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Hoda Hamze, Mandana Akia, Farshad Yazdani. *Optimization of biodiesel production from the waste cooking oil using response surface methodology*.

In this research, transesterification of the waste cooking oil has been studied. Response surface methodology (RSM) based on Box–Behnken design was used to investigate the effects of the main operating parameters, including the methanol to oil molar ratio, catalyst concentration, and reaction temperature, on the biodiesel yield. The results revealed that the catalyst concentration is the most important parameter. The maximum biodiesel yield under the optimized conditions was 99.38 wt.%. Thermogravimetric analysis (TGA) was used for the determination of biodiesel conversion and the results were compared with that of gas chromatography (GC) analysis, showing a very small difference. Furthermore, an empirical quadratic equation has been presented to show the relation between biodiesel conversion and product viscosity.

- Keywords: Biodiesel; Waste cooking oils; Response surface methodology; Optimization; Thermogravimetric analysis; Viscosity

Mohamed I. Badawy, Mohamed E.M. Ali, Montaser Y. Ghaly, Mohamed A. El-Missiry. *Mesoporous simonkolleite–TiO2 nanostructured composite for simultaneous photocatalytic hydrogen production and dye decontamination*.

In the present work, mesoporous simonkolleite–TiO2 composite was prepared with sol–gel method. The composite photocatalysts were characterized by X-ray diffraction (XRD), diffuse reflectance spectroscopy (DRS), and Raman spectroscopy. Also, surface area and particle size were analyzed using BET equation. The photocatalytic hydrogen production with simultaneous decolorization of Remazole Red (F3B) dye was investigated over TiO2 and simonkolleite–TiO2 composite under UV–vis light irradiation. It was worthy to be noted that the rate of hydrogen production over simonkolleite–TiO2 is higher that produced over TiO2. The maximum amount of photocatalytic-produced hydrogen was 2.1 mmol and 3.3 mmol within 240 min using TiO2 and simonkolleite–TiO2 composite, respectively. The specific production rate of hydrogen from photocatalytic conversion of dye was calculated. Improvement of apparent quantum yield (22.07%) after 5 h was achieved upon addition of simonkolleite to TiO2. This high apparent quantum yield proves that the system proposed in this study could be a hopeful approach toward using sunlight energy as outlook energy source. The obtained results suggested that a new process for H2 production from wastewater could be

achieved. The process also provides a method for degradation of organic pollutants with simultaneous H2 production.

- **Keywords:** Hydrogen production; Photocatalytic; Dye degradation; Renewable energy; Photocatalyst; Mesoporous simonkolleite–TiO2

Carmen Paduraru, Lavinia Tofan, Carmen Teodosiu, Ion Bunia, Nita Tudorachi, Ovidiu Toma. *Biosorption of zinc(II) on rapeseed waste: Equilibrium studies and thermogravimetric investigation*s.

The removal of heavy metals from aqueous effluents so as to avoid their toxic, bioaccumulation and biomagnification effects to humans and environment is usually realized by means of physical, chemical treatment, and biological processes. The aim of this study is to evaluate the potential of rapeseed waste from biodiesel production as a biosorbent for Zn(II) ions. The ability of the rapeseed waste for Zn(II) biosorption exhibited a maximum at pH 4.5–5. The removal efficiency of Zn(II) from solution with an initial concentration of 72 mg L−1 varied from 39% to 89% for an increase of the rapeseed waste dose from 2 to 30 g L−1. The amount of Zn(II) retained on the tested rapeseed increased with increasing metal ion concentration, but the Zn(II) sorption percentage decreased. The equilibrium data are fitted to the Langmuir isotherm better than to the Freundlich isotherm. The kinetics of Zn(II) biosorption process follows a pseudo-second order model. The thermal stability of the rapeseed before and after Zn(II) biosorption was studied by thermogravimetric analysis. It was found that the zinc loaded rapeseed exhibits a better initial thermal stability than the original rapeseed, presumably due to the cross linking generated by the intermolecular complexation of Zn(II) ions. In both cases, the thermal decomposition takes place according to some reassembling kinetic models, in two phases with order n reactions. The results of this study strongly suggest the possibility to use rapeseed as an effective biosorbent for Zn(II) ions removal from aqueous effluents (municipal/industrial wastewaters).

- **Keywords:** Biosorption; Zinc; Rapeseed; Thermogravimetry; Isotherms; Wastewater

Hani Aburas, Ayhan Demirbas. *Evaluation of beech for production of bio-char, bio-oil and gaseous ma*terials.

Evaluation of Oriental beech (Fagus orientalis L.) was investigated with aspect of thermo-chemical conversion to obtain bio-char, bio-oil and gaseous. When the pyrolysis temperature increased, the bio-char yield decreased. A high temperature and smaller particles increase the heating rate resulting in a decreased bio-char yield. The bio-char obtained are carbon rich, with high heating value and relatively pollution-free potential solid biofuel. The liquefaction yield sharply increased with increasing the temperature near critical temperature and after that. In the pyrolysis, increases of liquid yields are considerably sharply for all of the samples with increasing of pyrolysis temperature from 690 K to 720 K. The beechnut oil was converted to biodiesel in supercritical methanol without using the catalyst. Experiments have been carried out in an autoclave at 493, 523 and 593 K, and with molar ratios of 1:6–1:40 of the oil to methanol. The yield of alkyl ester increased with increasing the molar ratio of oil to alcohol.

- **Keywords:** Beech wood; Beechnut; Pyrolysis; Biochar; Beechnut oil; Biodiesel

Ali Fakhri, Sajjad Behrouz. *Comparison studies of adsorption properties of MgO nanoparticles and ZnO–MgO nanocomposites for linezolid antibiotic removal from aqueous solution using response surface methodology*.

In this investigation, the adsorption measure of linezolid antibiotic onto MgO nanoparticles and ZnO–MgO nanocomposites were performed. The adsorbents were characterized by different techniques such as XRD, SEM, TEM and BET. The parameters influence such as the pH, adsorbent dosage and temperature was tested and evaluated by Box–Behnken Design combined with response surface methodology. Performing adsorption tests at optimal conditions set as 0.5 g L−1 of adsorbent, pH 10 and 308 K make admit to obtain high adsorption turnover (123.45 and 140.28 mg g−1 for MgO nanoparticles and ZnO–MgO nanocomposites, respectively). A good compromise between predicted and experimental data in this research was observed. The experimental equilibrium data fitting to Langmuir, Freundlich, Tempkin and Dubinin–Radushkevich models indicate that the Langmuir model is a best model for evaluation of adsorption behavior. Kinetic evaluation of experimental data indicated that the adsorption operations followed well pseudo-second-order models. The adsorption capacity of ZnO–MgO nanocomposites is higher than MgO nanoparticles that because of the ZnO–MgO nanocomposites have high specific surface area.

- **Keywords:** Box–Behnken Design; Response surface methodology; Aqueous solution; Adsorption; Antibiotic; MgO nanoparticles; Kinetics studies

Xinxiao Lu, Deming Wang, Wei Shen, Hetang Wang, Chaobing Zhu, Jianan Liu. *Experimental investigation of the pressure gradient of a new spiral mesh foam generator*.

Foam is used as part of an effective dust suppression method in underground coal mines, but conventional foaming devices severely restrict its popularization and application due to the high cost of foam preparation, poor applicability and high pressure loss. Therefore, a new spiral mesh foam generator is designed, and its performance is investigated and evaluated experimentally. The results show that the pressure gradient of the spiral mesh foam generator increases with the increase of foam concentration in water. There is a large pressure gradient gap between the top and bottom at both ends of the foam generator. However, the gap disappears and uniform foam is generated in the middle section of the foam generator. When the pressure gradient is higher than minimum pressure gradient, the foam production quantity will increase sharply. Based on the length of spiral mesh and operating conditions determined, the new foam generator is applied to produce foam for dust suppression in the heading face of coal mines. A good foaming effect, less pressure loss and high dust suppression efficiency suggest that the new foam generator will greatly promote the large-scale application of foam technology used to suppress dust in underground coal mines.

- **Keywords:** Dust; Foam; Spiral mesh; Pressure gradient; Air flow rate

Zhang Haoran, Lluis Sanmiquel Pera, Yaojiang Zhao, Carla Vintro Sanchez. *Researches and applications on geostatistical simulation and laboratory modeling of mine ventilation network and gas drainage zone*.

