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A systematic Process Graph (P-Graph) framework for Palm Process Residue Recovery via Chemical Reaction Pathway

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ABSTRACT

Oleochemical industry generates a significant amount of palm process residue during the hydrogenation of fatty acids or methyl esters. This residue consists of medium- to long-chain fatty alcohols and alkanes with overlapping boiling points. Efficiently recovering fatty alcohols for commercial use and utilizing alkanes for jet fuel, lubricants, and gasoline is highly beneficial. However, separating fatty alcohols from alkanes using conventional distillation is challenging and expensive due to the difficulty in maintaining the required temperature differentials for phase changes, particularly when a high reflux ratio is needed. Promising solutions to this challenge includes converting fatty alcohols into derivatives with distinct boiling points from alkanes through halogenation which enables subsequent separation to be done efficiently via distillation, and the use of extractive distillation with entrainer designed to alter the relative volatilities of fatty alcohols and alkanes to be far away from one for efficient separation. While achieving high performance is essential, it is equally important to balance the recovery pathway with the need for sustainability across economic, environmental, and social dimensions. An effective recovery pathway should not only optimize efficiency and productivity but also minimize environmental impact, prioritize safety, and reduce potential health hazards. To address this, this work presents a systematic process graph (P-graph) framework to generate thermodynamically feasible reaction pathways to convert target components in the mixture. This is followed by the identification of the conversions of thermodynamically feasible reaction pathways where pathway with the highest conversion was evaluated by incorporating recovery efficiency and economic. The framework also integrates the consideration of safety, health, and environmental (SHE) aspects for both products and processes using index based SHE assessments. By integrating various index-based safety and health assessments alongside sustainability metrics, this framework systematically identifies the optimal trade-off between SHE and economic performance. As a result, a sustainable

recovery pathway for fatty alcohols and alkanes from palm process residue can be developed, ensuring the developed recovery pathway is not only efficient and economically viable but also safe, environmentally sustainable, and socially responsible.

KEY WORDS

Palm process residue; Process graph (P-graph); Chemical reaction pathway; Sustainability; Safety, health, and environmenta

BIOGRAPHY

Ir. Dr. Ng Lik Yin is a Senior Lecturer in the Department of Engineering, School of Engineering and Technology, Sunway University. His specialisation covers areas of Process System Engineering (PSE), especially on computer-aided molecular design (CAMD) and synthesis, integration and optimisation of biomass processing processes. As an advocate for clean and sustainable future, Lik Yin is utilising his research expertise in designing green products, synthesising green production processes, and synthesising sustainable consumption and production frameworks. Lik Yin is also active in industrial consultation projects, working with industries on utilities conservation projects and providing training to engineers on sustainable development.

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