3D CFD study of hydrodynamics and mass transfer phenomena for spiral wound membrane submerged-type feed spacer with different node geometries and sizes

Y.K. Chong[b], Y.Y. Liang[a,b], W.J. Lau[c], G.A. Fimbres Weihs[d]

[a] Centre of Excellence for Advanced Research in Fluid Flow (CARIFF), Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan, Pahang, Malaysia

[b] College of Engineering, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan, Pahang, Malaysia

[c] Advanced Membrane Technology Research Center, School of Chemical and Energy Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

[d] The University of Sydney, School of Chemical and Biomolecular Engineering, NSW 2006, Australia

ABSTRACT

Modification of the spacer geometry is a promising approach to increase the efficiency of reverse osmosis (RO) spiral wound membrane modules. Column nodes and spherical nodes are considered in this three-dimensional computational fluid dynamic (CFD) study to evaluate the hydrodynamic and mass transfer performance of submerged spacers with different node geometries and sizes. Small-scale CFD analysis results reveal that the column node has better mass transfer performance than the spherical node geometry because column nodes divert more flow to the filaments, leading to higher local velocity at the region between the filament and wall. Furthermore, when the dimensionless node diameter ratio of the column nodes increases from 0.3 to 1.2, Sherwood number and wall shear increase by 25% and 8% respectively at the expense of higher global friction factor (44%). A sea water RO full-scale analysis revealed that column node spacers yield higher average flux than spherical nodes and conventional spacers at high feed inlet velocity (> 0.1 m/s), because the mixing effects by the spacer that improve mass transfer are more prominent.

KEYWORDS

Desalination; Spiral wound membrane; Modeling; CFD

ACKNOWLEDGMENTS

The authors would like to thank the Ministry of Higher Education for providing financial support under Fundamental Research Grant Scheme For Research Acculturation Of Early Career Researchers (FRGS – RACER) No. RACER/1/2019/TK02/UMP//1 (University reference RDU192603) as well as additional financial support under UMP Internal Research grant RDU190378.