Improvement of membrane distillation performance with 3D printed spacer containing carbon nanotubes

Seongeom Jeong[a], Sanghyun Jeong[a,] *

[a] School of Civil and Environmental Engineering, Pusan National University, Busan 46241, South Korea

*Corresponding author: sh.jeong@pusan.ac.kr, +82-(0)51-510-2895

Abstract:

Membrane distillation (MD) is one of desalination processes using hydrophobic membrane. In this process, the membrane is a barrier between liquid and vapor, which is generated the temperature difference between hot and cool water. The MD process was transferred heat and mass through the membrane, so it is sensitive to polarization effects including both temperature and concentration polarizations. In this study, we used the feed spacers to loosen the polarization effects. The feed spacer in MD process acts as turbulence promoters suppressing the temperature and concentration boundary layer near the membrane surface. We made a spacer using 3D printer and optimized feed spacer design to 45° crossing angles and 4 mm arrangement interval of spacer filaments, and 1.0 mm thickness of spacer. Membrane performance improvement tests were conducted using a variety of materials including carbon nanotubes, graphene, and magnesium peroxide. Only carbon nanotubes were able to inhibit concentration polarization significantly. In addition, the carbon nanotubes spacer was maintained membrane hydrophobicity of 88% even after 12 h of the MD operation in the 1900 ppm of calcium sulfate treatment (the virgin membrane was 32% and the commercial spacer was 67%). The virgin membrane and commercial spacer showed a significant flux drop even at volume concentration factor (VCF) 2.0 and 2.5, respectively, while the carbon nanotubes spacer maintained the flux (20 L/m^2h) at VCF 5 and disrupted the flux drop considerably. A real-time monitoring of scaling on the membrane proved that scaling was hardly formed on the membrane even at VCF 5.0 when using carbon nanotubes spacer (the virgin membrane and commercial spacer were densely scaled on the membrane at VCF 2.0 and 3.0, respectively). Therefore, the carbon nanotubes spacer could improve the MD performance, and inhibit the formation of scaling on the membrane by reducing the concentration polarization.

Keywords: 3D printer, Carbon nanotubes, Membrane distillation, Membrane scaling, Spacer