The mine disaster of gas at working face and goaf creates a risky working environment for miners, and causes a mass of casualties in mining industry around the world. The key points of resolving the gas problem are to properly increase fresh air volume in ventilation network, exactly determining the gas emission zone, and implementing a reasonable gas drainage plan. This article provides multiple gas control methods with the aim of improving the gas drainage knowledge and techniques. Both of the CFD model and the mini mine gas emission zone based on U + L type ventilation network are established, and the gas distribution and movement rules of working face and goaf are accurately obtained during the numerical and laboratorial simulation experiments are performed. The results reveal that gas problems at working face and goaf cannot be effectively resolved by only increasing the air volume; instead, it must be combined with optimizing the ventilation network and excavating special gas drainage

tunnels. The experimental results also demonstrate that the most effective gas extraction spot constantly varies with the zone where mining activities are performed. Therefore, the arrangement of gas drainage tunnels is determined according to the obtained rules and experimental results. The field verification results show that the layout of the drilling boreholes is rational and effective; the gas drainage quantity is reliable and stable, which indicates that it is valid and feasible to arrange the layout of gas drilling tunnels based on the combination experimental results of numerical simulations and laboratory tests.

- **Keywords:** Gas hazard; U + L ventilation; Numerical simulation; Laboratory test; Gas drainage

Maryamossadat Kazemi, Cavus Falamaki. *Study on the kinetics and mechanism of the catalytic oxidation reaction of Mn2+ using clinoptilolite supported δ-MnO2 nano-catalyst*.

This work comprehends a thorough study of the catalytic oxidation of dissolved manganese in the presence of MnO2 coated clinoptilolite as catalyst. The catalytic oxidation of manganese ions in water using catalysts like MnO2 is always in competition with the rapid adsorption of manganese ions on the oxide material (catalyst and the support). Therefore, a clear understanding of the catalytic oxidation reaction of dissolved manganese has remained a matter of debate. In this work, the initial adsorption reaction could be distinguished from the catalytic oxidation reaction. It has been shown that an optimum pH, ca. 8.5, exists for which the oxidation reaction proceeds at high rate and near complete removal of manganese from the liquid phase is feasible. The catalyst is ineffective at lower pH's, for which manganese adsorption on the zeolite agglomerate is dominant. A mechanism for the catalytic oxidation of manganese has been presented.

- **Keywords:** Manganese removal; Clinoptilolite; Catalysis; Adsorption; Catalytic oxidation; Nano-catalyst

Martin J. Goodfellow, Paul Dewick, Jonathan Wortley, Adisa Azapagic. *Public perceptions of design options for new nuclear plants in the U*K.

An important consideration for any new nuclear build programme is an understanding of the public's viewpoint, as in many countries this can influence the direction of future energy markets. This paper presents a first attempt at understanding public views on the design of new nuclear plants. A survey of 1304 adults in the UK was carried out using a questionnaire developed in this research. The study suggests that the general public are willing and able to express preferences for design aspects of nuclear power plants and that meaningful information can be obtained to inform designers. Responses indicate that public preferences are consistent with current design practice for nuclear power plants. Further analysis reveals that public preferences related to plant design are not influenced strongly by their existing attitudes. Our findings contribute to the literature on the governance of energy supply technologies and the involvement of the public in the innovation process. We argue that involving the public in the design of nuclear power plants is an important aspect of a more transparent, participatory approach intended to improve trust in the governance of future energy supply options.

- **Keywords:** Nuclear power; Public perceptions; Risk management; Design; Innovation process; Energy supply governance

S. Vasanth, S.M. Tauseef, Tasneem Abbasi, S.A. Abbasi. *CFD simulation of pool fires situated at differing elevation*.

When two or more pool fires happen to burn so close to each other that they interact, they are termed ‘multiple pool fires’ (MPF). Past accident analysis reveals that MPFs occur quite frequently in chemical process industries. Controlled experiments done so far to

study MPFs have indicated that MPFs lead to increase in the fuel burning rate, flame height and heat release rate (HRR) but the nature and the extent of the impacts of different factors on these manifestations is as yet poorly understood. In this context computational fluid dynamics (CFD) appears to be a tool which can enable more detailed and realistic simulation of MPFs than other possible approaches, especially due to its ability to closely approximate the underlying physical phenomena. In tank farms there are situations where different storage tanks are placed at different elevations yet close to each other. If such tanks happen to catch fire, the resulting fires may influence each other in a manner that may be a function of the difference in the tanks' elevation. However no CFD study has been carried out which addresses this type of situation. Hence an attempt has been made to employ CFD to study MPFs involving two pools with fuel surfaces are at different elevations. Results reveal that good correlation is possible between the experimental findings and the CFD simulations.

- **Keywords:** Pool fires; Flame interaction; Computational fluid dynamics; Flame characteristics; Multiple pool fires; Tank farms

Olivier Pennetier, Mame William-Louis, André Langlet. *Numerical and reduced-scale experimental investigation of blast wave shape in underground transportation infrastructur*.

When an explosion occurs in a tunnel, the study of the blast wave quickly becomes complicated, owing to the multiple propagation patterns of the blast wave (incident wave, regular and Mach reflections) and to the geometrical conditions. Considering this problem, two patterns can be revealed. Near the explosive, the well-known free-field pressure wave can be observed. After multiple reflections on the tunnel's walls, this overpressure behaves like a one-dimensional (1D) wave. One aim of this paper is to determine the position of this transition spherical-to-planar wave propagation in a tunnel using both numerical and reduced-scale experiments, and thereby validate the dedicated law established in a previous work. For this purpose, a detonation of TNT in a tunnel with a cross-section of up to 55 m2 is considered. Results show good agreement between the numerical simulations and experiments. The transition zone between the three-dimensional (3D) and the 1D wave is well detected. An application to a simplified subway station is also investigated which shows that significant planar waves can be transmitted to the neighboring stations via the junction tunnels.

- **Keywords:** Blast wave; Confined domain; Reduced scale experiment; 3D numerical simulation; Risk assessment

Abhilash T. Nair, M. Mansoor Ahammed. *Water treatment sludge for phosphate removal from the effluent of UASB reactor treating municipal wastewater*.

Aluminium-based water treatment sludge was used as a coagulant for removing/recovering phosphate from the effluent of upflow anaerobic sludge blanket (UASB) reactor treating municipal wastewater. The effect of three variables, namely sludge dose, initial pH and fresh coagulant (poly-aluminium chloride, PACl) dose was studied using response surface methodology. About 87% phosphate removal could be obtained at the optimum conditions of sludge dose 13.8 g/L, initial pH 6, and fresh PACl dose 5.8 mg Al/L. In order to achieve a similar phosphate removal, a dose in the range of 30–40 mg Al/L of fresh PACl was required. The results suggest that water treatment sludge can be reused as a coagulant for post-treatment of UASB reactor effluent treating municipal wastewater and can be considered as a promising alternative for removing phosphate which can substantially reduce the consumption of fresh PACl. The sludge generated during this process could potentially be used in land application which results in recycling of phosphate.

- **Keywords:** Coagulation; Phosphate removal; UASB reactor; Water treatment sludge; Response surface methodology; Optimisation

Hamid Jahanian, Adam Lucas. *The role of component arrangement in complex safety instrumented systems—A case study*.

The arrangement of components plays a key role in the performance of complex Safety Instrumented Systems (SIS), in which a SIS logic solver is interlocked with other logic solvers, to share a final element, for instance. The position of the components and the way they are utilized affects the reliability characteristics, such as the Probability of Failure on Demand (PFD), Spurious Trip Rate (STR), architectural sensitivity and model uncertainty. This case study uses quantitative and qualitative approaches to elaborate on various aspects of component arrangement in complex SIS. Numerous simplified models are analyzed; new classification is introduced for SIS components based on their response to demand; a set of guidelines are developed for SIS architecture design, with a focus on component arrangement; and the use of these guidelines is demonstrated in a real-life example, where an existing turbine SIS is modified to incorporate a new over-speed protection system. The simplified models and the turbine upgrade project are also used to explain the issue of unknowns and uncertainties in reliability analysis and how these issues can be addressed in SIS architecture by optimizing component arrangement.

- **Keywords:** Complex safety instrumented systems; SIS component arrangement; Model uncertainty; PFDavg; SIS; Safety systems optimization

Mehrrad Saadatmand, Hooman Foroughi, Tingsong Dai, Trinayan Misra, Tsilla Bensabath, Ramin Farnood. *Odor fading in natural gas distribution systems*.

