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Mariem Chtourou, Maryam Mallek, Montserrat Dalmau, Julian Mamo, Eric Santos-Clotas, Abdelhamid Ben Salah, Khaled Walha, Victoria Salvadó, Hèctor Monclús. *Triclosan, carbamazepine and caffeine removal by activated sludge system focusing on membrane bioreactor*. Pages 1-9.

Alternative processes need to be designed for the treatment of industrial effluents containing pharmaceutical and personal care products to improve their quality, permit the reuse of water for industrial applications and meet the standards set by environmental regulations prior to discharge. This type of effluent is a major source of water pollution since conventional activated sludge-based treatments are not effective in removing micropollutants. Carbamazepine, caffeine and triclosan are important trace contaminants commonly found in wastewater treatment plants, and were selected as target compounds to be treated in a cyclic anoxic/aerobic membrane bioreactor. This study aims to evaluate the biomass' characteristics and activity, and its influence over membrane fouling when treating the aforementioned compounds. Caffeine is known to be partially biodegraded whereas triclosan can inhibit microorganism's activity. In order to evaluate this effect, complimentary batch experiments were set up to determine whether triclosan might inhibit nitrification. Low ammonia removal efficiencies were observed in both experimental systems, therefore suggesting that nitrification was being inhibited probably due to the presence of triclosan. The ultrafiltration membrane bioreactor process demonstrated to be an efficient and appropriate technology for chemical oxygen demand removal, achieving an average of 97%, for caffeine reaching up to 93.7±9.7 removal efficiencies, and 89.7±8.3% for triclosan. For carbamazepine the removal was lower (36.2±6.8%) due to its recalcitrance. Furthermore, biomass filterability indicators displayed high sludge deterioration increasing substantially the fouling.

- **Keywords:** Membrane bioreactor; Batch reactor; Emerging organic contaminants; Fouling; Nitrification; Triclosan

Prasenjit Chakraborty, Soumya Banerjee, Sumit Kumar, Sutonu Sadhukhan, Gopinath Halder. *Elucidation of ibuprofen uptake capability of raw and steam activated biochar of Aegle marmelos shell: Isotherm, kinetics, thermodynamics and cost estimation*. Pages 10-23.

The present study investigates the sorption capabilities of raw and steam activated biochar derived from Aegle marmelos (wood apple) shell in the removal of ibuprofen (IBP) from aqueous solution. The influence of various parameters viz. initial ibuprofen concentration (1–45mgL−1), contact time (0.5–24h), temperature (15–45°C), adsorbent

dosage (0.033–3.33gL−1), pH (2–6) and agitation speed (100–180rpm) were considered for ibuprofen sorption by wood apple biochar (WAB) and wood apple steam activated biochar (WASAB). WAB and WASAB achieved maximum removal of 90% and 95% respectively from aqueous solution at 15°C and 20°C respectively. Optimum IBP removal was found at pH 2 for WASAB and 3 for WAB, dose 0.33gL−1 for WAB and 1gL−1 for WASAB, agitation speed 150 for WAB and 120 for WASAB, initial concentration of 15mgL−1 and 30mgL−1 for WAB and WASAB respectively and temperature of 15°C for WAB and 20°C for WASAB. Morphological analyses of the adsorbents suggested increase in active adhesion site after activation of the biochar.The elemental analysis showed an increase in carbon and oxygen percentage in the adsorbents, which confirm the existence of ibuprofen after adsorption. Ibuprofen sorption by WAB and WASAB followed Langmuir and Freundlich isotherms respectively and the process obeyed pseudo second order kinetic model in both the cases. The thermodynamic study suggested the process to be exothermic, spontaneous and feasible in nature. The cost estimation study indicated the cost-effectiveness of the indigenously developed adsorbents for their utilization in the removal of ibuprofen from contaminated water. Therefore, the biochar derived from the shell of Aegle marmelos exhibited potential role towards adsorptive removal of pharmaceutical compounds from aqueous solution.

- **Keywords:** Ibuprofen; Aegle marmelos; Isotherm; Kinetics; Thermodynamics; Cost estimation

Caroline Borges Agustini, Michael Meyer, Marisa Da Costa, Mariliz Gutterres. *Biogas from anaerobic co-digestion of chrome and vegetable tannery solid waste mixture: Influence of the tanning agent and thermal pretreatment*. Pages 24-31.

Mesophilic anaerobic co-digestion of mixtures of solid wastes from tanneries containing chromium and vegetable tannins was investigated in an orthogonal array. The effect of thermal pretreatment on shavings was evaluated as well. The biogas and methane productivity in terms of VSS was assessed. The treatment efficiency was also evaluated in terms of variation of organic and inorganic load. All assays with chromium-containing sludge showed on average 19.6ml of biogas/gVSS added, 8.15ml of methane/gVSS added, 4.8% VSS reduction, 60.4% BOD5 reduction, 55% TOC reduction, 67% IC increase and 54.6% TN increase, showing greater mineralization of the residue when compared to the assays with vegetable tannin sludge, which has proven to be toxic. The origin of shavings was not significant in any parameter due to the small proportion of this residue in assays. The thermal pre-treatment was beneficial only for assays with vegetable tannins, since there was evidence that the heating mechanism degraded part of the phenolic organic matter and consequently reduced its toxicity.

- **Keywords:** Anaerobic co-digestion; Chromium; Vegetable tannin; Tannery solid waste; Thermal pretreatment

Sathish Paulraj Gundupalli, Subrata Hait, Atul Thakur. *Classification of metallic and non-metallic fractions of e-waste using thermal imaging-based technique*. Pages 32-39.

Electronic waste (e-waste) is generated at a rapid pace due to technological advancement and thereby reduced obsolescence age of electrical and electronic equipment (EEE). E-waste comprises of many useful recyclable materials such as metallic fractions (MFs), like aluminum and copper and non-metallic fractions (NMFs), such as plastic, printed circuit boards (PCB) and glass. Classification of MFs and NMFs from e-waste is of great significance from the viewpoint of recycling of materials and resource recovery. In this paper, we focus on the classification of MFs and NMFs from e-waste using thermal imaging-based technique operated in the long-wave infrared range (LWIR)

8–15μm. We use a feature vector comprising of mean intensity, standard deviation and the image-sharpness extracted from the thermograms of individual materials present in e-waste. We developed a classification model to classify the feature vectors into broad categories of metal, PCB, plastic, and glass. We conducted several experiments on simulated e-waste to validate the developed approach and obtained a classification success rate in the range of 84–96%. We believe that the proposed approach is a viable solution for multi-material classification of e-waste into broad categories and can be scaled up to fit for an e-waste recycling plant.

