Process Safety and Environmental Protection

rok 2009, ročník 87

Číslo 6 (November 2009)

C.P. Lin, H.K. Chang, Y.M. Chang, S.W. Chen, C.M. Shu. *Emergency response study for chemical releases in the high-tech industry in Taiwan : a semiconductor plant example*. Pages 353-360.

In the past two decades, there has been continuous investment and expansion of semiconductor, photoelectric panel, or solar cell plants in the high-tech industry. For example, establishing a semiconductor plant costs about US$ 3 billion. In addition, the output value of integrated circuits (IC) of Taiwan as a whole is estimated to be about US$ 5.215 billion, and globally of US$ 275.2 billion in 2008. A large amount and a variety of specialty gases or chemicals are applied during processes in high-tech facilities and these chemicals are characterized by inflammability, toxicity, and corrosiveness. Accidents may result once errors or leaks occur in any part of the supply chain, which consists of storage facilities, supply equipment, process machines, and tail gas elimination devices. Personnel casualties can result in serious situations. This study discusses the emergency response procedures and common response defects in semiconductor plants with a view to enhancing emergency response effects and capabilities, avoiding casualties, reducing property loss and shortening operation interruption.

- **Keywords:** Semiconductor; High-tech industry; Risk; Specialty gases; Emergency response procedures

Hirokazu Sugiyama, Ulrich Fischer, Elena Antonijuan, Volker H. Hoffmann, Masahiko Hirao, Konrad Hungerbühler. *How do different process options and evaluation settings affect economic and environmental assessments? : a case study on methyl methacrylate (MMA) production processes*. Pages 361-370.

We present an investigation on how economic and environmental assessment results change when different process options or evaluation settings are considered. As the main case study the production technology of methyl methacrylate (MMA) is investigated. Six commercial processes using different reaction routes are modelled and evaluated with respect to their economic and environmental performance. On these six base case models different process options and evaluation settings are considered and the resulting impacts on the assessment results are quantified. Major findings of the study are that the more decision-variables become fixed, the smaller becomes the impact of the decisions

still to be taken—but not only with respect to the economic performance but also with regard to the environmental assessment result. Along the process development steps the potential impacts on the economic and environmental performance decrease to the same degree. The results obtained for the evaluation settings do not show such a systematic pattern as those for the process options. This finding indicates that decision makers face many options in the economic and especially the environmental assessment of chemical processes which might lead to quite different magnitudes in variability due to either the choice of method or the choice of method parameters. This paper demonstrates that the resulting variability might be crucial with respect to the decision making outcome.

- **Keywords:** Environmentally conscious process design; Cumulative Energy Demand (CED); Methyl methacrylate (MMA) processes; Early design phases

Azmi Mohd Shariff, Chan T. Leong. *Inherent risk assessment : a new concept to evaluate risk in preliminary design stage*. Pages 371-376.

Quantitative Risk Assessment (QRA) has been a very popular and useful methodology which is widely accepted by the industry over the past few decades. QRA is typically carried out at a stage where complete plant has been designed and sited. At that time, the opportunity to include inherent safety design features is limited and may incur higher cost. This paper proposes a new concept to evaluate risk inherent to a process owing to the chemical it uses and the process conditions. The risk assessment tool is integrated with process design simulator (HYSYS) to provide necessary process data as early as the initial design stages, where modifications based on inherent safety principles can still be incorporated to enhance the process safety of the plant. The risk assessment tool consists of two components which calculate the probability and the consequences relating to possible risk due to major accidents. A case study on the potential explosion due to the release of flammable material demonstrates that the tool is capable to identify potential high risk of process streams. Further improvement of the process design is possible by applying inherent safety principles to make the process under consideration inherently safer. Since this tool is fully integrated with HYSYS, re-evaluation of the inherent risk takes very little time and effort. The new tool addresses the lack of systematic methodology and technology, which is one of the barriers to designing inherently safer plants.

- **Keywords:** Quantitative Risk Assessment; Inherent risk; Inherent safety; Consequence estimation; Inherently safer design

Mohamed Hédi Romdhana, Didier Lecomte, Bruno Ladevie, Caroline Sablayrolles. *Monitoring of pathogenic microorganisms contamination during heat drying process of sewage sludge*. Pages 377-386.

The sewage sludge from wastewater treatment plant is a potential source of infectious organism. The number and type of pathogens in sludge depends on various factors namely, the wastewater source, the type of treatment plant, and other environmental factors such as the biological medium offered by the sewage sludge. The principal sludge-borne diseases are presented followed by discussion on biological aspect of growth and occurrence. The overall objective of this work is to estimate kinetic reduction of pathogen population in sludge during different thermal-drying process including: the agitated conductive drying, drum drying, solar drying, and fry-drying. The temperature curves were reported from literature except frying data which were determined in experiment. In order to apply the temperature influence on pathogens population, kinetic parameters for the thermal inactivation (D, z-values) were chosen from literature. Values of concentrations of each pathogen were also extracted from scientific review of pathogens in bio-solids. This study conducted to resolve the survival kinetic of Hepatitis A viruses. The result showed that a concentration of 7×10^4 cfu/100 ml initially present in the sewage sludge is significantly reduced during the heat drying processes except the

solar plant. The sewage sludge is completely disinfected when heated for 20 min, 10 min, and 10 s, respectively, during the agitated conductive process, vacuum fry-drying, and drum drying process.

