Reduced-order modelling of flow and concentration polarization in membrane systems with permeation

Foo Sheng Chan[a], Chee Keong Tan[a], Pesila Ratnayake[b], Yong Yeow Liang[c,d]

[a]Department of Chemical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia
[b]23, Rix Drive, Upper Coomera, Queensland, 4209, Australia
[c]Faculty of Chemical and Natural Resources Engineering, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan, Pahang, Malaysia
[d]Centre of Excellence for Advanced Research in Fluid Flow (CARIFF), Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan, Pahang, Malaysia

ABSTRACT

Modelling of concentration polarization (CP) is important to ensure a successful membrane system design. Although computational fluid dynamics (CFD) remains a common approach to study CP, it usually requires a long computational time to investigate a short simulated time in membrane systems. In this work, we proposed a reduced-order model to predict CP in membrane systems with permeation. We modify Berman's velocity profile and incorporated it to the reduced-order model of the mass transfer equation. The proposed model shows excellent agreement with CFD results, while offering a reduction of two orders of magnitude in computational time. We also validate the model with published experimental data and demonstrate that the model can predict permeate flux in close proximity under various operating conditions. The proposed model offers an attractive alternative to solving the full Navier-Stokes and mass transfer equations, and opens the possibility to further investigate various approaches to reduce concentration polarization.

KEYWORDS

Concentration polarization, Reduced-order model, Varying permeate flux, Reverse osmosis, Membrane

DOI: https://doi.org/10.1002/aic.16851

ACKNOWLEDGEMENT

This research is supported by University of Malaya research grant Bantuan Penyelidikan Kecil (BK021-2017) and Universiti Malaysia Pahang research grant (Project number RDU170324).