- **Keywords:** E-waste; Recyclables; Material classification; Thermal imaging; Automated sorting; Recycling

Ming-hong Wu, Lin Li, Ning Liu, De-jin Wang, Yuan-cheng Xue, Liang Tang. *Molybdenum disulfide (MoS2) as a co-catalyst for photocatalytic degradation of organic contaminants: A review*. Pages 40-58.

Photocatalytic degradation is an emerging, efficient and energy-save technology for the removal of organic contaminants from the water environment. With the development of two-dimensional functional materials, molybdenum disulfide (MoS2) has become one of the most popular emerging co-catalysts due to its high photocatalytic activity, strong adsorptivity, low cost and non-toxicity, especially applied to the photocatalytic degradation of organic contaminants. In this paper, we review the recent research progresses of graphene, carbon-nitrogen compounds, TiO2 and bismuth compounds supported on MoS2 co-catalyst, which were applied to photocatalytic degradation of various organic contaminants such as methylene blue (MB), methyl orange (MO) and rhodamine B (RhB), etc. Meanwhile, the basic processes of photocatalytic degradation of organic pollutants have also been briefly analyzed and compared. More importantly, MoS2 co-catalyst plays an integral role in nanocomposites, especially in accelerating photo-induced electron transport and reducing electron recombination rates. It is indicated that MoS2-based composites are promising photocatalysts for photocatalytic degradation of environmental pollutants.

- **Keywords:** Molybdenum disulfide; Two-dimensional (2D) materials; Photodegradation; Organic pollutants; Heterojunctions

Yusuke Koshiba, Takashi Hasegawa, Hideo Ohtani. *Numerical and experimental study of the explosion pressures and flammability limits of lower alkenes in nitrous oxide atmosphere*. Pages 59-67.

Abstract: This article reports an experimental and numerical investigation of the explosive properties of flammable mixtures of lower alkenes in nitrous oxide atmospheres. The motivation for this study was to reduce fire/explosion risks in industrial facilities that handle nitrous oxide. In this study, explosion pressures and lower and upper flammability limits were experimentally determined at an initial temperature of approximately 20°C and an initial pressure of 101.3 kPa. The lower alkanes/alkenes methane, ethane, n-butane, ethylene, and propylene were tested. To precisely estimate the upper flammability limits of alkane–alkene–N2O and alkene–alkene–N2O mixtures, we proposed a modified VAFT (variable adiabatic flame temperature) method. Experimental measurements and numerical calculations clearly demonstrated that (i) alkene–N2O mixtures exhibit higher explosion pressures than the corresponding alkene–O2 mixtures under fuel-lean conditions, (ii) Le Chatelier's equation successfully predicts the lower flammability limits of alkane–alkene–N2O and alkene–alkene–N2O mixtures, and (iii) the modified VAFT method can predict the upper flammability limits of alkane–alkene–N2O and alkene–alkene–N2O mixtures more accurately than Le Chatelier's equation.

- **Keywords:** N2O; Lower and upper flammability limits; Explosion pressure; Variable adiabatic flame temperature (VAFT); Olefin; Gas explosion

Omama Kamoun, Ines Ayadi, Mohamed Guerfali, Hafedh Belghith, Ali Gargouri, Hèla Trigui-Lahiani. *Fusarium verticillioides as a single-cell oil source for biodiesel production and dietary supplements*. Pages 68-78.

A newly isolated oleaginous fungus called E4-2 and identified as Fusarium verticillioides was selected as a potential source of lipid production using glucose as carbon source and a mixture of ammonium chloride and yeast extract as nitrogen sources. A maximum lipid accumulation of 1.88g/L and a lipid cell content of 38% were obtained at optimal pH and temperature equal to 5 and 30°C, respectively. Moreover, the E4-2 strain can grow on a variety of low-cost agro-waste carbon sources. Interestingly, waste cooking oils (1.67g/L) and soap stock of refined olive oil pomace (1.25g/L) were optimal for a maximum lipid accumulation. Gas chromatography analysis of the extracted lipids revealed that, similar to some vegetal oils, the prominent fatty acid (FA) constituents were C18:1 (34.65%), C18:2 or ω6 (30.78%) and C16:0 (25.61%) with a high ω6 content. More interestingly, the ω3 content rose from 0.86 to 1.71 when culture temperature was set from 30 to 25°C. The predictive determination of biodiesel properties from fatty acids profile suggests that E4-2 lipids may favorably be used for biodiesel production. All these characteristics argue in favor of the great biotechnological potential of the lipids produced by our strain.

- **Keywords:** Oleaginous fungus; Biodiesel; Fusarium verticillioides; Lipid; Optimization

Marcin Śliwiński. *Safety integrity level verification for safety-related functions with security aspects*. Pages 79-92.

The article is devoted some important issues of the functional safety analysis, in particular the safety integrity level (SIL) verification of safety functions to be implemented within the distributed control and protection systems with regard to cyber security aspects. The procedure for functional safety management includes hazard identification, risk analysis and assessment, specification of overall safety requirements and definition of safety functions. Based on risk assessment results the safety integrity level (SIL) is determined for consecutive safety function. These functions are implemented within industrial control system (ICS) that consist of the basic process control system (BPCS) and/or safety instrumented system (SIS). Determination of required SIL related to required risk mitigation is based on semi-quantitative evaluation method. Verification of SIL for considered architectures of BPCS and/or SIS is supported by probabilistic models with appropriate data and model parameters including cyber security-related and uncertainty aspects. A method based on quantitative and qualitative information is proposed for SIL verification with regard of the evaluation assurance levels (EAL), the security assurance levels (SAL) and the number of protection rings described in the SeSa methodology. A method for SIL verification, based on so called differential factor is presented.

- **Keywords:** Safety integrity level; Integrated functional safety & cyber security; Differential factor

Peng Cai, Wen Nie, Yun Hua, Wenle Wei, Hu Jin. *Diffusion and pollution of multi-source dusts in a fully mechanized coal face*. Pages 93-105.

In order to provide theoretical guidance for dust prevention and treatment, as well as environmental protection for mines, we investigated the diffusion and pollution of multiple sources in a fully mechanized coal face using CFD-DPM based airflow-dust coupling method, and analyzed the distributions of dust particle diameter at different

positions. Results show that, the air was mainly leaked from three positions in the mining area, 6m away from the air inlet on the leeward side, the position where the hydraulic prop was moved and the middle part of the shearer. A high-velocity airflow zone was formed around the shearer's front roller, with airflow velocity up to 2.2m/s. The dusts produced by the advancing support were superposed with the dusts from the roller's coal cutting, and a high-concentration dust zone with a length of approximately 2m was formed at the front roller, with dust concentration as high as 3000mg/m3. Within 40m from the air outlet, a great number of dusts larger than 70μm settled. Finally, the field measured results of airflow and dust concentration verified the accuracy of the simulation of dust diffusion and pollution behaviors in the fully mechanized coal face.

