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Design of a stirred batch reactor with scale-up to ensure efficient degumming process at a larger scale
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Abstract
This study investigates the design of a stirred batch reactor with scale-up for the degumming of crude palm oil (CPO) using phosphoric acid (H3PO4). Laboratory-scale experiments were conducted in a triple-neck round vessel, followed by a scale-up to a larger-scale flat-bottom stirred tank reactor. Traditional scale-up methods using geometric similarity criteria are ineffective for reactors with different geometries; hence, this work introduces an improved approach using degumming efficiency, measured by gum concentration, as the similarity criterion to design the reactor. Computational Fluid Dynamics (CFD) was employed to model the velocity distribution and mass transfer processes, predicting gum concentration evolution through gum mass balances in the oil and aqueous phases. The simulation results showed that maintaining a minimum impeller speed of 93 rpm in the larger reactor effectively reproduced the best degumming efficiency observed in the laboratory reactor at 500 rpm and 60 °C. A strong correlation (R2 = 0.963) was found between the modeled and empirical Sherwood numbers, indicating successful scale-up. This research demonstrates that degumming efficiency in a laboratory triple-neck round vessel can be numerically reproduced in a larger flat-bottom stirred tank reactor, providing valuable insights into the hydrodynamic characteristics unique to each geometry and marking a pivotal step in reactor scale-up methodologies. © 2024

Author Keywords
Computational fluid dynamics; Degumming process; Mass transfer coefficient; Non-geometric scale-up; Stirred batch reactor

Index Keywords
Batch reactors, Computational fluid dynamics, Efficiency, Geometry, Palm oil, Tanks (containers); Degumming process, Geometric scale, Gum concentration, Large-scales, Mass-transfer coefficient, Non-geometric scale-up, Scale-up, Similarity criteria, Stirred batch reactor, Stirred-tank reactors; Mass transfer

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