxidation*. Pages 330-338.

To explore the microstructure and oxidation reactivity of crushed coal, the free radicals and functional groups of coals with different ranks in the crushing process were analyzed based on electron paramagnetic resonance (EPR) and Fourier transform infrared (FTIR) spectrometry. The low-temperature oxidation of different-sized crushed coals was also researched with the aid of a self-built experimental system. The results show that there exists a critical particle size range in the promotion process of the oxidation reactivity of coal. The range is 0.180−0.224 mm for lignite and 0.125−0.224 mm for anthracite. After the coal is crushed to 0.180−0.224 mm, the crushing process begins to exert a weaker effect on the consumption of aliphatic hydrocarbon groups. For the −OH group, the slight increase in the range of 0.180−0.280 mm almost never occurs in the low-rank lignite but is present in bituminous coal and anthracite. Moreover, the rate of CO consumption in the reaction is higher than its rate of generation, whereas for the product CO, the rate of consumption is lower than the generation rate. The free radical concentration of oxidized coal is greatly affected by the crushing process. In the particle size range of 0.074−0.125 mm, low-temperature oxidation has the weakest effect on free radical concentration. The oxidation and crushing effects are both strongest for the minimum particle size of 0−0.074 mm.

- **Keywords:** Crushing process; Free radical; Functional group; Aliphatic hydrocarbon; Oxidation reactivity

Lujian Lin, Shuai Tang, Xuesong Wang, Xuan Sun, Anqi Yu. *Adsorption of malachite green from aqueous solution by nylon microplastics: Reaction mechanism and the optimum conditions by response surface methodology*. Pages 339-347.

Nylon microplastics and malachite green (MG) coexist ubiquitously in the coastal aquaculture areas. Factors controlling MG adsorption to aged and virgin nylon microplastics were identified. The microplastics were characterized by scanning electron microscope equipped with the energy dispersive X-ray spectroscope (SEM-EDAX) and Fourier transform-infrared (FTIR) spectroscopy to elucidate the possible interaction mechanism. The MG adsorption closely conformed to the pseudo-second-order model and the Langmuir isotherm. The MG uptake by the aged nylon microplastics significantly decreased with an increase in solution Pb2+ concentration while the effect of Pb2+ on MG uptake by the virgin microplastics was negligible. The optimum conditions for MG uptake by aged nylon microplastics obtained were 33.51 mg g−1 at initial MG concentration of 57 mg L−1, initial solution pH of 6.84 and aged nylon microplastics dosage of 1.66 g L−1 by use of response surface methodology (RSM). Desorption efficiencies (%) of MG/nylon microplastics combinations in gut surfactant were significantly higher than those in the water, which indicates MG with nylon microplastics has the higher potential for transport to organisms. Overall, the results of this study highlight the role of surface carboxyl functional groups and H-bonding, which both jointly regulate the adsorption of MG on aged nylon microplastics.

- **Keywords:** Nylon microplastics; Malachite green; Response surface methodology; Desorption

Yan Wang, Yangxian Liu, Yong Wang. *Oxidation absorption of hydrogen sulfide from gas stream using vacuum ultraviolet/H2O2/urea wet scrubbing system*. Pages 348-355.

Hydrogen sulfide has serious harm to human body and equipment. Advanced oxidation technology shows excellent development prospect for hydrogen sulfide (H2S) removal due to strong oxidation ability and green process. This article proposed a novel separation process for H2S from gas stream using vacuum ultraviolet (VUV)/H2O2/urea wet scrubbing system in a VUV-spraying scrubber, and studied the effectiveness of H2S removal and removal pathways using VUV/H2O2/urea wet scrubbing system. Results indicated that the highest H2S removal efficiency was up to 98.2 % under optimal experimental conditions. Increasing UV-light intensity and solution pH improved the H2S removal efficiency. Increasing flue gas flow rate and H2S concentration decreased the H2S removal efficiency. The increase of H2O2 concentration, reaction temperature, liquid-gas ratio or urea concentration first increased and then reduced the H2S removal efficiency. H2S was removed by five pathways such as ionization, urea absorption, H2O2 oxidation, photolysis and ·OH oxidation. Photolysis and ·OH oxidation were the two major pathways for the H2S removal.

- **Keywords:** Vacuum ultraviolet/H2O2/urea; OH radicals; Gaseous hydrogen sulfide; (H2S); Photochemical; Urea absorption

Chaojie Wang, Xiaowei Li, Changhang Xu, Yue Niu, Yujia Chen, Shengqiang Yang, Buzhuang Zhou, Chenglin Jiang. *Study on factors influencing and the critical value of the drilling cuttings weight: an index for outburst risk prediction*. Pages 356-366.

To judge the coal and gas outburst (hereinafter referred to as 'outburst') risk of working faces in coal roadways according to the index of drilling cuttings weight (DCW), the influence factors and critical value of DCW were investigated. The study was conducted

by deducing the theoretical calculation formula for DCW and using a set of self-designed, self-machined measuring apparatus for DCW which can be used to simulate the working face in a real coal roadway. The theoretical calculation formula for DCW indicates that the DCW increases with the increase of in situ stress and gas pressure while it also increases with decreasing coal strength. Among the three factors, with the change of gas pressure, the change in DCW is the smallest. On this basis, so that the critical value of DCW for judging the outburst risk of coal masses can better indicate the outburst risk at a working face, the tests for measuring DCWs under different outburst risk levels were carried out by using a set of apparatus for outburst risk which can be used to simulate the working face in a coal roadway by taking gas pressure as a controllable factor. The test results show that, with increasing outburst risk in a simulated coal seam, the DCW linearly increases at first and then suddenly rises. It also implies that the gas pressure exerts significant influences on DCW only when the outburst risk of a coal mass increases to a certain degree. There is a linear relationship between DCW and initial expansion energy of released gas (IEERG). On this basis, according to the critical values of IEERG indicating weak outburst and strong outburst risks, the critical values of DCW for outburst risk are judged. By using discriminant analysis, it can be obtained that the critical value of DCW when a weak outburst occurred is 4.88 kg/m. The critical value can be used to distinguish data samples with measured DCWs having weak outburst risk, whose accuracy reaches 89.47%. The critical value of DCW when a strong outburst occurred is 7.55 kg/m, which can accurately (100%) distinguish between data samples from weak and strong outbursts based on the measured DCWs. The final judgement accuracy of outburst risk is 93.75%.