- **Keywords:** Fully mechanized coal face; Airflow streamlines; Dust particle diameter; Dust concentration; CFD-DPM; Dust pollution

Domenica Mosca Angelucci, Sara M. Di Cesare, M. Concetta Tomei. *Kinetic study of two-step mesophilic anaerobic-aerobic waste sludge digestion: Focus on biopolymer fate*. Pages 106-114.

Kinetics of the sequential anaerobic–aerobic digestion operated under mesophilic conditions on waste activated sludge of a full-scale wastewater treatment plant was investigated. Special focus was given to the fate of proteins and carbohydrates, given the influence of biopolymers on dewatering properties of the sludge. Kinetic tests were performed to characterize the suspended solid degradation and the trend of biopolymers in both digestion steps. Volatile solid degradation rates were 0.93 and 0.52kgVSm−3d−1 in anaerobic and aerobic conditions, respectively. Different models (1st order, Michaelis-Menten, Valentini and Contois) have been compared for VS degradation: Contois equation provided the best data fitting (correlation coefficients ≥0.99). Evolution of biopolymers during two-step process exhibited a similar pattern: during the anaerobic phase, an increase of about one order of magnitude was observed for carbohydrates and of 100% for proteins, while in the aerobic bioreactor both decreased of 29 and 73%, respectively. Data from kinetic tests were employed to model the biopolymer patterns taking into account their production from the hydrolysis of particulate organic substrate and their biodegradation in the different anaerobic and aerobic reaction environments. Michaelis-Menten equation gave satisfactory predictions of the biopolymer fate with correlation coefficients ranging from 0.92 to 0.97, for both carbohydrates and proteins.

- **Keywords:** Sludge stabilization; Anaerobic-aerobic sequential sludge digestion; Biopolymers; Carbohydrates; Proteins; Kinetic modelling

Prerna Jain, William J. Rogers, Hans J. Pasman, M. Sam Mannan. *A resilience-based integrated process systems hazard analysis (RIPSHA) approach: Part II management system layer*. Pages 115-124.

The Chemical Process Industry has witnessed an increase in process safety challenges and changes in the global public perception of risk. The key hazard identification and analysis methods used in the industry follow a univariate analysis which limits them in their approach to consider multiple factors, complex interactions among system components, and their relationships. It is evident that the majority of incidents are a result of human, organizational, mechanical, and operational failures. Most methods lack the anticipation element as well as the full scenario anatomy of incident–initiation, propagation, and termination. Furthermore, the incompleteness of possible scenarios may lead to the reduction or absence of essential risk reduction measures. The hazard analysis method for a complex socio-technical system, such as a process plant, should incorporate the following characteristics: consideration of all system components (e.g., processes, human operations, equipment, instruments, and control systems), all plausible deviations, a multi-disciplinary team, and proper documentation. Analyzing the extent of the resilience of the whole system, with respect to the plant and management

system layers and strengthening weaknesses, is expected to result in significant reduction of unexpected failures and threats to develop and terminate as mishaps. To this end, in Part I (Jain et al., 2018b), the paper presented the Resilience-based Integrated Process Systems Hazard Analysis (RIPSHA), proposed a bi-layered approach that takes two distinct layers into account, and treated the second layer called the Plant System. In Part II, the first layer, called the Management System is presented that comprises three rational sub-systems for analysis-process safety culture and leadership, operational discipline, and process safety systems. This work establishes and presents worksheets and guidewords based on resilience metrics for management systems hazard analysis. The paper closes with a case study on tank explosion accident to illustrate the key concepts of the management system layer hazard analysis.

- **Keywords:** Management system; Hazard analysis; Resilience; Process safety systems; Operational discipline; Process safety culture

Santosh P. Ghuge, Anil K. Saroha. *Catalytic ozonation of dye industry effluent using mesoporous bimetallic Ru-Cu/SBA-15 catalyst*. Pages 125-132.

Catalytic ozonation was employed for the degradation of aqueous solution containing reactive orange 4 (RO4) azo dye and textile dye industry effluent using mesoporous bimetallic Ru-Cu/SBA-15 catalyst. The catalyst was synthesized and characterized using BET, SEM, TEM and EDX techniques. The effect of operational parameters like initial solution pH and ozone dose on the degradation of RO4 azo dye was studied. The degradation pathway of the dye solution was investigated using radical scavenger t-butanol. The optimum values of initial solution pH and ozone dose were found to be 9 and 5g/m3 respectively. A colour removal efficiency of 100% and COD removal efficiency of 70.4% of RO4 dye aqueous solution were obtained at the optimum conditions after 21min and 60min of catalytic ozonation respectively. The colour and COD removal pathways were governed by direct ozone molecular and hydroxyl radical mechanism respectively. The bicarbonate ions present in the textile dye industry effluent were found to act as radical scavengers, thereby, lowering the COD removal efficiency significantly. The removal of bicarbonate ions from the effluent prior to its ozonation enhanced the COD removal efficiency from 30.2% to 90% after 4h of catalytic ozonation.

- **Keywords:** Catalytic ozonation; Dye industry effluent; Mesoporous Ru-Cu/SBA-15; RO4 azo dye

Yunzi Hu, Chenyu Du, Nattha Pensupa, Carol Sze Ki Lin. *Optimisation of fungal cellulase production from textile waste using experimental design*. Pages 133-142.

Abstract: Abundant textile waste has raised increasing concerns worldwide in developing novel circular textiles approach. This study investigated the optimum cellulase production from textile waste by Aspergillus niger CKB. Textile wastes consisting of cotton and polyester in various ratios were used as low-cost feedstock. Three types of cultivation media were compared in solid state fermentation and Mandels medium with yeast extract selected due to its superior cellulase production. Conditions including moisture, pH, inoculum size and organic nitrogen were evaluated and optimised via response surface methodology. Supplementary carbon sources and cellulase inducers were also employed to enhance fungal growth and cellulase production. The results indicated that the optimised fermentation method significantly improved cellulase producing efficiency and enzyme activity by 88.7% and 25.8%, respectively. The maximum cellulase activity reached 1.56 FPU g−1 in 6days. The outcomes led to the efficient recovery of glucose and polyester, which could contribute to a closed-loop recycling strategy for the textile industry, and enable the transition to an advanced circular textiles economy.

- **Keywords:** Cotton; Fungal cellulase; Response surface methodology; Solid state fermentation; Textile waste

Huaimin Wang, Guneet Kaur, Nattha Pensupa, Kristiadi Uisan, Chenyu Du, Xiaofeng Yang, Carol Sze Ki Lin. *Textile waste valorization using submerged filamentous fungal fermentation*. Pages 143-151.

