Predicting optimal back-shock times in ultrafiltration hollow fiber modules II: Effect of inlet flow and concentration dependent viscosity - DTU Orbit (03/12/2018)

Predicting optimal back-shock times in ultrafiltration hollow fiber modules II: Effect of inlet flow and concentration dependent viscosity

This paper concerns mathematical modeling and computational fluid dynamics of back-shocking during hollow fibre ultrafiltration of dextran T500. In this paper we present a mathematical model based on first Principles, i.e., solving the Navier-Stokes equation along with the continuity equation for both the solute and the solvent. We investigate the validity of the estimate On the optimal back-shock time, i.e., the back-shock time needed to achieve the highest permeate flux, published in a previous paper by the authors (Vinther et al., Predicting optimal back-shock times in ultrafiltration hollow fibre membranes. J. Membr. Sci. 470 (2014) 275-293 [33]). Furthermore, the simulations have been performed with two different inlet velocities, i.e., crossflow velocities and are clone with and without a concentration dependent viscosity. This enables us, for the first time, to investigate the effect of different inlet velocities and the effect of a concentration polarization on the observed rejection and the permeate flux, as a function of different back-shock times. In all cases the average permeate flux and the observed rejection during one period of back-shocking were found to be higher than the steady-state values - representing the long time behavior of a similar separation process performed without back-shocking - when using the optimal back-shock time. It is concluded that the estimate of the optimal back-shock time is in good agreement with the optimal time found in the simulations performed in this paper. Furthermore, it is found that the optimal back-shock time increases when the viscosity is allowed to depend on the concentration. It is found that this can be explained by a decrease in the velocity tangential to the membrane due to the increase in viscosity where the concentration is high - resulting in a longer time for the concentration polarization to be convected tangentially along the membrane surface. The ratio between the average flux over a back-shock cycle and the steady-state flux is found to increase with increasing inlet velocity. Furthermore, this ratio increases when the viscosity depends on the concentration. This is due to the relatively lower steady-state value when the viscosity depends on the concentration. Moreover, an increase in observed rejection is found when using back-shocking. The increase in observed rejection is found to be largest when the inlet velocity is high and the viscosity depends on the concentration. (C) 2015 Elsevier B.V. All rights reserved.

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