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Pressure driven flow in porous tubular membranes NILS TILTON, University of Maryland, DENIS MARTINAND, ERIC SERRE, University of Aix-Marseille, RICHARD LUEPTOW, Northwestern University — We consider the steady laminar flow of a Newtonian incompressible fluid in a porous tubular membrane with pressure-driven transmembrane flow. Due to its fundamental importance to membrane filtration systems, this flow has been studied extensively both analytically and numerically, yet a robust analytic solution has not been found. The problem is challenging due to the coupling between the transmembrane pressure and velocity with the simultaneous coupling between the axial pressure gradient and the axial velocity. We present a robust analytical solution which incorporates Darcy's law on the membrane surface. The solution is in the form of an asymptotic expansion about a small parameter related to the membrane permeability. We verify the analytical solution with comparison to 2-D spectral direct numerical simulations of ultrafiltration and microfiltration systems with typical operating conditions, as well as extreme cases of cross-flow reversal and axial flow exhaustion. In all cases, the agreement between the analytical and numerical results is excellent. Finally, we use the analytical and numerical results to provide guidelines about when common simplifying assumptions about the permeate flow may be made. Specifically, the assumptions of a parabolic axial velocity profile and uniform transmembrane velocity are valid only for small permeabilities.

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