Textile waste is one type of municipal solid waste growing rapidly in recent years. In Hong Kong, 306t of textile waste were produced daily in 2015 and more than 90% of these ended up in landfill. This is the first paper which utilizes textile wastes as substrate for cellulase production via submerged fungal fermentation, the resultant fungal cellulase was subsequently utilised in textile waste hydrolysis for recovery of glucose and polyester. Trichoderma reesei ATCC 24449 was selected with the highest cellulase activity (18.75FPU/g) after cultivation using textile blending cotton/polyester 40/60 as substrate. Cellulase production was upscaled in a 5-L bioreactor and the resultant cellulase was used in textile waste hydrolysis. Glucose recovery yield of 41.6% and 44.6% were obtained using fungal cellulase and commercial cellulase, respectively. These results suggest the proposed process has a great potential in treating textile waste and facilitating the recovery of glucose and polyester as value-added products.

- **Keywords:** Cellulase; Hydrolysis; Submerged fungal fermentation; Textile waste; Waste recycling

N. Jafri, W.Y. Wong, V. Doshi, L.W. Yoon, K.H. Cheah. *A review on production and characterization of biochars for application in direct carbon fuel cells*. Pages 152-166.

This review explores two areas: firstly, the production of biochars from an array of different woody and non-woody waste biomass through pyrolysis and its physical-chemical characterization. Secondly, the influence of the structural properties of biochars for application in direct carbon fuel cells (DCFCs) is also explored. The need for developing low cost and environmentally favourable carbon fuel material puts lignocellulosic biomass-derived char (biochar) into the forefront. This char fuel is produced from biomass feedstock by the process of slow pyrolysis which is regarded as the most common route of production. The degree and magnitude of decomposition of each of the biomass components is dependent on process variables such as feedstock type, reaction temperature and heating rate. The generated biochar is then utilized as a fuel in a DCFC. This review establishes an understanding of the most significant properties of the biochar fuels which include proximate analysis (information of moisture, ash, volatile and fixed carbon content), and ultimate analysis (C, H, N, S and O composition), heating values and surface area. The H/C and the O/C atomic ratios are considered as important pyrolysis indicators required for a better quality fuel.

- **Keywords:** Lignocellulosic biomass; Pyrolysis; Biochar; Direct carbon fuel cell

Weidong Zhao, Xiaoyin Zhang, Jianquan Huang, Kang Ni, Junfeng Wang. *Hydrogenation of bio-oil via gas-liquid two-phase discharge reaction system*. Pages 167-177.

In view of current technical problems of catalyst coking inactivation, poor equipment safety and large amount of hydrogen consumption, which are caused by high hydrogen pressure and operating temperature in bio-oil hydrogenation, an innovative gas-liquid two-phase discharge reaction system was constructed and applied to actualize the hydrogenation of bio-oil under catalyst-free, normal temperature and pressure conditions. Single-factor experiments were performed to explore the effects of working voltage, gas-flow rate and reaction time on the deoxygenation rate and high heating

value of refined bio-oil. Furthermore, with the results of multi-factor orthogonal experiments, the operating parameters optimization model for the deoxidation rate of bio-oil was developed. The reasonable reaction pathways for the hydrogenation of various oxygenated compounds under gas-liquid two-phase discharge reaction conditions were well inferred. Under optimized operating parameters, the deoxidation rate of 65.26% with the high heating value of 35.15MJ/kg of bio-oil were achieved. GC–MS analysis results demonstrated that aldehydes, ketones were completely diminished, and alcohols, esters, phenols and acids were decreased. A remarkable increase of hydrocarbons was revealed, which indicated the quality of bio-oil was significantly improved. As a result, this gas-liquid two-phase discharge reaction system can perform hydrogenation of bio-oil efficiently.

- **Keywords:** Bio-oil; Non-thermal plasma; Gas-liquid two-phase discharge; Hydrogenation

E. Raper, T. Stephenson, D.R. Anderson, R. Fisher, A. Soares. *Industrial wastewater treatment through bioaugmentation*. Pages 178-187.

Bioaugmentation of activated sludge processes through the addition of microorganisms is employed with the aim of enhancing treatment, in particular the removal of priority pollutants. With industrial wastewaters, studies have covered target pollutants including ammonia and polycyclic aromatic hydrocarbons (PAHs): compounds that are regulated around the globe. However, bioaugmentation is a technique that has been associated with doubt in regard to its ability to benefit treatment processes. Failure of bioaugmentation has been reported to be associated with numerous factors that include the growth rate being lower than the rate of washout, insufficient inoculum size and substrate availability. Limitations of bioaugmentation can be overcome through techniques that include increased inocula dosing, pre-acclimatisation of inocula in side-stream reactors, addition of nutrients and surfactants and application of sufficient acclimatisation periods. Surveys of the literature show that a key area for further research should be towards acquiring a better understanding of the degradation pathways where bioaugmentation is applied. There also remains a need to undertake bioaugmentation efficacy studies at full scale with test and control streams. Further reporting on the economic viability of the technique is also necessary.

- **Keywords:** Bioaugmentation; Industrial wastewater; Nitrogen; Polycyclic aromatic hydrocarbons; Phenol

Teerayut Bunma, Prapan Kuchonthara. *Synergistic study between CaO and MgO sorbents for hydrogen rich gas production from the pyrolysis-gasification of sugarcane leaves*. Pages 188-194.

This study focused on investigating the sorption-enhanced hydrogen (H2)-rich gas production during the pyrolysis-steam gasification of biomass in a two-stage fixed-bed reactor. The mixed CaO/MgO sorbents were employed in order to enhance the H2 production through the water-gas shift reaction associated with the capturing of CO2. The CaO/MgO sorbents prepared by dry- and wet-physical mixing with different molar ratios were examined. In addition, the effect of different devolatilization temperatures (400–800°C) and gasification temperatures (600–800°C) on the H2 yield were explored. It was found that the dry-mixed CaO/MgO sorbent exhibited a synergistic effect in the pyrolysis-steam gasification of the biomass, where a CaO:MgO molar ratio of 2:1 gave the highest H2 yield (16.8mmol/gbiomass) and H2 concentration (75.0%). The wet-mixed sorbent gave superior results, affording a higher H2 yield (21.2mmol/gbiomass) and H2 concentration (79.8%) with the same CaO: MgO molar ratio of 2:1. The CO2 yield was also reduced to 1.14mmol/gbiomass compared to that with the dry mixed sorbent (1.72mmol/gbiomass). The oxygenated compounds mainly derived at the devolatilization temperature of 600°C were conceivably preferable to the sorption-

enhanced hydrogen production in the gasification, leading to the highest yield and concentration of H2. Increasing the gasification temperature above 600°C provided a higher H2 yield but caused a lower H2 concentration. A comprehensive discussion on these aspects related to volatile components released from different temperatures and reactivity of sorbents is provided.

