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Visualizing Hydrated Polymeric Membranes Using X-Ray Microscopy

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Membrane separations are used in a variety of applications with water treatment technologies being one of the most notable ones. For a number of these technologies, like nanofiltration, reverse osmosis, forward osmosis, membrane bioreactors and electrodialysis, the membranes used are polymeric materials. In all of these applications the pore structure of the membrane influences its performance, and especially in forward osmosis, the influence is significant. Different types of polymers, both hydrophilic and hydrophobic, are used to make these membranes and the membrane structure can vary based on the polymer's interaction with water and other ionic solutions in contact with it. Thus there have been several studies on characterizing the structures of polymeric membranes in an effort to correlate it to their performance. A majority of these studies characterized the membranes in their dry state. The working state of the membranes, however, is in the hydrated state and there can be significant differences in the structure of the membrane in the wet vs. dry state [1]. In this study, we have characterized polymeric membranes in their hydrated state to see how effectively the pore structure is wetted out with water and to ultimately determine water connectivity in the pores to see how the membrane pore structure contributes to water transport. The technique used in this study was x-ray microscopy (XRM) and we have previously used it extensively to characterize polymeric materials in their dry state [2, 3]. The images have been used, in addition to calculate % water saturation (to determine % wetted porosity) and water connectivity, to also see if there are any changes to the polymeric structure as a result of swelling/de-swelling behaviors. This study is, according to the best of our knowledge of the literature in this field, the only work where hydrated polymeric membranes have been characterized for the metrics listed above. The findings from this work can benefit researchers in membrane separations to better understand the behavior and performance of polymeric membranes.

References

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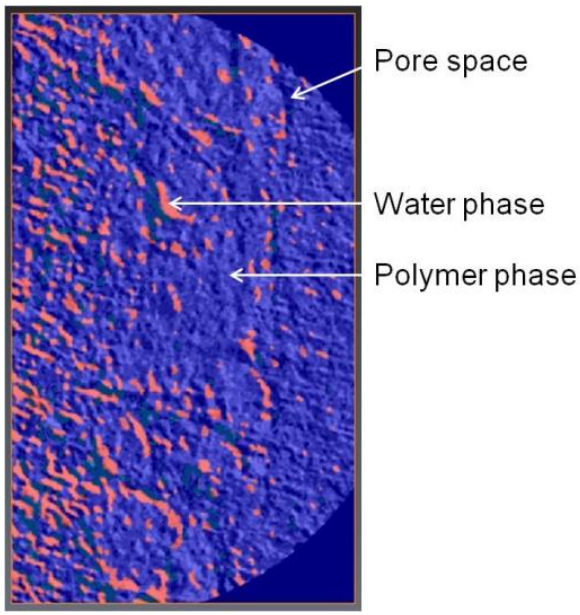

Fig.1. Reconstructed 3D XRM images of a hydrated nylon microfiltration membrane from 3M showing the presence of water in the pores of the membrane. The pore, water and polymer phases are marked on the image. Image analysis was performed using Avizo™Fire.

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