Slovak Society of Chemical Engineering
Institute of Chemical and Environmental Engineering
Slovak University of Technology in Bratislava

PROCEEDINGS

51st International Conference of the Slovak Society of Chemical Engineering SSCHE 2025

Hotel DRUŽBA
Jasná, Demänovská Dolina, Slovakia
May 27 - 30, 2025

Editors: Assoc. Prof. Mário Mihaľ

ISBN: 978-80-8208-158-2, EAN: 9788082081582

Published by the Faculty of Chemical and Food Technology Slovak Technical University in Bratislava in Slovak Chemistry Library for the Institute of Chemical and Environmental Engineering; Radlinského 9, 812 37 Bratislava, 2024

Sauer, L., Přibyl, M.: Enzyme synthesis and continuous flow separation of (R)-1-phenylethanol in a modular microfluidic system, Editors: Mihaľ, M., In *51st International Conference of the Slovak Society of Chemical Engineering SSCHE 2025*, Jasná, Demänovská Dolina, Slovakia, 2025.

Enzyme synthesis and continuous flow separation of (R)-1-phenylethanol in a modular microfluidic system

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Key words: (R)-1-phenylethanol, Continuous flow production, Microfluidics, Enantiomer

The synthesis of enantiomerically pure compounds remains a key challenge in chemical engineering, particularly for industrial applications. Microfluidic systems, which significantly enhance reaction and transport processes, offer a promising approach to overcoming this challenge. In this study, we present a modular microfluidic platform designed for the continuous production of (R)-(+)-1-phenylethanol (R-PE) from racemic 1-phenylethyl acetate (PEAc). The system integrates a packed-bed reactor (PBR) with immobilized lipase for enantioselective hydrolysis and a slug flow extractor (SFE) for efficient removal of unreacted substrate using hexane. Kinetic analysis of the enzymatic process revealed competitive inhibition by R-PE, while extraction studies provided insights into separation efficiency and mass transfer characteristics. By optimizing residence times in both modules, we achieved nearly 90% yield of R-PE within a total reaction time of 260 s - up to 100 times faster than conventional batch reactors. Our results demonstrate how precise kinetic and transport data can be leveraged to design efficient continuous-flow processes for the rapid production of optically active compounds.

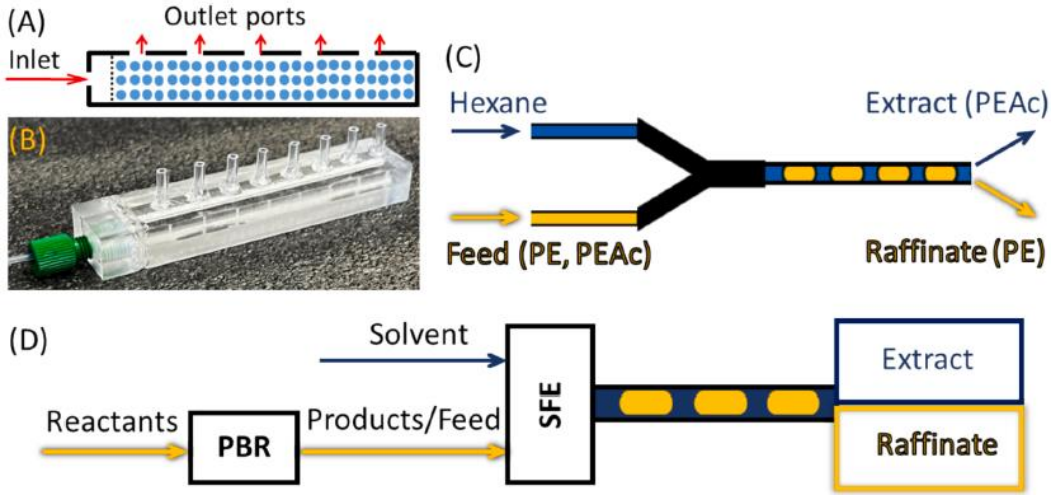

Fig. 1: A scheme (A) and photo (B) of PBR, a scheme of SFE (C), a scheme of the modular microfluidic system (D).