- **Keywords:** Sorption-enhanced hydrogen production (SEHP); Pyrolysis; Steam-gasification; Catalyst and sorbent

Qin Xu, Shengqiang Yang, Jiawen Cai, Buzhuang Zhou, Yanan Xin. *Risk forecasting for spontaneous combustion of coals at different ranks due to free radicals and functional groups reaction*. Pages 195-202.

To explore the reaction mechanism of spontaneous coal combustion and the indicators for forecasting this risk, reaction characteristics of free radicals and functional groups during low-temperature oxidation of coal with different ranks were analyzed by electron spin resonance (ESR) and Fourier transform infrared (FTIR) spectroscopy. Combined with gas chromatography of CO, other indicators besides the main indicator gas CO were researched to forecast spontaneous coal combustion. The results showed that with increasing oxidizing temperature in the range of 30°C–230°C, the production of free radicals changed from slow to rapid after being oxidized and heated above characteristic temperatures, depending on the coal grade. The oxygen-containing functional groups in coal of all ranks mainly include OH, CO, CO and COOH, whose reaction trends varied widely. The concentration and production rate of free radicals and the CO functional group in coal can be regarded as the leading indicators.

- **Keywords:** Spontaneous coal combustion; Electron spin resonance; Fourier transform infrared spectroscopy; Carbon monoxide

Andréa Fernanda S. Costa, Clarissa Daisy C. Albuquerque, Alexandra A. Salgueiro, Leonie A. Sarubbo. *Color removal from industrial dyeing and laundry effluent by microbial consortium and coagulant agents*. Pages 203-210.

This study investigated the decolorization of the effluent from a dyeing and laundry industry by autochthonous microorganisms biostimulated by glucose and ammonium sulfate. The microbial consortium was effective in reducing the color by biodegradation of industrial dyes by enzymatic action. In the aerobic biological treatment, the largest removal of color was obtained with a 22 factorial design in the presence of 1.25% vv−1 microbial consortium at 50rpm agitation. In this condition, the color average of the treated effluent reached 138mgPtl−1 and the decolorization of the treated effluent was approximately 90%. The turbidity of the effluent was reduced by a physicochemical treatment, using tannin and a flocculation polymer under different pH with a 23 factorial design. The largest reduction of turbidity and further removal of color were obtained in the presence of 0.3mgl−1 tannin and 15ppm flocculation polymer at pH 7.5. Under these conditions a turbidity reduction of 79% and a decolorization of 96% were reached for the effluent. The wastewater resulting from the biological and physicochemical treatments can be launched directly into the water resource due to the high efficiencies of color removal of the effluent from dyeing and laundry industry.

- **Keywords:** Decolorization; Industrial effluent; Biodegradation; Microbial consortium; Coagulation-flocculation

David Torrado, Andres Pinilla, Mariangel Amin, Carlos Murillo, Felipe Munoz, Pierre-Alexandre Glaude, Olivier Dufaud. *Numerical study of the*

***influence of particle reaction and radiative heat transfer on the flame velocity of gas/nanoparticles hybrid mixtures*. Pages 211-226.**

A one-dimensional model was developed to determine the flame velocity of a gas mixture explosion through a two-phase media containing nanoparticles. The mass and energy balances, which take into account a semi-global reaction mechanism with 10 reactions for methane and one carbon nanoparticles combustion, were solved by the finite volume method. The flame propagation model shows a good agreement with commercial software (Premix) to estimate the final temperature, the mass fraction of burnt gases and the flame velocity. For methane/carbon black nanoparticles hybrid mixtures, the numerical model evidences that the insertion of 10μm particles (agglomerates diameter) does not influence significantly the flame velocity. Nevertheless, if the particle diameter of the dispersed dust is equals to 75nm (diameter of the primary particles), a considerable increase of 23% of the flame propagation velocity is obtained when only 6gm−3 are added to the combustible mixture. Hence, the results of the numerical model suggest that the heat radiation contribution has a promoting effect on the flame propagation and it is consistent with the experimental increase on the explosion severity for some methane/carbon black hybrid mixtures.

- **Keywords:** Nanoparticles; Hybrid mixtures; Dust explosions; Burning velocity; Radiative transfer

Alla P. Toropova, Andrey A. Toropov, Emilio Benfenati, Sara Castiglioni, Renzo Bagnati, Alice Passoni, Ettore Zuccato, Roberto Fanelli. *Quasi-SMILES as a tool to predict removal rates of pharmaceuticals and dyes in sewage*. Pages 227-233.

Removal rates for pharmaceuticals and dyes have been modelled using so-called quasi-SMILES, which are representations of the above processes. Quasi-SMILES is an extend of the simplified molecular input-line entry system (SMILES) where, in addition to information on the molecular structure, the codes of physicochemical conditions are included. In addition, these codes can be a representation for various eclectic circumstances, such as presence or absence of light, impact of x-Rays beems, as well seasons (e.g. summer—winter). Analysis of quasi-SMILES of pharmaceuticals by Monte Carlo technique, applied via the CORAL software, shows it is possible to build predictive models using a one-variable correlation between optimal (flexible) descriptors and the removal rates. Removal rates used to build the model were obtained from recent publications including seasonal differences. The statistical characteristics of the best models for removal rates of pharmaceuticals and dyes are quite good for external validation set.

- **Keywords:** Risk assessment; Pharmaceuticals; Removal rates; QSPR/QSAR; OECD principles; Monte Carlo method; CORAL software

L. Quesada, A. Pérez, M. Calero, G. Blázquez, M.A. Martín-Lara. *Reaction schemes for estimating kinetic parameters of thermal decomposition of native and metal-loaded almond shell*. Pages 234-244.

This research aims to provide a better knowledge of the thermal decomposition of almond shell and this material loaded with heavy metals in a previous stage of biosorption (cadmium, copper, chromium, nickel and lead). Firstly, isolation of constituents of the almond shell was carried out. According to chemical analysis almond shell was constituted of an 8.2% of moisture; 1.6% of hot water soluble compounds; 0.34% of ethanol soluble compounds; 50.8% of extract-free lignin; and 49.2% of extract-free holocellulose. Then, experiments were performed by thermogravimetric analysis (TGA) and differential thermogravimetry (DTG) under inert and air atmosphere

at a heating rate of 15K/min for each isolated fraction. After that, adequate reactions schemes were proposed to find kinetic parameters. Independent reactions were formulated for each constituent and kinetic parameters were obtained for each isolated material in a sequential procedure. Finally, the validation of the proposed schemes was verified by the goodness of fitting between experimental and simulated TG and DTG curves. It was observed that cadmium, copper, chromium, nickel and lead present in metal-loaded almond shell did not modify significantly the values of kinetic parameters which describe the thermal decomposition processes.

- **Keywords:** Almond shell; Biosorption; Heavy metals; Kinetics; Reaction schemes; Thermal decomposition

Francesca Demichelis, Silvia Fiore, Maurizio Onofrio. *Pre-treatments aimed at increasing the biodegradability of cosmetic industrial waste*. Pages 245-253.

