298d A Novel Evaluation and Characterization Technique for Solvent Resistant Nanofiltration (Srnf) and Reverse Osmosis (Srro) Membranes

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Abstract

The need to develop a reproducible and effective technique for evaluating and characterizing Solvent-Resistant NanoFiltration (SRNF) and Reverse Osmosis (SRRO) Membranes is pertinent for their proper selection and application. SRNF and SRRO membranes are of particular utility in the biochemical, petrochemical, commodity chemicals, and pharmaceutical industries. However, most of SRNF and SRRO membranes that are made from polymer have limited stability in harsh chemical environments involving polar aprotic solvents that can swell or dissolve the polymers used in these membranes. This paper describes a protocol for assessing and selecting SRNF and SRRO membranes for a particular task. The procedure involves the following steps: (1) swelling (shrinkage) and compaction tests, from which both the chemical and pressure compatibility of the membrane are obtained; (2) membrane performance tests to obtain the apparent rejection, separation factor, and relative recoveries of solute and solvent; and (3) application of an irreversible thermodynamics model to obtain generalized performance parameter comprising the hydraulic permeability, reflection coefficient, solute permeability and intrinsic rejection. Membrane swelling and/or compaction characterization is done using Ultrasonic Time-Domain Reflectometry (UTDR) in conjunction with a high pressure permeation cell flow loop especially designed to accommodate polar aprotic solvents. Commercial grade SRNF membranes, the STARMEM-122 (MWCO ~ 220 Daltons) and MPF-44 (MWCO ~250 Daltons), were used in this study. Mixtures of dimethyl formamide (DMF) (99.97 % ACS reagent grade) and deionized water (18.2 M Ohms conductivity) were used as the solvents while leucine (MW~353.4) was used as the solute. Preliminary results revealed that the STARMEM-122 swelled by 1.14 % and 5.2 % based on the initial thickness for 25 wt % and for 75 wt % aqueous DMF, respectively for a 24-hour exposure. In contrast the MPF-44 shrank by 5.28 % and 6.35 % based on the initial thickness for 10 wt % and 50 wt % aqueous DMF, respectively, for 24 and 10 hours exposure, respectively. MPF-44 membranes exposed to concentrated aqueous DMF solution exhibited gradual color change to blue which suggested possible degradation. The membrane inelastic deformation and percent compaction of the virgin STARMEM-122 membrane were found to 48.14+/-6.63 micron and 46.4+/- 6.0 %, respectively, when subjected to 2.75 MPa (400 psi) maximum for 30 minutes. The Young's modulus, deformation stress and strain for the virgin STARMEM-122 membrane were found to be 1.46 0.09 MPa (212.00+/-12.90 psi), 144.44+/-9.60 kPa (20.94+/-1.39 psi), and 0.0987+/-0.0012, respectively. These preliminary results suggest STARMEM-122 membrane can be used on NF application involving polar aprotic solvents such as concentrated aqueous DMF. The results also demonstrate an effective protocol for assessing SRNF and SRRO membrane performances.