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3D-printed rotating spinnerets create membranes with a twist

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Abstract

Round hollow fiber membranes have been well established in applications such as gas separation, ultrafiltration and blood dialysis. Yet, it is well known that geometrical topologies can introduce secondary flow patterns counteracting mass transport limitations, stemming from diffusion resistances and fouling. We present a new systematic methodology to fabricate novel membrane architectures. We use the freedom of design by 3D-printing spinnerets, having multiple bore channels of any geometry. First, such spinnerets are stationary to fabricate straight bore channels inside a monolithic membrane. Second, in an even more complex design, a new mechanical system enables rotating the spinneret. Such rotating multibore spinnerets enable (A) the preparation of twisted channels inside a porous monolithic membrane as well as (B) a helical twist of the outside geometry. The spun material systems comprise classical polymer solutions as well as metal-polymer slurries resulting in solid porous metallic monolithic membrane after thermal post-processing. It is known that twisted spiral-type bore channel geometries are potentially superior to straight channels with respect to mass and heat polarization phenomena, however their fabrication was cumbersome in the past. Now, the described methodology enables membrane fabrication to tailor the membrane geometry to the needs of the membrane process. To showcase the delicate interplay between the geometry and radial and axial flow conditions, we report fluid mechanical simulations and flow magnetic resonance imaging measurements for a twisted tri-bore membrane during permeation.

Keywords: Additive manufacturing, Spinneret design, Twisted hollow fiber membrane, Helical membrane, Multibore

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