This work investigated physic-chemical pre-treatments aimed at improving anaerobic digestion (AD) of cosmetic industrial waste produced by a plant belonging to L'Oréal Group. A mixture designed according to relative abundances of waste was considered: sludge from internal wastewater treatment plant (54%-wt), residues of shampoo/conditioner (31%-wt), mascara sludge (13%-wt), food waste (2%-wt). The mixture had 80% VS/TS and COD equal to 1240 mg O2/gVS; soluble fraction of COD was 22%. Investigated pre-treatments were: chemical, thermal, sonication and various combinations; their performances were assessed through the disintegration rate (DR, the increment of soluble COD due to the pre-treatment compared to the unaltered sample). Best results were achieved from TA – thermo-alkaline (120min at 50°C) with DR 64.4% and TAS – thermo-alkaline-sonication (15min at 80°C and 40kHz) with DR 66.1%. The benefits of AD on pre-treated waste mixture were: 50% increase in methane yield (0.14Nm3/kgVS) and 5–7%-wt reduction of waste amount. From technical, energy and economic viewpoints, the proposed technical solution can provide an interesting perspective, fully consistent with Circular Economy principles.

- **Keywords:** Biogas; Cosmetic; Economic analysis; Industrial waste; Pre-treatment

Tim Stock, Michael Obenaus, Sascha Kunz, Holger Kohl. *Industry 4.0 as enabler for a sustainable development: A qualitative assessment of its ecological and social potential*. Pages 254-267.

In 2015, the General Assembly of the United Nations adopted the Agenda 2030 which counts 17 indivisible and self-sustaining goals. These so-called Sustainable Development Goals are intended to serve as a foundation for a transformation of the global economies towards a sustainable development. This transformation process should be built on an economic development in accordance with social equality and within ecological boundaries. As essential stakeholders for a global sustainable development, industrial organizations have to shift towards a novel paradigm which puts an emphasis on sustainable value creation. Industrial value creation has gone through radical changes during the last years. Since the 2010s, the so-called fourth industrial revolution (Industry 4.0) can be observed. The state of the art in research and technology for Industry 4.0 and sustainability is outlined. The potential for sustainable value creation in Industry 4.0 is qualitatively assessed for a macro and micro perspective based on a literature review and expert interviews. The assessment unfolds that the value creation might positively contribute to a sustainable development in many cases. Critical areas with expected negative contributions related to the quantity of materials used, primary energy consumption, and working conditions are identified and elaborated in more detail. A demonstrator for an intelligent cube production is investigated in order to verify the results of the assessment. This demonstrator is currently set up in China as part of a Sino-German Research Institute.

- **Keywords:** Sustainable development; Industry 4.0; Value creation; Sustainability assessment

Sabino De Gisi, Raffaele Pica, Patrizia Casella, Michele Notarnicola. *Dealing with a cluster of large centralized municipal wastewater treatment plants: A case study*. Pages 268-278.

The article deals with a cluster of large centralized municipal wastewater treatment plants (LCMWWTPs) assessing the main economic, energy, environmental and management aspects. With reference to the case study of the Regi Lagni system (Southern Italy), composed of five WWTPs for an overall effective population of 2,235,800 inhabitants the study focused first on the multi-disciplinary characterization of the system investigated and then on potential future upgrading options, identifying the best suitable solution. For the scope, several indicators such as running costs, energy consumptions, Greenhouse Gas Emissions (GHG), waste for landfilling and two scenarios were defined. The first scenario focused on the role of anaerobic digestion while the dewatered sludge was sent to landfill. The second scenario implemented the same operations of the previous one although the construction of a thermal treatment plant for the dewatered sludge was also planned. Results showed how LCMWWTPs could be characterised by low resilience; the upgrading of plants to comply with the increasingly stringent legal limits was difficult, especially where works were carried out to ensure continuity of operation. Multi-criteria analysis allowed the cluster system based on anaerobic digestion to be the best solution from an economic, energy and environmental point of view.

- **Keywords:** Energy consumption; GHG emissions; Regi Lagni; Running costs; Sludge management; Wastewater engineering

Yang An, Xiaocen Wang, Bin Yue, Liqun Wu, Zhigang Qu, Ying Liu, Huanhuan Yue, Daxian Yan. *Natural gas pipeline safety monitoring technique based on chaotic characteristics of the detected signals*. Pages 279-284.

Hydrate plugging and leakage are big issues in natural gas industry which can lead to huge economic costs, serious environmental destruction and life loss. In this paper, the acoustic reflection theories for leakage detection are studied and the chaotic characteristics of the detected signals are analyzed to distinguish hydrate plugging and leakage. A monitoring prototype system has been built for trials, in which incident acoustic waves are emitted into a pipeline by a transmitter and reflected waves caused by hydrate plugging or leakage are acquired by a receiver near the transmitter and amplified for further analysis. The experimental results demonstrate that the system can detect and locate both hydrate plugging and leakage at multiple positions online with good accuracy. Signal analysis results indicate that the difference in the chaotic characteristics of the detected signals for hydrate plugging and leakage could be used to distinguish the two types of abnormal events.

- **Keywords:** Natural gas pipeline safety monitoring; Hydrate plugging; Leakage; Acoustic; Chaos

Nuhaa Soobhany. *Remediation potential of metalliferous soil by using extracts of composts and vermicomposts from Municipal Solid Waste*. Pages 285-295.

The intervention management strategy to mitigate ecotoxicity in a heavy metal (HM)-contaminated soil was evaluated through a new soil remediation technique trial by using extracts of composts and vermicomposts from Municipal Solid Waste (MSW). The MSW

composts and vermicomposts which were >9.423mm in size referred as coarse and those <0.991mm denoted as ground. The reduction percentage (R) for both compost-extracts and vermicompost-extracts from coarse samples was in the order of Ni>Co>Cu>Cd >Cr>Zn. Results showed that treatments with compost-extracts from ground samples removed 90.83% Ni, 90.45% Co, 84.64% Cu, 79.01% Cd, 76.85% Cr and 76.77% Zn from the contaminated soil. On the contrary, treatments with vermicompost-extracts from ground samples caused moderately higher reduction in Ni (91.52%), Co (90.69%), Cu (85.18%), Cd (81.42%), Cr (79.06%) and Zn (79.02%). The remediation factors (RFs) of the HMs from the ground vermicompost-extracts can be classified in the order: Ni (8.06–10.98)>Co (8.28–10.61)>Cu (5.44–5.76)>Cd (2.82–4.41)>Zn (2.93–3.77)>Cr (1.37–2.11) whilst a lower RF value was obtained for the remediation treatments from the ground compost-extracts. Yet, in contrast of using compost-extracts from both coarse and ground samples to remediate metalliferous soil, data analysis revealed that vermicompost-extracts were more proficient in the mitigation of the concentration of HMs.