- **Keywords:** Sewage sludge; Wastewater; Drying; Frying; Solar; Pathogens; Microbial disease; Microorganism; Thermal inactivation

Ning Liu, Hong-you Cui, De Yao. *Decomposition and oxidation of sodium 3,5,6-trichloropyridin-2-ol in sub- and supercritical water*. Pages 387-394.

Sodium 3,5,6-trichloropyridin-2-ol (STCP) is a necessary precursor compound for the production of chlorpyrifos and triclopyr, which are extensively used as pesticide and herbicide, respectively. In the process of STCP production, however, large amount of wastewater containing STCP is discharged, which causes increasingly environmental concerns. Therefore, it is of great significance to develop a rapid and effective method for the disposal of containing STCP contaminants. In this work, the thermal decomposition of STCP in sub- and supercritical water was investigated using a continuous tubular reactor. While STCP was stable below 280 °C, it could be effectively decomposed at elevated temperature. FT-IR spectra of the decomposition products indicated that the pyridine ring structure in the STCP molecule was stable even at temperatures up to 400 °C. The decomposition reaction was mainly caused by the substitution of Cl groups in the STCP molecule with OH groups, resulting in polyhydroxylated pyridines as the major decomposition product. Moreover, high pressure favored the substitution reaction. To completely decompose STCP into non-toxic or low toxic compounds, supercritical water oxidation (SCWO) was employed to evaluate the oxidation of STCP using H_2O_2 as an oxidant. It was found that STCP could be completely oxidized to H_2O, CO_2 and corresponding inorganic ammonium salts with an oxidation rate of 99%.

- **Keywords:** Sodium 3,5,6-trichloropyridin-2-ol; Supercritical; Subcritical; Oxidation; Decomposition

Naman Cissoko, Zhen Zhang, Jinghui Zhang, Xinhua Xu. *Removal of Cr(VI) from simulative contaminated groundwater by iron metal*. Pages 395-400.

The Cr(VI) removal from simulative contaminated groundwater using zero-valent iron (Fe^0) filings, Fe^0 powder and nanoscale Fe^0 in batch experimental mode was studied. Cr(VI) is a primary pollutant of some soils and groundwater. Zero-valent iron, an important natural reductant, could transform Cr(VI) to Cr(III) which is much less toxic and immobile. The Cr(VI) removal percentage was 87% at a metal to solution ratio of 6 g l^{-1} for commercial iron powder (200 mesh) in 120 min, and 100% Cr(VI) was removed when the metal to solution ratio was 10 g l^{-1}. The results demonstrates that the Cr(VI) removal percentage was affected apparently by pH, the amount of Fe powder and the reaction temperature. The Cr(VI) removal percentage with nanoscale Fe^0 was much higher than those with Fe^0 filings or Fe^0 powder at the same reaction time. Electrochemical analysis of the reaction process led to the conclusion that the Cr(VI) trended to form Cr(III) hydroxide under the reaction conditions. The kinetics analysis showed that Cr(VI) reduction by Fe^0 could be described as a pseudo-first-order kinetics model.

- **Keywords:** Hexavalent chromium; Iron; Nanoscale; Reduction; Remediation

Jiajie He, Clifford R. Lange, Mark Dougherty. *Laboratory study using paper mill lime mud for agronomic benefit*. Pages 401-405.

Annual ryegrass (*Lolium perenne* L.) is an important cool-season forage grass in the southeastern US. Since large portions of soils in this region are too acidic for optimum ryegrass production, there exists an opportunity to use lime mud waste from numerous regional pulp and paper mills as an agricultural liming material. In this study, four lime mud application rates, 2.25 (L_1), 4.51 (L_2), 9.01 (L_3), and 22.50 (L_4) ton ha^{-1}, dry weight basis, and a control (L_0) were evaluated for response to ryegrass growth during the first 6 weeks to estimate an optimum application range over the testing soil for future field test. Results indicated that applied lime mud slowed ryegrass germination and seedling emergence, with differences of whole plant length among treatments L_0–L_4 significant only during the first three weeks. Differences of whole plant dry weight among treatments L_0–L_4 reduced thereafter. The initial soil pH increase due to the lime mud application dropped in treatments L_1–L_4 by the end of the 6-week experiment. The optimum lime mud application range was estimated between L_2 and L_3, which provided higher ryegrass yields (kg ha^{-1}) of 84 and 80 over 77 of the control and complied with the Code of Federal Regulation, CFR 40 Part 503 for land application.

- **Keywords:** Lime mud; Land application; Paper mill; Solid waste; Environment compliance