Since natural gas is odorless, to assure the customer safety, odorants are added to it to alarm the consumer in the case of a gas leak. Although the odorization is a common practice in natural gas distribution systems, odor fading has been reported in pipelines, which is a great safety risk. This paper summarizes results of experiments conducted to investigate possible chemical and physical mechanisms responsible for odor fading. In these experiments, X-ray photoelectron spectroscopy (XPS) and gas chromatography were used to check the possible interactions of tertiary butyl mercaptan (TBM) as odorant with the pipe material. Evidences of chemisorption, adsorption and desorption of TBM on the iron oxide inside the pipe were observed. It was found that by increasing pressure, rusted surface of the pipe, and temperature or by decreasing the gas flow rate and odorant concentration the mercaptan removal was increased.

- **Keywords:** Odor fading; Natural gas; Mercaptan; Pickling; Pipeline; TBM

Mahmoud Abbasi, Ali Reza Soleymani, Jalal Basiri Parsa. *Degradation of Rhodamine B by an electrochemical ozone generating system consist of a Ti anode coated with nanocomposite of Sn–Sb–Ni oxide*.

An ozonation process was performed using a recycled electrochemical ozone generator system. A titanium based electrode, coated with nanocomposite of Sn–Sb–Ni was applied as anode in a laboratory-made electrochemical reactor. A constant flow rate of 192 mg/h of generated ozone was entered to an ozonation reactor to contact with a typical target pollutant, i.e., Rhodamine B (Rh.B) molecules in aqueous solution. Four operational parameters such as: initial dye concentration, pH, temperature and the contact time were evaluated for the ozonation process. Experimental findings revealed that for a solution of 8 mg/L of the dye, the degradation efficiency could reach to 99.5% after 30 min at pH 3.7 and temperature of 45 °C as the optimum conditions. Kinetic studies showed that a second order equation can describe the

ozonation adequately well under different temperatures. Also, considering to the importance of process simulation, a three-layered feed forward back propagation artificial neural network model was developed. Sensitivity analysis indicated order of the operational parameter's relative importance on the model output as:

time ≫ pH > Rh . B initial

concentration > temperature.

- **Keywords:** Electrochemically generated ozone; Degradation; Kinetic; Modeling; Artificial neural network

Saud Al-Anbari, A. Khalina, Ali Alnuaimi, A. Normariah, A. Yahya. *Risk assessment of safety and health (RASH) for building construction*.

In this research Risk Assessment of Safety and Health RASH method for building construction has been developed with risks classified into Safety Risks and Health Risks. 11 factors representing safety risks and 8 factors representing health risks were identified based on field survey in Oman. 40 Safety and Health specialists were involved in carrying out risk assessment using the existing method of risk analysis RA and the proposed RASH method. It was found that RASH method resulted in superior accuracy for assessment of risk zones than the existing RA method. The accuracy by RASH was almost twice the accuracy by RA. The overall percentages of the correct answers for the four scenarios using the RASH method and the RA method were 72.5 percent and 40 percent respectively. The proposed RASH method gave fewer errors than the existing RA method for all scenarios. Two scenarios were found to be the most problematic ones with largest overestimation of risks occur when using the existing RA method. Wilcoxon Ranked Test showed that the two methods are significantly different (z = −3.357, p > 0.01). The new method RASH is statistically acceptable and it resulted in better response in terms of estimating the risk than the RA method.

- **Keywords:** Occupational; Safety; Health; Risk Assessment; Oman; Construction

Saeed Yari, Saeed Abbasizadeh, Seyyed Ebrahim Mousavi, Mojtaba Saei Moghaddam, Abdolsamad Zarringhalam Moghaddam. *Adsorption of Pb(II) and Cu(II) ions from aqueous solution by an electrospun CeO2 nanofiber adsorbent functionalized with mercapto groups*.

A novel PVP/CeO2/TMPTMS nanofiber adsorbent was prepared by the electrospinning method. The prepared nanofibers were characterized by scanning electron microscope (SEM), Brunauer–Emmert–Teller (BET), Fourier transform infrared (FTIR) and Brrett–Joyner–Halenda (BJH) analysis. The results showed that surface area of PVP/CeO2/TMPTMS/P123 is almost five times greater than PVP/CeO2/TMPTMS nanofiber adsorbent. Batch experiments were carried out as a function of solution pH, contact time, initial concentration and temperature. The kinetic data of Pb(II) and Cu(II) ions were well described by the double-exponential model. The maximum adsorption capacities of PVP/CeO2/TMPTMS nanofiber by applying the Langmuir equation were found to be 0.439 mmol/g (90.9 mg/g) for Pb(II) and 1.390 mmol/g (88.3 mg/g) for Cu(II) ions. qm of PVP/CeO2/TMPTMS/P123 nanofiber was found to be 1.315 mmol/g (272.3 mg/g) for Pb(II) and 4.145 mmol/g (263.4 mg/g) for Cu(II) ions. Thermodynamic studies showed that adsorption process was favored at higher temperature. The adsorbent can be easily regenerated with desorbing agent of 0.1 M HNO3. The inhibitory effect of competitive Cu(II) ion on the Pb(II) adsorption was greater than the inhibitory effect of competitive Pb(II)

ion on the Cu(II) adsorption in the binary systems and the adsorption affinity of the tested metals is Cu(II) > Pb(II).

- **Keywords:** Electrospinning; PVP/CeO2/TMPTMS/Pluronic123 nanofiber; Adsorption; Lead(II); Copper(II); Kinetic models

Rouzbeh Abbassi, Faisal Khan, Vikram Garaniya, Shuhong Chai, Christopher Chin, Khandoker Abul Hossain. *An integrated method for human error probability assessment during the maintenance of offshore facilities*.

The paper presents a novel approach for Human Error Probability (HEP) assessment by integrating the Success Likelihood Index Method (SLIM) with the Technique of Human Error Rate Prediction (THERP). In this approach, the SLIM has been embedded within the THERP framework to generate the nominal HEP data when it is unavailable. The developed methodology is implemented to an offshore condensate pump maintenance task. In the first step of this study, the human error was estimated considering all the standard tools and procedures which are in place. In the second step, as an additional measures, radio frequency identification (RFID) based tools are utilized and HEP is recalculated. Without the application of RFID tools, the HEP value is found to be 5.7244 × 1022 or estimated as 5.72% with an uncertainty bound of 1.1448 × 10−2–1.1452 × 10−1. With RFID tools, it is reduced to 4.6342 × 10−2 or 4.63%, with an uncertainty bound of 2.145 × 10−2–2.089 × 10−1 which yields a net HEP reduction of 1.09%.

- **Keywords:** Human factor; Errors; Probability; THERP; SLIM; RFID

Ana Nielfa, Raul Cano, Marc Vinot, Eduardo Fernández, Maria Fdz-Polanco. *Anaerobic digestion modeling of the main components of organic fraction of municipal solid waste*.

The organic fraction of municipal solid waste (OFMSW) is composed of several heterogeneous organic and inorganic wastes. The diversity of composition, the high volatile solid content and the biodegradable material that this waste offers make it quite an interesting option for anaerobic digestion (AD). Depending on the substrate composition, the biological degradation and kinetics of the AD could vary. Biochemical methane potential (BMP) tests are used as a tool to evaluate the methane production of several fractions of OFMSW, in order to study the influence of each fraction in the final mixture. The kinetic parameters of methane curves and the prediction of final productions are studied by different approaches to model equations using linear, exponential, logistic and Gaussian models. The analyses of the fractions indicate that organic substrates such as meat/fish which are in a small proportion in the final mixture, obtain major productivities (291 ± 3 mlCH4/gVS), however others such as paper (217 ± 5 mlCH4/gVS) could have their productivity enhanced due to their high VS present in the final mixture. Both the Gomperzt and the first order model fit reasonably with all the fractions, although substrates with lag phase adjust only to the Gompertz model explaining 99% of the experimental results.

- **Keywords:** Anaerobic digestion; Organic fraction of municipal solid waste; Fraction; Biochemical methane potential; Model; Composition

C. Pritchard, A. Yang, P. Holmes, M. Wilkinson. *Thermodynamics, economics and systems thinking: What role for air capture of CO2*?