- **Keywords:** Contaminated soil; Remediation; Vermicompost-extract; Heavy metal; Compost-extract; Remediation factor

Chaojie Wang, Shengqiang Yang, Xiaowei Li. *Simulation of the hazard arising from the coupling of gas explosions and spontaneously combustible coal due to the gas drainage of a gob*. Pages 296-306.

The spontaneous combustion of residual coal and potentially subsequent gas explosions that occur during gas drainage of the gob were investigated. The 1262 fully-mechanized mining face of the Dingji Coal Mine (Huainan, China) was used as a research benchmark. The methane and oxygen distributions were simulated as well as the temperature field associated with different gas-drainage models. Using a steady-state simulation method for temperature cut-off, linear superimposition of various parameters was used to determine the hazardous zones arising from the coupling of gas and spontaneously combustible coal. The results show that when gas drainage is applied, the range of oxidation zone is different with different gas drainage modes. Among three different drainage modes, when applying the buried pipes and cross-measure boreholes mode, the methane concentration near the working face and in the upper corner of the return airway not only can be effectively reduced, but the size of the oxidation zone in the gob is the smallest. Based on the model of buried pipes, cross-measure boreholes and surface wells, the coupled gas–coal hazard zones were derived. The results show that the coupled hazard zone shifts to the deeper parts of the gob as a result of gas drainage, and the scope of the hazard zone is enlarged in the strike, dip, and vertical directions to different extents. The cooling effect is better when the nitrogen is injected into the deep part of the gob rather than the shallow part. Furthermore, nitrogen injected from double boreholes in the deep part appears to exert the largest cooling effect.

- **Keywords:** Fully-mechanized mining face; CFD model; Gas disaster; Gas explosion; Nitrogen injection

Ehsan Arzaghi, Mohammad Mahdi Abaei, Rouzbeh Abbassi, Vikram Garaniya, Jonathan Binns, Christopher Chin, Faisal Khan. *A hierarchical Bayesian approach to modelling fate and transport of oil released from subsea pipelines*. Pages 307-315.

Abstract: The significant increase in global energy demand has drawn the attention of oil and gas industries to exploration of less-exploited resources. Arctic offshore region is reported to hold a great proportion of un-discovered oil reserves. While this can be a promising opportunity for the industry, more exploration activities will also increase the possibility of oil spill during the entire process including production and transport. A

comprehensive risk assessment based on Ecological Risk Assessment (ERA) method is then required during the planning and operation stages of future Arctic oil production facilities. In the exposure analysis stage, ERA needs an evaluation of the oil concentration profile in all media. This paper presents a methodology for predicting the stochastic fate and transport of spilled oil in ice-infested regions. For this purpose, level IV fugacity models are used to estimate the time-variable concentration of oil. A hierarchical Bayesian approach (HBA) is adopted to estimate the probability of time to reach a concentration (TRTC) based on the observations made from a fugacity model. To illustrate the application of the proposed method, a subsea pipeline accident resulting in the release of 100t of Statfjord oil into the Labrador Sea is considered as the case study.

- **Keywords:** Fugacity; Fate and transport; Bayesian inference; Hierarchical Bayesian modelling; Oil spill

Arnesh Telukdarie, Eyad Buhulaiga, Surajit Bag, Shivam Gupta, Zongwei Luo. *Industry 4.0 implementation for multinationals*. Pages 316-329.

Delivering on digitalization for large multinational business, in the contemporary context of global operations and real time delivery, is a significant opportunity. Operations of localised facilities independent of global operations can result in compromised global synergies. Centralised functions such as research and development, optimisations of assets, corporate planning (strategy, investment planning, financial), and supply chain together with any other function deliver significant business value. Integration of these functions via industry 4.0 delivers significant business value, delivering strategic and operational benefits. This research proposes a global system approach, as defined by industry 4.0 (vertical, horizontal and total business integration), to this challenge, from ERP through manufacturing systems down to instrumentation. The proposed work resolves the inter-site challenges together with global standardization and inter-functional integration. This proposed architecture is reinforced by a simulation illustrating the benefits of the integrated business.

- **Keywords:** Business optimisation; Industry 4.0; Organization information processing theory; Smart production systems

Hang Ma, Xiao Feng, Bo Zeng. *Self-anticorrosion for the combustion tower of heat recovered thermal process phosphoric acid production*. Pages 330-347.

When a combustion boiler is used to recover heat released from yellow phosphorus combustion for phosphoric acid production, serious corrosion of the inner wall of the combustion tower caused by high temperature acid substances becomes a very critical problem. Based on pilot experiments, we found that a layer of anti-corrosion protective coating can be generated and adhered on the inner wall of the combustion tower by controlling the process parameters, including RH2O - P4O10(the molar ratio of moisture of feeding air to the phosphorus pentoxide produced from reaction) and TA (the temperature of the outlet gas from the combustion tower). This coating can prevent high temperature acid gas from directly contacting the inner wall of the combustion tower, so that the tower can be effectively protected from corrosion. This work innovatively realizes the self-anticorrosion of the combustion tower through controlling the reaction conditions. The main composition and preliminarily conjectured molecular structure of this costing was firstly identified by the analyzing its chemical components, physical and chemical properties, crystal form, and other detection data. Finally, operating conditions for stabilizing this coating were proposed and verified based on an industrialized production process.

- **Keywords:** Thermal process phosphoric acid; High temperature anticorrosion; Reaction self-anticorrosion; Cross-linked phosphoric substance; Heat recovery

Yousef A. Alhamdani, Mimi H. Hassim, Salim M. Shaik, Aishah A. Jalil. *Hybrid tool for occupational health risk assessment and fugitive emissions control in chemical processes based on the source, path and receptor concept*. Pages 348-360.

Fugitive emissions are unavoidable releases that occur continuously throughout a process plant or wherever there are connections or seals between the process fluids and the external environment. The daily exposure of workers to such emissions, typically spread across an entire chemical plant, poses a serious threat to their health and safety. Previous works have focused on assessing the occupational health risks in chemical plants through indexes such as the inherent occupational health index and the integrated inherent safety index. The indexes serve as good proxy indicators for potential sources of occupational hazards (chemicals, process conditions) and process equipment. However, by considering the Source-Path-Receptor (SPR) model, the eventual health risk is also dependent on the path and receptor, where a potential leakage and exposure can occur, respectively. Typically, chemical plants are fitted with controls and mitigation measures known as protection layers (PL) to control hazards. Hence, the occupational health risks in chemical plants due to fugitive emissions require a more holistic methodology for assessment and evaluation. Therefore, a hybrid framework for assessing the occupational health risks from fugitive emissions was developed by adopting and integrating the concepts of source-path-receptor, layers of protection and hierarchy of control. The generic protection layers identified were classified according to the traditional hierarchy of controls. At the source, the protection layers identified were hazard elimination/substitution, inherently safer design, and engineering controls. Next, the maintenance and equipment reliability were identified as PL along the exposure path. Finally, at the receptor, worker-exposure was linked to management systems, procedural safety behaviour and culture. Therefore, the proposed methodology can be used for benchmarking and performance tracking of occupational health risk in a chemical plant over time, as the methodology includes the time-varying parameters of plant maintenance, management system compliance, safety behaviour and culture.

