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PII: S0376-7388(17)31525-9
DOI: http://dx.doi.org/10.1016/j.memsci.2017.08.028
Reference: MEMSCI15494

To appear in: *Journal of Membrane Science*

Received date: 30 May 2017
Revised date: 8 August 2017
Accepted date: 9 August 2017

Cite this article as: Sarah M. Dischinger, James Rosenblum, Richard D. Noble, Douglas L. Gin and Karl G. Linden, Application of a Lyotropic Liquid Crystal Nanofiltration Membrane for Hydraulic Fracturing Flowback Water: Selectivity and Implications for Treatment, *Journal of Membrane Science,* http://dx.doi.org/10.1016/j.memsci.2017.08.028

Application of a Lyotropic Liquid Crystal Nanofiltration Membrane for Hydraulic Fracturing Flowback Water: Selectivity and Implications for Treatment

Sarah M. Dischinger[a1], *James Rosenblum*[b1], *Richard D. Noble*[a], *Douglas L. Gin*[a,c], *Karl G. Linden*[b*]

[a]Department of Chemical and Biological Engineering

[b]Department of Civil, Environmental, and Architectural Engineering, and

[c]Department of Chemistry and Biochemistry, University of Colorado, Boulder, CO 80309, USA

sarah.dischinger@colorado.edu

james.rosenblum@colorado.edu

richard.noble@colorado.edu

douglas.gin@colorado.edu

karl.linden@colorado.edu

[*]Corresponding Author

Abstract

A thin-film composite, bicontinuous cubic lyotropic liquid crystal polymer (TFC Q_I) membrane with uniform-size ionic nanopores was studied for the treatment of hydraulic fracturing flowback water. The TFC Q_I membrane performance was compared to those of a commercial nanofiltration (NF) membrane (NF270) and a commercial reverse osmosis (RO) membrane (SW30HR) for the filtration of flowback water from the Denver-Julesburg Basin. The permeability, salt rejection, and organic solute rejection for each membrane was evaluated. The results obtained illustrate that the TFC Q_I membrane maintained its performance to a similar degree as the commercial NF and RO membranes while demonstrating a unique selectivity not observed in the commercial membranes. Specifically, the TFC Q_I membrane rejected 75% of the salt while recovering 9.6% of the dissolved organic carbon (DOC) and 50% of the water. Of particular interest was the recovery of labile DOC, which was assessed through biodegradation experiments. Analysis following biodegradation of the TFC Q_I membrane permeate demonstrates the membrane's ability to recover labile DOC in a reduced-saline permeate. Improved recovery of labile DOC (increased to 22%) was demonstrated by reducing the pH of the flowback water. Therefore, the selectivity of the TFC Q_I membrane provides an opportunity to recover resources from hydraulic fracturing flowback.

Graphical abstract

[1] Both S. Dischinger and J. Rosenblum are first authors and contributed equally to this work.