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DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

CEVE Seminar Series

Concentration Polarization in a Simple Shear Flow: An Analytic Solution Approach

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Pressure-driven membrane filtration can be categorized into reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF). RO/NF can remove monovalent and multivalent ions, and UF/NF can reject macromolecules and particulate materials. While diffusion and convection of solutes are balanced on the membrane surface during filtration, the concentration of solutes being filtered is higher near the membrane surface in comparison to that in the bulk phase. This ubiquitous phenomenon of biased concentration, normal to the membrane surface, is termed concentration polarization (CP), which reduces the net driving force by promoting an osmotic pressure gradient and may further cause membrane fouling.

To date, CP phenomenon in a simple shear flow of crossflow filtration is not fully understood because of the mathematical complexity of the mass balance equation although numerical solutions can predict the performance of crossflow filtration under certain operating conditions. Previous analytic approaches include film theory, integral solution method, similarity solution method, and excess concentration method. Each approach was developed with its own assumptions and approximations, which somewhat fail to rigorously mimic the interfacial phenomenon. In this light, the present theory provides unified analytic solutions for profiles of solute concentration and permeate flux with minimal approximations at the governing equation level. Assuming that the crossflow velocity is fast enough in comparison to the permeate velocity, a unique variation of solute concentration is obtained with an axial inflection of the permeate flux. The ratio of applied pressure and feed osmotic pressure is a critical parameter that can change the permeate flux profile along the axial direction. An asymptotic behavior of permeate flux decline provides a larger exponent (in magnitude) than that from conventional theories and represents a steeper slope of the decline. A holistic understanding of CP in a simple shear flow can be provided by the analytic solution of this theory.

Bio

Dr. Albert Kim is an Associate Professor of Civil and Environmental Engineering at the University of Hawaii at Manoa. He received his Ph.D. from the University of California at Los Angeles. Dr. Kim has been awarded a National Science Foundation CAREER award and a University of Hawaii Regents' Medal for Excellence in Research.

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3:45 PM
Ryon Lab, Room 201
Refreshments will be served at 3:30 PM