- **Keywords:** In situ stress; Gas pressure; Coal strength; Gas expansion energy; Coal roadway; Outburst risk

Samy Yousef, Maksym Tatariants, Regita Bendikiene, Rita Kriūkienė, Gintaras Denafas. *A new industrial technology for closing the loop of full-size waste motherboards using chemical-ultrasonic-mechanical treatment*. Pages 367-379.

Development of a new sustainable pilot scale technology for recycling of Waste Printed Circuit Boards (WPCBs) is a challenging and time-consuming task, especially since the situation with electronic waste is worsening yearly in terms of environmental hazard and valuable material loss. Therefore, this research is oriented towards quickly approaching the industrial level and recycling a full-size waste motherboard (MB) using a combined technique presented by three treatment types: chemical, ultrasonic, and mechanical. Here, chemical is the main treatment type with an aim to liquefy Brominated Epoxy Resin (BER) using an organic solvent eventually separating all layers of MB, while mechanical and ultrasonic treatments are used to accelerate the BER dissolution process. The treatment was performed in a new reactor designed especially for that purpose. Spent solvent was regenerated several times during the treatment by a rotary evaporator to avoid solvent saturation as well as to extract the BER. Ultraviolet-Visible Spectroscopy, FTIR, NMR, metallographic microscope, SEM and EDX were the used to study the obtained BER, fiberglass, and metal. The results indicated that MB was composed of five fiberglass layers adhered by BER (67wt.%), two copper layers and tracks (19.4wt.%), through-hole pads (12wt.%). In addition, it was noted that through-hole pads contained Palladium coating. Finally, based on the economic evaluation of the new technology, a conclusion was drawn that the application of this technology on an industrial scale can provide an economic return up to ~2,300$ per ton of WPCBs (without precious metals recovery). In addition, applying the developed approach on an industrial scale gives a possibility to decrease carbon footprint by −1868kg CO2-eq/t of WPCBs.

- **Keywords:** Waste printed circuit board (WPCB); Recycling; Motherboard; Chemical-ultrasonic-mechanical treatment; Circular economy

Bing Liu, Peng An, Jie Chen, Xiaochen Xu, Lifen Liu, Fenglin Yang. *A novel method for preparation of polyaluminum phosphoric sulfate (PAPS) coagulant using SAPO-34 mother liquor: Characterization and coagulation performance*. Pages 380-391.

Polyaluminum phosphoric sulfate (PAPS), which is a composite coagulant, was prepared using SAPO-34 mother liquor that was obtained from the process of synthesizing SAPO-34 molecular sieve. After the pretreatment of the SAPO-34 mother liquor, 80.50 % of the triethylamine in the mother liquor was recycled by fractional distillation and the residual triethylamine was oxidized and decomposed by ozone. Furthermore, during the preparation of PAPS, the effects of [P]/[Al], [OH]/[Al] molar ratios, and reaction temperature were examined, and the optimum preparation conditions were determined by response surface methodology. Results showed that the optimum PAPS preparation conditions were n(P)/n(Al)=0.25, n(OH)/n(Al)=1.05, and temperature of 85°C. In addition, the structure and morphology of PAPS were characterized by scanning electron microscope (SEM), X-ray photoelectron spectroscopy (XPS) and X-ray diffraction (XRD), and the coagulation performances were evaluated by kaolinite synthetic water treatment. The results indicate that complex compounds are formed in the synthesis of PAPS. Finally, on comparison with PAC and Al2(SO4)3·18H2O, PAPS exhibits better coagulation performance in removing turbidity and total phosphorus, when the dosage is 40mg/L.

- **Keywords:** Coagulation; Mother liquor; Polyaluminum phosphoric sulfate; Turbidity removal; Residual phosphorus concentration

Yu Zhang, Guanghu Lian, Chunying Dong, Meiqiang Cai, Zhijun Song, Yuejing Shi, Liguang Wu, Micong Jin, Zongsu Wei. *Optimizing and understanding the pressurized vertical electro-osmotic dewatering of activated sludge*. Pages 392-402.

Pressurized vertical electro-osmotic dewatering (PVEOD) is an emerging mechanical technology for deep dewatering of wastewater sludge. In this study, the influence of main operation variables including sludge dosage, voltage, mechanical pressure on electro-osmotic dewatering was investigated. Response surface method (RSM) was applied to evaluate and optimize the interactive effects of the three major operating variables. The results indicated the optimum conditions to be 2.70MPa of mechanical pressure, 18.33V of voltage and 0.0169kWh/kg water of energy consumption. Layered distribution study was conducted between anode side and cathode side to investigate the vertical changes of moisture content, zeta potential, three-dimensional excitation emission matrix (3D-EEM) spectra of extracellular polymeric substances, the concentration of proteins and polysaccharides. The morphology changes of sludge observed by microscope images unveiled the possible mechanisms of enhancing the sludge dewaterability in the PVEOD process. The electrochemical at electrodes and electro-osmosis are important for interpreting the dryer sludge at anode layer.

- **Keywords:** Electro-Osmotic dewatering; Activated sludge; Sludge properties; Extracellular polymeric substance (EPS)