Air capture has recently been advanced by several parties as a solution to the problem of constraining – and ultimately reducing – atmospheric CO2 in response to climate change. However, there are significant barriers pertaining to scale, energy needs and cost, which will hugely challenge the effectiveness and practicality of air capture. This paper examines the thermodynamics, energetics and economics and politics of air capture. These compare unfavourably with alternative approaches to atmospheric greenhouse gas reduction. An analysis is made of the energy cost of the one favoured DAC technology for which experimental results are available in the open literature – temperature/vacuum swing adsorption, and of one point source capture technology – oxyfiring of refinery FCCUs. We also examine the engineering effort required to implement atmospheric capture on a scale at which it could significantly reduce atmospheric levels of CO2; and questions are addressed regarding its practicability and appropriateness. The analysis demonstrates that air capture remains at best a peripheral activity, at worst a distraction, until point sources of greenhouse gas emissions such as power stations, industrial flue gases, shale gas wellheads, anaerobic digestion plants and landfill sites have been completely decarbonised. When these and so many other unaddressed factors are affecting our global climate, the pursuit air capture, the ultimate "end-of-pipe" solution, is inappropriate.

- **Keywords:** Direct air capture; Flue gas capture; Negative emissions technologies; Fugitive emissions; Energy efficiency; Refinery operations

Ersin Üresin, Halil İbrahim Saraç, Alper Sarıoğlan, Şiringül Ay, Fehmi Akgün. *An experimental study for H2S and CO2 removal via caustic scrubbing system*.

In this study, removal of hydrogen sulfide (H2S) and carbon dioxide (CO2) from simulated syngas has been studied on one column scrubbing system. Gas flow rate as a measure of gas residence time and superficial gas velocity, gas composition, inlet H2S load, flow modes (countercurrent and cocurrent) and packing geometry were the parameters in the design and/or operation of an acid gas scrubber system. Better H2S scrubbing efficiencies have been obtained in countercurrent flow mode than that of cocurrent flow mode. When accordingly designed, static mixer with its superior performance on H2S removal overweighed to structured packings. The coexistence of CO2 and H2S has been shown to increase the sodium hydroxide (NaOH) consumption along the scrubber column thereby decreasing the H2S removal efficiency at higher H2S loads. The gas residence time as changing with the gas velocity was found to be more dominant on acid gas removal efficiency than the effect of superficial gas velocity within the experimented range. A gas residence times of equal or above 3 s were seemed to be closer to the optimum point.

- **Keywords:** Gas clean up; Packed bed gas scrubbers; Hydrogen sulfide removal; CO2 removal; NaOH; Static mixer

Mamdoh R. Mahmoud, Nick K. Lazaridis, Kostas A. Matis. *Study of flotation conditions for cadmium(II) removal from aqueous solutions*.

Flotation conditions for cadmium(II) removal from aqueous solutions were investigated. Precipitate flotation techniques "of the first kind" (PFFK) and "of the second kind" (PFSK) were tested, using potassium ethyl xanthate (KEtX) as a precipitating agent for cadmium(II). The surfactants sodium dodecyl sulfate (SDS) and hexadecyltrimethylammonium bromide (HDTMA) were used as collectors for PFFK. The effects of KEtX and collector concentrations, induction time, bubbling time, solution pH and some foreign ions on cadmium(II) removal were studied. Under optimum conditions,

cadmium(II) could be removed by PFFK by ~93% and >99% using SDS and HDTMA, respectively. By PFSK, removal of about 64% for cadmium(II) was obtained. The two developed precipitate flotation methods were also tested for simultaneous removal of cadmium(II), nickel(II) and cobalt(II) from distilled water and tap water. The effectiveness of PFFK suggests its employment for metal-polluted wastewaters.

- **Keywords:** Cadmium(II); Flotation; Precipitation; Removal; Surfactant; Potassium ethyl xanthate

Peter Okoh, Stein Haugen*. Improving the robustness and resilience properties of maintenance*.

Industries with major accident potential, e.g. the process industries, are usually characterized by high degree of technological and organizational complexity, and hence are fortified with layers of protection (barriers). The energy-barrier risk control model is dominant and tends to be applied by such industries over time, sometimes without paying attention to the vulnerability of the complex organizational setting encompassing production, maintenance, support and the environment. In the same vein, process industries may prioritize production at the expense of safety systems and the organizational network. Maintenance is known to be a key means of keeping safety systems functional, yet, in this paper we wish to explore how its values can be further uncovered to improve the robustness and resilience of the socio-technical system as a whole. This paper intends to investigate what robustness and resilience properties exist in maintenance and how these can be improved in relation to maintenance interaction with other areas such as production and support and in turn improve the robustness and resilience of the process industries organization. The objective is to improve the robustness and resilience of the organization as a whole. This is realized on the basis of the perspectives of organizational accidents: energy-barrier model, normal accident theory (NAT), high reliability organizations (HRO) theory, man-made disaster (MMD) theory, conflicting objectives, adaptation and drift (COAD) theory and resilience engineering. Based on this, recommendations for improving the maintenance robustness and resilience were proposed.

- **Keywords:** Maintenance; Robustness; Resilience; Organization; Organizational accident; Process industry

D. Mombelli, C. Mapelli, S. Barella, A. Gruttadauria, U. Di Landro. *Laboratory investigation of Waelz slag stabilization*.

Electric Arc Furnace dusts are considered hazardous waste due to their high heavy metals content (zinc, lead, etc.). The Waelz process is one of the most efficient technologies, in terms of capacity and quality, able to recover nearly the 90% of zinc contained in such EAF dusts. Unfortunately, the resulting slag still has eco-compatibility problems, although its mechanical and chemical properties are suitable for civil engineering applications. Stabilization tests, by quartz addition, were performed on EAF dusts in a laboratory furnace. Temperature, treatment time and cooling rate were varied in order to define the best conditions for regulating the formation of a stable microstructure able to hinder the release of substances. Microstructural characterization was carried-out using SEM and XRD analysis. Leaching tests were performed according to EN 12457-2 standards and water analyses were performed using ICP-OES. The best chemical stability was achieved when dust powders were mixed with 20% of silica and water-cooled.

- **Keywords:** EAF dusts; Waelz process; Waelz slag; Stabilization process; Silica addition; Leaching test

P.J. Thomas, G.J. Vaughan. *Testing the validity of the "value of a prevented fatality" (VPF) used to assess UK safety measures*.

The "value of a prevented fatality" (VPF), the maximum amount that it is notionally reasonable to pay for a safety measure that will reduce by one the expected number of preventable premature deaths in a large population, is published by the UK Department for Transport (DfT). The figure, updated for changes in GDP per head, is used by the DfT, the Health and Safety Executive and other UK regulatory bodies as well as very widely in the process, nuclear and other industries as the standard by which to judge how much to spend to reduce harm to humans. The paper tests the validity of the 1999 study on which the VPF is based and finds that that study fails numerous tests of its validity. It is concluded that there is no evidential base for the VPF that has been used for many years in the UK and is still in standard use today. Given the difficulties evident in the interpretation of survey results, an urgent re-appraisal is needed of alternative statistical methodologies that can allow robust regulatory and industry safety decision making and, vitally, give adequate protection to the UK public and to those working in the UK's transport, process, nuclear and other industries.

- **Keywords:** Safety; Health and safety; Value of a prevented fatality; VPF; Department for Transport; Health and Safety Executive

Miljana Prica, Savka Adamovic, Bozo Dalmacija, Ljiljana Rajic, Jelena Trickovic, Sanja Rapajic, Milena Becelic-Tomin. *The electrocoagulation/flotation study: The removal of heavy metals from the waste fountain solution*.

The objective of this study was to investigate the possibility of heavy metals (copper, zinc and nickel) removal from the waste fountain solution by the electrocoagulation/flotation (ECF) treatment. After the printing process, the fountain solution changes its composition due to direct contact with different printing materials (plates, inks, etc.) and becomes enriched with metals. The effect of operational parameters, such as electrode materials and combinations, current density, interelectrode distance and operating time, was studied. Also, response surface methodology (RSM) was applied to evaluate the effect of main operational variables and to get a balanced removal efficiency of metals from waste fountain solution by ECF treatment. The iron/iron electrode combination yields a higher percentage of copper and zinc removal efficiency (>95% and >80%, respectively), while for nickel the aluminum/iron and iron/aluminum electrode combinations (>95 and >85%, respectively) proved to be more successful. The optimum interelectrode distance was 1.0 cm (for copper) and 1.5 cm (for zinc and nickel) for all current densities. Heavy metal removal efficiency increases with the increase of electrolysis time for all electrode combinations. Also, the increase of current density improves the ECF removal efficiency. Based on the results obtained through RSM, the optimized parameters for the ECF waste fountain solution treatment for metal removal were identified as: Fe(−)/Al(+) electrode with interelectrode distance of 1.5 cm, operating time of 60 min and current density of 8 mA cm−2. Overall, the ECF treatment was proven very efficient in the removal of heavy metals from the waste fountain solution under optimum conditions.