- **Keywords:** Fugitive emissions; Occupational health; Health hazard; Leak hazard; Exposure hazard

Rui He, Xinhong Li, Guoming Chen, Yanchun Wang, Shengyu Jiang, Chenxiao Zhi. *A quantitative risk analysis model considering uncertain information*. Pages 361-370.

Bayesian network (BN) has been proven to be an excellent method that can describe relationships between different parameters and consequences to mitigate the likelihood of accidents. Nevertheless, the application of BN is limited due to the subjective probability and the static structure. In reality, available crisp probabilities for BN are generally insufficient, the system under consideration cannot be precisely described since the knowledge of the underlying phenomena is incomplete, which introduces data uncertainties. Furthermore, conventional BN have static structures, which results the model to have structure uncertainties. This paper presents a Dynamic BN-based risk analysis model to characterize the epistemic uncertainty and illustrates it through a case on the offshore kick failure. Linguistic variables are transformed into probabilities to represent data uncertainties by applying fuzzy sets and evidence theory. Structural uncertainties caused by conditional dependencies and static models were addressed by utilizing dynamic BN. Based on the model, a robust probability updating and dynamic risk analysis are conducted, through which critical events with potential risks of causing accidents are identified and a dynamic risk profile is obtained. The case study indicates that it is a comprehensive approach for quantitative risk analysis in offshore industries under uncertainties.

- **Keywords:** Dynamic Bayesian network; Fuzzy sets; Evidence theory; Uncertain information; Offshore kick

Kamal Jyoti Maji, Mohit Arora, Anil Kumar Dikshit. *Premature mortality attributable to PM2.5 exposure and future policy roadmap for 'airpocalypse' affected Asian megacities*. Pages 371-383.

Fine particulate matter, PM2.5, has been associated with significant health effects including cardiovascular diseases, lung diseases, cancer and premature deaths. The PM2.5-related health impacts are notable for megacities across the globe, but Asian megacities have been suffering much more. The Phenomenon of smog-hit cities became so common recently that the term 'airpocalypse' has become synonymous with polluted air. This study reports PM2.5-related long-term mortality for the year 2016 in 13 megacities of China, India, Bangladesh and Pakistan using an integrated exposure risk (IER) model. This study assesses the mortality associated with health outcomes attributable to PM2.5 particularly: cerebrovascular disease (stroke, CEV), ischemic heart disease (IHD), chronic obstructive pulmonary disease (COPD) and lung cancer (LC) among adults (≥25years) and the acute lower respiratory infection (ALRI) for infants (<5years). It further provides an estimation of the potential health benefits in future years under various scenarios realizing the PM2.5 concentration levels of (a) the goals of Air Pollution Prevention and Control Action Plan target (APPCAP) for China; (b) current policies (CP) and best practice emission control (BPEC) scenarios and (c) Interim Targets (ITs) and Air Quality Guidelines (AQG) for PM2.5 for all megacities. It is estimated that in 2016, PM2.5-related mortality in Shanghai, Beijing, Chongqing, Tianjin, Guangzhou and Shenzhen was 17.6, 18.2, 10.4, 9.8, 7.6 and 6.4 thousand respectively. In Indian megacities, the premature deaths were 14.8, 10.5, 7.3, 4.8 and 4.8 thousand in Delhi, Mumbai, Kolkata, Bangalore and Chennai respectively. Total mortality in Dhaka and Karachi was estimated to be 9.1 and 7.7 thousand. The CP is not enough to protect the public health in future in all the megacities. In China, PM2.5 levels will reduce under CP but PM2.5-related deaths will increase by 14–30%, primarily due to increase in overall population growth and urban migration patterns. In other megacities, the PM2.5-related deaths will increase by 39.32–85% in CP scenario, mostly due to the increase of PM2.5 in CP scenario. Though China has taken initial steps with pollution control targets and strategy, there is an urgent need for government policy in India, Bangladesh and Pakistan. This study highlights the need for urgency in setting up decisive air quality targets by megacity authorities and advocates for joint regional efforts to control air pollution.

- **Keywords:** PM2.5 pollution; Asian megacity; Premature mortality; Current policies

Aafaq ur Rehman, Jin Woong Baek, Eldon R. Rene, Natalia Sergienko, Shishir Kumar Behera, Hung-Suck Park. *Effect of process parameters influencing the chemical modification of activated carbon fiber for carbon dioxide removal*. Pages 384-396.

Climate change issues and acid rain episodes have triggered new research directions and the conceptualization of new preventive approaches to reduce toxic gases from entering the environment. The reduction of carbon dioxide (CO2) levels in the indoor environment are also one of the challenging human safety issues during emergency incidents and rescues; for instance, a building fire. The use of an activated carbon fiber (ACF) based mask is not only effective to filter CO2 but it is also practically easy to use during such demanding situations. Such modified adsorbents will have high adsorption volume, fast adsorption rates and good thermal, acid and alkaline resistance properties. For the emergency mode considering fires, the major task is atmospheric recovery. Thus, CO2 concentration in the post-fire smoke could be high. The smoke in the room causes

suffocations and unconsciousness leading to fatal injuries. In this study, ACF was modified using copper nitrate trihydrate [Cu (NO3)2.3H2O] by impregnation and carbonization (450°C), followed by its characterization. The modified ACF (Cu-ACF-12) showed large surface area (1147m2g−1), high micropore volume (0.45cm3g−1) and an average pore size of 1.57nm. CO2 removal tests were carried out in a lab scale fixed bed adsorption column using the modified ACF. The process parameters were optimized based on a Box-Behnken Design (BBD) and tested in the following ranges: gas flow rate – 150–250mlmin−1, moisture content – 0–40% and modification of the ACF impregnated with copper (Cu) – 4–12wt.%. The experimental results were statistically interpreted to elucidate the main and interaction effects. The modification of ACF showed positive effects on CO2 removal, while gas flow rate and moisture content decreased the CO2 removal. Under the optimal conditions, (gas flow rate – 150mlmin−1, moisture content – 0% and modification of the ACF – 8%), CO2 removal capacity of 2.31mmol of CO2g−1 Cu-ACF was obtained.

- **Keywords:** Adsorption; Carbon dioxide removal; Impregnation; Pore area; Response surface methodology; Optimization