The evolving role of feed spacer in membrane systems – from passive bystander to active participant

Sreedhar Nurshaun[1], Thomas Navya[2], Kumar Mahendra[1], **Hassan A. Arafat**[1]*

1. Center for Membrane and Advanced Water Technology, Khalifa University, Abu Dhabi, UAE
2. Cranfield Water Science Institute, Cranfield University, Bedfordshire MK43 0AL, UK

* *hassan.arafat@ku.ac.ae*

Abstract

Feed spacers have undergone a significant evolution over the past decade, beyond their initial deployment as simple place-holders and turbulence promoters in the feed channel. Recently, the wide potential of enhancing spacer design has become evident. The crucial role played by spacers in the initial development of various kinds of membrane fouling has been a critical factor in driving the development of novel spacers as a tool to minimize fouling. In parallel, the urgent need to suppress concentration polarization and to reduce energy costs and carbon footprint of membrane processes, particularly desalination, has propelled the development and fabrication of progressively complex spacer designs. These spacers, which trigger a higher membrane's mass transfer capacity, will also be necessary to fully harness the potential of the next generation of ultra-high permeability membranes. 3D printing has helped in accelerating this process, as spacer design modifications for increased turbulence and minimal fouling have become a prominent avenue of spacer research. The surface chemistry of spacers has been modified as well, as researchers look to minimize the attachment of bacteria and scalants on the spacer surface to protect the membrane. As we transition into the next phase of spacer research, the development of functionalized spacers is gaining popularity, as membranologists increasingly consider feed spacers as a target for innovative coatings that can perform an active role in the feed channel for a variety of applications, such as photocatalysis in water treatment and wetting mitigation in membrane distillation. The maturing of smart materials and 4D printing is also expected to further drive spacer research in this direction, as highly targeted shape memory alloys can potentially be used for specific functions such as membrane cleaning, pressure reduction and fouling mitigation.

Keywords: feed spacer; desalination; functional spacers; surface chemistry; 3D printing; fouling;