- **Keywords:** Electrocoagulation/flotation treatment; Fountain solution; Waste; Heavy metals; Response surface methodology; Metals

Denglong Ma, Zaoxiao Zhang, Yun Li. *Investigation of gas purging process in pipeline by numerical method*.

Gas purging processes in pipeline safety maintenance were studied using the Computational Fluid Dynamics (CFD) methods. A new model (model 1) closer to actual working conditions and another two-side injection model were investigated. The simulation results showed that the relative purging efficiency of model 1 decreases compared to the ideal model (model 0), and two-sided injection model increases the efficiency relative to the single sided purging model. In addition, the models with different intake methods, outlet positions, outlet sizes and outlet pressures were simulated. If the outlet is opened after delaying some time, purging efficiency is improved. Furthermore if "relay purging" method is adopted, the efficiency is increased by 18% with two gas inlets and by 11% with a single inlet. The outlet position affects the average velocity in the last purging time. If the outlet diameter is equal or larger than that of the inlet, the purging efficiency is much higher.

- **Keywords:** Hot work; Nitrogen replacement; Gas purging; Oil and gas transportation; Pipeline

Francis Hassard, Jeremy Biddle, Elise Cartmell, Bruce Jefferson, Sean Tyrrel, Tom Stephenson. *Rotating biological contactors for wastewater treatment – A review*.

Rotating biological contactors (RBCs) for wastewater treatment began in the 1970s. Removal of organic matter has been targeted within organic loading rates of up to 120 g m−2 d−1 with an optimum at around 15 g m−2 d−1 for combined BOD and ammonia removal. Full nitrification is achievable under appropriate process conditions with oxidation rates of up to 6 g m−2 d−1 reported for municipal wastewater. The RBC process has been adapted for denitrification with reported removal rates of up to 14 g m−2 d−1 with nitrogen rich wastewaters. Different media types can be used to improve organic/nitrogen loading rates through selecting for different bacterial groups. The RBC has been applied with only limited success for enhanced biological phosphorus removal and attained up to 70% total phosphorus removal. Compared to other biofilm processes, RBCs had 35% lower energy costs than trickling filters but higher demand than wetland systems. However, the land footprint for the same treatment is lower than these alternatives. The RBC process has been used for removal of priority pollutants such as pharmaceuticals and personal care products. The RBC system has been shown to eliminate 99% of faecal coliforms and the majority of other wastewater pathogens. Novel RBC reactors include systems for energy generation such as algae, methane production and microbial fuel cells for direct current generation. Issues such as scale up remain challenging for the future application of RBC technology and topics such as phosphorus removal and denitrification still require further research. High volumetric removal rate, solids retention, low footprint, hydraulic residence times are characteristics of RBCs. The RBC is therefore an ideal candidate for hybrid processes for upgrading works maximising efficiency of existing infrastructure and minimising energy consumption for nutrient removal. This review will provide a link between disciplines and discuss recent developments in RBC research and comparison of recent process designs are provided (Section 2). The microbial features of the RBC biofilm are highlighted (Section 3) and topics such as biological nitrogen removal and priority pollutant remediation are discussed (Sections 4 and 5). Developments in kinetics and modelling are highlighted (Section 6) and future research themes are mentioned.

- **Keywords:** Bioaugmentation; Biofilm; Biological wastewater treatment; Biological nitrogen removal; Modelling; Rotating biological contactor

Ali Reza Soleymani, Javad Saien, Sungmin Chin, Hoang Anh Le, Eunseuk Park, Jongsoo Jurng*. Modeling and optimization of a sono-assisted photocatalytic water treatment process via central composite design methodology.*

This work focuses on modeling and optimization of a sono-assisted photocatalytic decolorization process of a model pollutant, azo dye C.I. direct red 16 (DR16). In the process, a high temperature thermal decomposition nano synthesized titanium dioxide (TD-TiO2) was applied as photocatalyst. Central composite design (CCD) methodology was used for designing the experiments, modeling and optimization of the process. A quadratic model was established to describe dependency of the decolorization efficiency (DE), as the model response, to some effective operational parameters, i.e. the catalyst dosage, pH and the dye initial concentration. The ANOVA analysis confirmed that all of the variables have significant influence on the model response. Under the established optimum conditions, 92.4% DE was achieved after 45 min; however, to access desirable mineralization efficiency, the process should be continued up to 120 min. All withdrawn samples from the reaction media during the process showed no antibacterial activity, which indicates safety of the treated effluent for disposal into the environment. Also studies showed that the process proceeds via two parallel branches of photolysis and photocatalysis, where propagation of the ultrasonic waves into the reaction media plays a vital promoting role on the latter branch.

- **Keywords:** Nano TiO2; Photocatalysis; Experimental design; Modeling; Optimization; Mineralization

Guido Mastrantonio, Laura Battaioto, Carla Jones, Marcos Coustet, Hector Chandi, Diego K. Yamul. *Chemical conversion of paper industry effluents into carboxymethylcellulose*.

The synthesis of carboxymethylcellulose was investigated using effluents containing short cellulose fibers. Carboxymethylcellulose was synthesized according to the slurry process using different amount of sodium hydroxide and different incubation times at 30 °C after the etherification reaction as variables. Characterization of the product was conducted by Fourier transformed infrared spectroscopy, X-ray diffraction, degree of substitution, average degree of polymerization, water imbibing capacity, color, rheological properties, apparent viscosity and trace elements content. Incubation time slightly increased the yield of the reaction and the degree of substitution during the first 12 h. The reaction yield and degree of substitution both decreased when the initially concentration of NaOH was increased from 7.0 g/mL to 10.5 g/mL. The carboxymethylcellulose obtained was darker and had lower hydration properties than commercial samples. Trace elements content suggests that the product could be only used in paint factories or building materials industries.

- **Keywords:** Short cellulose fibers; Carboxymethylcellulose; Paper; Recycled sludge; Effluents; Solid Waste

Yanjie Gao, Yan Xue, Zhi-guo Lǔ, Ziheng Wang, Qiang Chen, Ning Shi, Feng Sun. *Self-accelerating decomposition temperature and quantitative structure–property relationship of organic peroxides*.

This work presents a new approach to predict thermal stability of organic peroxides based on quantitative structure–property relationship methods. The data set consists of self-accelerating decomposition temperature (SADT) of 39 organic peroxides, part of which is obtained from the Recommendations on the Transport of Dangerous Goods and the other part is obtained from C600 calorimetry. Descriptors computed using RM1 semi-empirical quantum mechanical method are selected to describe the above-mentioned 39

molecules. Partial least-squares method and multiple linear regression method are used to select the descriptors and SADT model. At last, a four-descriptor correlation equation is obtained using a cross validation method: a correlation coefficient R > 0.9 and a predictive coefficient Q2 > 0.85.

- **Keywords:** Organic peroxide; Self-accelerating decomposition temperature; Quantitative structure–property relationship; Multi-linear regression; modeling; thermal decomposition; kinetics parameters; material thermal hazard

Lai Yee Lee, Daniel Zhao Bing Chin, Xin Jiat Lee, Nishanth Chemmangattuvalappil, Suyin Gan. *Evaluation of Abelmoschus esculentus (lady's finger) seed as a novel biosorbent for the removal of Acid Blue 113 dye from aqueous solutions*.

The use of a new biosorbent derived from Abelmoschus esculentus (A. esculentus) seed for the removal of Acid Blue 113 (AB113) in aqueous solutions was investigated in batch mode. Biosorption studies were carried out under varying operational parameters including initial pH, biosorbent dosage, contact time, initial dye concentration and temperature. The results indicated that the biosorption properties were strongly dependent on initial pH. Fourier transform infrared spectroscopy analysis revealed that hydroxyl, carboxylic and amide functional groups present on the biosorbent surface were involved in the dye removal process. Equilibrium data were best fitted by the Langmuir model. The maximum biosorption capacity was 169.9 ± 3.1 mg g−1 at 25 °C and initial pH 5.5. The kinetic data were in good agreement with the pseudo-second-order kinetic model. The process was controlled by diffusion through boundary layer at the initial stage followed by intra-particle diffusion at the later stage. Thermodynamic evaluation showed that the process was endothermic and spontaneous. The present study suggests that A. esculentus seed with maximum biosorption capacity which compared well with values reported in the literature can be a potential biosorbent for AB113 dye removal.

- **Keywords:** Biosorption; Acid Blue dye; Abelmoschus esculentus; Lady's finger; Isotherm; Kinetic

Tevfik Aysu, Ayhan Demirbaş, Aydın Şükrü Bengü, Mehmet Maşuk Küçük. *Evaluation of Eremurus spectabilis for production of bio-oils with supercritical solvents*.

Eremurus spectabilis samples were liquefied in organic solvents (methanol, ethanol and acetone) with (sodium hydroxide and ferric chloride) and without catalyst in a cylindrical reactor at temperatures of 270, 290 and 310 °C under supercritical conditions. The effects of liquefaction parameters such as temperature, catalyst and solvent on product yields were investigated. The liquid products were extracted with diethyl ether and benzene using an extraction procedure. The product yields in supercritical methanol, ethanol and acetone were found to as 41.6%, 53.8% and 64.3% in the non-catalytic runs at 310 °C, respectively. The highest conversion was obtained in supercritical acetone in the presence of ferric chloride (10%) at same temperature in the catalytic runs. The produced liquids in acetone were analyzed and characterized by elemental, Fourier transform infrared spectroscopy (FT-IR), gas chromatography–mass spectrometry (GC–MS). The liquid products (bio-oils) obtained with acetone contained various types of components including aromatics, nitrogenated and oxygenated compounds. As the bio-oils obtained exhibit high heat values, E. spectabilis is presented as a potential feedstock candidate for production of bio-fuels or valuable chemicals.

- **Keywords:** Biomass; Bio-fuel; Liquefaction; Eremurus spectabilis; Thermo-chemical process; Supercritical organic solvent

Liang Liu, Changle Pang, Shubiao Wu, Renjie Dong. *Optimization and evaluation of an air-recirculated stripping for ammonia removal from the anaerobic digestate of pig manure*.

An air-recirculated stripping involved two processes and did not require any pretreatment. First, stripping CO2 decreased the buffer capacity of the anaerobic digestate, thereby reducing the amount of lime used to achieve a high pH. Second, lime was added to increase pH and remove ammonia from the anaerobic digestate of pig manure. pH increased from 8.03 to 8.86 by stripping CO2 in the first process (gas-to-liquid ratio = 180) and further reached 12.38 in the second process (gas-to-liquid ratio = 300). During process optimization, the maximum ammonia removal efficiency reached 96.78% with a lime dose of 22.13 g. The value was close to 98.25%, which was the optimal result predicted by response surface methodology using the software Design-Expert 8.05b. All these results indicated that air-recirculated stripping coupled with absorption was a promising technology for the removal and recovery of nitrogen in the anaerobic digestate of pig manure.

- **Keywords:** Anaerobic digestate of pig manure; Response surface methodology; Air-recirculated stripping

Bo Zhang, Niuyang Zou, Wei Wang, Zhigang Wang. *Investigation of an accidental explosion in a nitromethane rectification process*.

An explosion that occurred during a nitromethane rectification process is investigated. Experiments were performed in an effort to elucidate the cause of the explosion. All test samples analyzed, including reaction product, crude product, 99% pure product and raffinate, were collected from the accident site. Gas chromatography was used to analyze the components of the samples, thermal analysis determined the exothermic character of the samples and the sample evaporating experiment recorded the reaction phenomena occurring at low liquid level. Based on the experimental results, the excess heat released by the decomposition of overheated raffinate is pinpointed as the root cause of the explosion.

- **Keywords:** Explosion; Thermal analysis; TD24; SADT; Nitromethane rectification process; Preventive measures

Yaobin Meng, Chao Lu, Yongjie Yan, Liangxia Shi, Jifu Liu. *Method to analyze the regional life loss risk by airborne chemicals released after devastating earthquakes: A simulation approach*.

Widespread chemical plants render human life more vulnerable to major natural disasters such as earthquakes. Recognizing the potential cascading threats initiated by a devastating earthquake, a general methodology for assessing the life loss risks introduced by airborne hazardous chemical dispersion following seismically induced chemical release (SICR) was proposed. With a 600 km × 600 km region in North China as a demonstrative study area, the dispersion of ammonia released from multiple relevant chemical plants that were supposed to be damaged by a devastating earthquake was simulated in a probabilistic manner. Using an ammonia toxicity-fatality relationship and its toxicity concentration threshold, regional life loss and spatial spread were evaluated. The life loss risk was found to be non-prominent but would be very contingent on unfavorable meteorological conditions. Non-parametric correlation analysis revealed that the respective effects of meteorological mixing parameters on the risk exhibit new features in a disaster context, that is, stronger mixing would cause elevation of risk in a region. This preliminary research implied that the risk of chemical-induced life loss after a devastating earthquake deserves attention and a thorough uncertainty evaluation in the future.

- **Keywords:** Airborne dispersion; Ammonia; Disaster chain; Earthquake; Risk; Na-Tech

Peng Liang, Wanmin Jiang, Lan Zhang, Jiafeng Wu, Jianshu Zhang, Dongjiang Yang. *Experimental studies of removing typical VOCs by dielectric barrier discharge reactor of different sizes*.

This research conducted both lab-scale and pilot-scale tests by selecting toluene as the typical volatile organic compounds (VOCs) and by using the promising non-thermal plasma oxidation technology – dielectric barrier discharge (DBD). To develop baseline engineering data to demonstrate the feasibility of application of self-made DBD reactors, the peak voltage, gas flow speed, initial toluene concentration, discharge frequency and duty ratio were studied. The results showed that toluene removal efficiency improves with increase of electrical voltage, frequency and duty ratio, and declines with increase of polar distance, gas flow speed and toluene initial concentration. When the voltage increases, the energy efficiency rises first and then drops. The energy efficiency reaches the climax when the energy density reaches 150.8 J/L and 101.7 J/L in the lab-scale experiment and pilot-scale experiment respectively.

- **Keywords:** Non-thermal plasma; Volatile organic compounds; Dielectric barrier discharge; Energy efficiency; Energy density; Toluene removal efficiency

Arnab Roy, Prashant Srivastava, Shishir Sinha. *Dynamic failure assessment of an ammonia storage unit: A case study*.

Chemical Process Industries usually contain a diverse inventory of hazardous chemicals and complex systems required to perform process operations such as storage, separation, reaction, compression etc. The complex interactions between the equipment make them vulnerable to catastrophic accidents. Risk and failure assessment provide engineers with an intuitive tool for decision making in the operation of such plants. Abnormal events and near-miss situations occur regularly during the operation of a system. Accident Sequence Precursors (ASP) can be used to demonstrate the real-time operating condition of a plant. Dynamic Failure Assessment (DFA) methodology is based on Bayesian statistical methods incorporates ASP data to revise the generic failure probabilities of the systems during its operational lifetime.´In this paper, DFA methodology is applied on an ammonia storage unit in a specialized chemical industry. Ammonia is stored in cold storage tanks as liquefied gas at atmospheric pressure. These tanks are susceptible to failures due to various abnormal conditions arising due process failures. Tank failures due to three such abnormal conditions are considered. Variation of the failure probability of the safety systems is demonstrated. The authors use ASP data collected from plant specific sources and safety expert judgement. The failure probabilities of some safety systems concerned show considerable deviation from the generic values. The method helps to locate the components which have undergone more degradation over the period and hence must be paid attention to. In addition, a Bayesian predictive model has been used to predict the number of abnormal events in the next time interval. The user-friendly and intuitive nature of the tool makes it appropriate for application in safety assessment reports in process industries.

- **Keywords:** Dynamic failure assessment; Bayesian theory; Ammonia tank failure; Abnormal event; Accident sequence precursor

Deepak Yadav, Meghna Kapur, Pradeep Kumar, Monoj Kumar Mondal. *Adsorptive removal of phosphate from aqueous solution using rice husk and fruit juice residue*.

The aim of the present study was to investigate the possible use of fruit juice (Citrus limetta) residue and rice husk as adsorbents for phosphate removal from aqueous solutions. Batch experiments were performed to achieve maximal phosphate removal by varying process parameters, like pH, contact time, temperature, adsorbent dose and initial solute concentration. FTIR studies revealed that OH, NO and CN groups are responsible for phosphate binding process. The maximum removal of phosphate was achieved as 95.85% at 298 K, adsorbent dose 3 g/L and pH 6.0 with acid treated fruit juice residue. Adsorption process was fitted with pseudo-first order kinetics at 298, 308 and 318 K, respectively. Various isotherm models and mass transfer mechanisms were studied for the removal of phosphate ions from aqueous solutions. Among various adsorption isotherms, Freundlich isotherm showed a better correlation with experimental data. The adsorption energy calculated from Dubinin–Radushkevich isotherm for the most efficient adsorbent indicated physical nature of adsorption.

- **Keywords:** Adsorption; Activated fruit juice residue; Phosphate; Activated rice husk; Batch process

Roberto Sanchirico, Paola Russo, Valeria Di Sarli, Almerinda Di Benedetto. *On the explosion and flammability behavior of mixtures of combustible dus*ts.

In the work presented in this paper, the explosion and flammability behavior of combustible dust mixtures was studied. Lycopodium, Nicotinic acid and Ascorbic acid were used as sample dusts. In the case of mixtures of two dusts, the minimum explosive concentration is reproduced well by a Le Chatelier's rule-like formula, whereas the minimum ignition energy is a linear combination of the ignition energies of the pure dusts. An unexpected behavior has been found in relation to the explosion behavior and the reactivity. When mixing Lycopodium and Nicotinic acid or Ascorbic acid, the rate of pressure rise of the mixture is much higher than the rate of pressure rise obtained by linearly averaging the values of the pure dusts (according to their weight proportions), thus suggesting that strong synergistic effects arise; but it is comparable to that of the most reactive dust in the mixture. The observed behavior seems to be linked to the presence of minerals in the Lycopodium particles which catalyze oxidation reactions of Nicotinic acid and Ascorbic acid, as suggested by TG analysis. In the case of mixtures of three dusts, a similar behavior is observed when the concentration of Lycopodium is twice that of the other two dusts.

- **Keywords:** Dust explosion; Dust mixtures; Maximum rate of pressure rise; Maximum pressure; Lycopodium; Catalytic reaction

Sumate Chaiprapat, Sunsanee Wongchana, Surapich Loykulnant, Chaveewan Kongkaew, Boonya Charnnok. *Evaluating sulfuric acid reduction, substitution, and recovery to improve environmental performance and biogas productivity in rubber latex industry*.

Sulfuric acid is heavily used in concentrated rubber latex factories to coagulate rubber particles in skim latex. The resulting sulfate-rich wastewater creates the onset of toxic H2S gas production in the wastewater holding ponds, causing severe corrosion to materials and community disturbance when dispersed to ambient air. This work identified and evaluated measures to reduce H2S production by minimizing sulfate concentration in the wastewater. Sulfuric acid use could be cut down by pre-removal of ammonia in the skim latex as well as a stricter manipulation of acid dosing. In search of a more benign chemical, a heat sensitive polymer was identified and tested as sulfuric acid substitute. The use of hydroxypropyl methylcellulose polymer (HPMC) changed wastewater characteristics and was found to increase biogas production approximately by 2.4 times in batch assay at the initial pH 7.0 and methane yield by 2.7 times in continuous digester

operation at HRT 7 days. Finally, a resource recovery option was evaluated. The remaining H2S in the produced biogas was oxidized in the biotrickling filter to sulfuric acid that has a potential to partially supplement the fresh acid. This work demonstrated an integrated approach in waste management to improve environmental performance, safety and energy recovery in the concentrated latex industry.

- **Keywords:** Polymer; Sulfuric acid; Biogas; Rubber latex; Biotrickling filter; H2S

H.V. Lee, Y.H. Taufiq-Yap. *Optimization study of binary metal oxides catalyzed transesterification system for biodiesel production*.

The focus of this study is to produce biodiesel using non-edible feedstock (Jatropha curcas oil) via heterogeneous base catalyzed transesterification reaction. The solid base catalysts, binary metal oxide (CaO–ZnO and CaO–La2O3) were selected for the transesterification of high acid jatropha oil. Furthermore, the design of experiments was performed using 5-level-4 factor central composite design coupled with response surface methodology (RSM) in order to optimize the transesterification conditions. Four process factors were evaluated: (1) reaction time (1–5 h), (2) methanol/oil molar ratio (15:1–30:1), (3) reaction temperature (40–200 °C) and (4) catalyst loading (1–5 wt.%). Based on the quadratic model generated from RSM, reaction temperature rendered the most significant effect for both CaO–ZnO and CaO–La2O3 catalyzed reactions, followed by catalyst loading and reaction time. Besides, both reaction models showed that interaction between reaction temperature with reaction time and catalyst loading has positively influenced the biodiesel yield. The highest conversion predicted for CaO–ZnO and CaO–La2O3 catalyzed reactions was 97.03% and 96.27%, respectively, with reasonable predictability and sufficient accuracy data (small error: 0.33–0.34%). Furthermore, the physicochemical characteristics of produced biodiesel were tested with compliance to ASTM D7851 and EN 14124.

- **Keywords:** Jatropha curcas oil; Response surface methodology; Catalyst; Optimization; Fuel properties; Transesterification; Mixed metal oxides; Statistical analysis

Gülbahar Akkaya Sayğılı, Hasan Sayğılı, Filiz Koyuncu, Fuat Güzel. *Development and physicochemical characterization of a new magnetic nanocomposite as an economic antibiotic remover*.

Maghemite (Y-Fe2O3) nanoparticles were impregnated to nanoporous carbon obtained from tomato waste (TWNC). The prepared magnetic composite (MTWNC) was characterized and used to remove tetracycline (TC) from water and then easily be separated from the medium by a magnetic technique. The morphologies and surface chemistries of both magnetic and non-magnetic nanoporous carbons were studied by FTIR, XRD, SEM, SEM-EDX, VSM, BET surface area, proximate and elemental analysis determinations. Batch adsorption studies were carried out and the effects of pH, initial TC concentration, adsorbent dose, ionic strength and temperature were investigated. The adsorption kinetics of TC on MTWNC could be expressed well by the pseudo-second order model, and sorption isotherms were described by Langmuir equation with maximum adsorption capacity of 60.60 mg/g at pH 4 and 50 °C. Thermodynamic parameters showed that the adsorption of TC onto MTWNC was feasible, spontaneous and endothermic. Furthermore, the recyclability of the adsorbent was tested with 0.01 M NaOH solution, and the results show that the synthesized composite adsorbent could be employed repeatedly in wastewater treatment.

- **Keywords:** Nanoporous carbon; Magnetic nanocomposite; Tetracycline adsorption; Tomato waste; Regeneration; Wastewater treatment

F. Gérardin, A. Cloteaux, N. Midoux. *Modelling of variations in nitrogen trichloride concentration over time in swimming pool water*.

In water, chlorine reacts with nitrogen-containing compounds to produce disinfection by-products such as nitrogen trichloride which induces ocular and respiratory irritations in swimming pool workers. This study proposes a model to predict variations in NCl3 concentration over time in a traditional indoor swimming pool as a function of its operating parameters and attendance. The model was developed taking into consideration the reaction mechanisms, thermodynamic equilibria, physico-chemical properties, and transfer mechanisms occurring at the pool's surface. This model was validated through a robust series of experiments over two days and two nights in a real swimming pool. The model was found to satisfactorily predict variations over time in the concentrations of the chemical species investigated, including nitrogen trichloride. The work presented constitutes a first step to extend the model at different swimming pools. This approach may also be used to study the influence of the main operating parameters and to evaluate the impact of setting up water treatment systems on nitrogen trichloride concentration.

- **Keywords:** Occupational exposure; Nitrogen trichloride; Disinfection by products; Modeling; Swimming pools; Chlorination

Michaela Perdochova, Katerina Derychova, Hana Veznikova, Ales Bernatik, Martin Pitt. *The influence of oxygen concentration on the composition of gaseous products occurring during the self-heating of coal and wood sawdust*.

This article deals with an assessment of the influence of oxygen concentration on the composition and amount of combustion products generated in the course of heating coal particles and wood sawdust at 150 °C. This was done both with normal air and at 15% oxygen in the air in an isothermal furnace. The generated gases were analyzed by a Fourier Transform infrared spectrometer. Results show that under both conditions, the same substances are formed: water, carbon dioxide, carbon monoxide and aliphatic hydrocarbons. However, the quantities changed. At 21% oxygen, the concentrations of carbon monoxide and methane were higher than at 15% oxygen both in coal and wood. The oxygen concentration was also found to affect the rates of release of CO and CO2. The rate of release of CO was higher at 21% oxygen, but that of CO2 was higher at 15%, indicating two different mechanisms. In all cases, the concentrations of these gases were higher for coal than for wood. The results have implications for the specification of safe conditions of storage of coal and wood substances and the selection of safety measures.

- **Keywords:** Coal; Wood sawdust; Gaseous products; Self-heating; Oxygen concentration

C. Arun, P. Sivashanmugam. *Investigation of biocatalytic potential of garbage enzyme and its influence on stabilization of industrial waste activated sludge*.

The decomposable waste thrown into the environment can be used to produce value added bio-product which in turn reduces the production of greenhouse gas. Garbage enzyme is one such value added product produced by fermentation of organic solid waste. In the present study enzyme activity and disinfectant potential of garbage enzyme was evaluated and its influence on reduction of total solids, suspended solids and pathogens in dairy waste activated sludge were studied. The result showed the garbage enzyme possesses protease, amylase and lipase activity and reduced 37.2% of total solids, 38.6% of suspended solids and 99% of pathogens in dairy waste activated sludge. This significant result may be helpful for researchers to compare the effectiveness of

earth-friendly garbage enzyme treatment of industrial sludge with various physical and chemical pre-treatment methods to improve the biogas production from the sludge digestion unit.

- **Keywords:** Decomposable waste; Fermentation; Value added product; Garbage enzyme; Disinfectant; Waste activated sludge

Wasi Z. Khan, Imad Najeeb, Madina Tuiyebayeva, Zhibeek Makhtayeva. *Refinery wastewater degradation with titanium dioxide, zinc oxide, and hydrogen peroxide in a photocatalytic reactor*.

This paper presents the photo-catalytic degradation of real refinery wastewater from National Refinery Limited (NRL) in Karachi, Pakistan, using TiO2, ZnO, and H2O2. The pretreatment of the refinery effluent was carried out on site and pretreated samples were tested at 32–37 °C in a stirrer bath reactor by using ultra-violet photo oxidation process. The degradation of wastewater was measured as a change in initial chemical oxygen demand (COD) and with time. Optimal conditions were obtained for catalyst type, and pH. The titanium dioxide proved to be very effective catalysts in photo-catalytic degradation of real refinery wastewater. The maximum degradation achieved was 40.68% by using TiO2 at 37 °C and pH of 4, within 120 min of irradiations. When TiO2 was combined with H2O2 the degradation decreased to 25.35%. A higher reaction rate was found for titanium dioxide. The results indicate that for real refinery wastewater, TiO2 is comparatively more effective than ZnO and H2O2. The experiments indicated that first-order kinetics can successfully describe the photo-catalytic reaction. The ANOVA results for the model showed satisfactory and reasonable adjustment of the second-order regression model with the experimental data. The ANOVA results also showed that pH is significant than reaction time and catalyst dosage of TiO2; and in case of ZnO, reaction time is significant than pH and catalyst dosage. This study proves that real refinery wastewater reacts differently than synthetic refinery wastewater, oil field produced water or oil water industrial effluent.

- **Keywords:** Photo-catalytic degradation; Refinery wastewater; Ultra-violet light; Titanium dioxide; Zinc oxide; Hydrogen peroxide

Nurull Muna Daud, Siti Rozaimah Sheikh Abdullah, Hassimi Abu Hasan, Zahira Yaakob. *Production of biodiesel and its wastewater treatment technologies: A review*.

The development of technologies providing alternatives to petroleum fuel has led to the production of biodiesel fuel. This paper reviews the methods used to produce biodiesel fuel from various types of sources such as palm oil, jatropha oil, microalgae, and corn starch. It also includes a brief description of the transesterification process and the point source of biodiesel wastewater, from which it is mainly generated. Biodiesel wastewater is characterized by high contents of chemical oxygen demand (COD), biological oxygen demand (BOD5), oil, methanol, soap and glycerol. The treatments developed so far for biodiesel wastewater are also described. The authors also investigate the significance, ability and possibility of biological aerated filter (BAF) to treat biodiesel wastewater discharged from a biodiesel fuel production plant. The whole treatment; coagulation-biological aerated filter (CoBAF); involves the pre-treatment of biodiesel wastewater using coagulation followed by the treatment using BAF.

- **Keywords:** Biodiesel; Biodiesel production; Transesterification; Biodiesel wastewater; Biodiesel wastewater treatment; Biodiesel wastewater management

Tom Bajcar, Franc Cimerman, Brane Širok. *Towards more detailed determination of third party impact on risk on natural gas pipelines: Influence of population density*.

The paper presents a refined way to quantify the effects of third party interference on risk that is posed on people by transmission pipelines for natural gas. The main focus is set on the influence of population density on risk. Using the interdisciplinary approach, the presented study combines the knowledge from relevant risk assessment recommendations, physical consequences of hazardous events, existing history databases of hazardous event frequencies and urban planning. A quantitative boundary between two most populated types of area was established. A flexible risk coefficient was determined for a suburban type of populated area that is dependent on average population density. Consequently, a new approach for determination of a hazard distance from the pipeline and area boundaries for calculation of average population density was presented. This differs from the established methods described in some guidelines, but is based on results of applied quantitative risk assessment. The final result is more accurate determination of risk levels in suburban areas. Described methods may serve as a supplement to the existing models for quantitative risk assessment on pipelines used in natural gas transportation and may be used by pipeline operators as well as policy- and decision makers.

- **Keywords:** Risk analysis; Natural gas; Pipelines; Third party interference; Population density; Suburban areas

M.A. Hadjipanayis, F. Beyrau, R.P. Lindstedt, G. Atkinson, L. Cusco. *Thermal radiation from vapour cloud explos*ions.

The current study estimates the radiation flux emitted from hot extended gas clouds characteristic of vapour cloud explosions along with the corresponding level of irradiance posed on particles suspended in the unburnt part of the cloud ahead of an advancing flame front. The data presented permits an assessment of the plausibility of combustion initiation by such particles due to forward thermal radiation. The thermal radiation will depend on the emissivity of the burned volume, which relates to the concentration of gaseous and particulate combustion products. A sensitivity analysis has been carried out to account for variations in the equivalence ratio, mixture pressure and radiative heat losses. The spatial distribution of irradiance ahead of the flame front has been computed by introducing appropriate geometrical factors to explore the impact of cloud size. Using fuel rich ethylene-air mixtures it has been shown that high flame emissivities can be achieved at path lengths of order 1 m even in the presence of very low soot volume fractions. The emissivity of gas-soot mixtures will hence be mainly determined by the soot concentration and to a lesser extent by the mixture temperature. Our analysis suggests that the role of forward thermal radiation as a contributing factor to flame propagation in large scale vapour cloud explosions can not currently be ruled out.

- **Keywords:** Radiation induced ignition; Vapour cloud explosions; Soot; Cloud size effects; Temperature effects; Impact of mixture composition

T. Matsushita, S. Hirai, T. Ishikawa, Y. Matsui, N. Shirasaki. *Decomposition of 1,4-dioxane by vacuum ultraviolet irradiation: Study of economic feasibility and by-product formation*.

We report the first use of vacuum ultraviolet (VUV) treatment to decompose 1,4-dioxane, a persistent organic contaminant that is difficult to remove by conventional drinking water treatment processes. The efficiency of VUV treatment was compared to that of VUV- and UV-based advanced oxidation processes (AOPs) (VUV/TiO2, VUV/H2O2, UV/TiO2, and UV/H2O2), and by-product formation was investigated. VUV treatment

decomposed 1,4-dioxane more rapidly than did UV and UV/TiO2 treatments. The decomposition rate was enhanced when VUV irradiation was combined with TiO2 or H2O2. VUV/H2O2 decomposed 1,4-dioxane more rapidly than UV/H2O2 at a low H2O2 dose (1 mg/L), but the rate difference became small at a high H2O2 dose (5 mg/L). Electrical energy per order analysis revealed that VUV treatment, and the VUV- and UV-based AOPs, were economically feasible for 1,4-dioxane decomposition. Using raw water samples, we investigated by-product formation during VUV treatment and the effect of VUV irradiation on chlorinated disinfection by-product formation potential. Although the samples contained high concentrations of bromide, no bromate was produced by VUV treatment. VUV treatment slightly decreased trihalomethane formation potential (THMFP), whereas haloacetic acid formation potential (HAAFP) was unchanged, and total aldehyde concentration increased. The trend in HAAFP agreed with that had been reported for the VUV irradiation with much higher dose (Buchanan et al., 2006), whereas the trend in THMFP was different from that with much higher dose. THMFP, HAAFP, and aldehyde concentration were reduced by subsequent treatment with granular activated carbon (GAC) or biological activated carbon (BAC). Nitrite was produced by VUV treatment but disappeared after subsequent BAC treatment. These results suggest that VUV treatment should be combined with GAC or BAC treatment to suppress by-product formation.

- **Keywords:** Activated carbon adsorption; Chlorination disinfection by-product; Haloacetic acid formation potential; Hydrogen peroxide; Photocatalyst; Trihalomethane formation potential