EXTENSION OF NANOCOMPOSITE TECHNOLOGY TO LOW PRESSURE MEMBRANE APPLICATIONS

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Summary

Originally commercialized for use in seawater applications, thin-film nanocomposite (TFN) membrane technology has recently been extended for use in low pressure reverse osmosis (RO) applications. This paper presents data demonstrating how the application of TFN RO membrane technology can lead to improvements in the permeability, selectivity and fouling resistance of low pressure RO membranes; and how those improvements influence low pressure system performance. In particular, low fouling TFN membranes are examined in seawater and low salinity water to demonstrate how alterations in membrane structure (charge, hydrophilicity, roughness) can result in improved system performance.

I. INTRODUCTION

Over the past several years, TFN membrane technology has demonstrated improved permeability and selectivity in seawater desalination applications leading to reduced energy consumption and increased plant productivity [1]. However, TFN technology was originally conceived not as a means to alter flux/selectivity, but rather as a method to change surface properties related to fouling. Further, the change in these surface properties was originally demonstrated in brackish water RO (BWRO) membranes, not in seawater RO (SWRO) membranes. In the original paper describing TFN RO membranes and the inclusion of zeolite Linde Type A (LTA), nanoparticles were found to increase hydrophilicity and negative surface charge, decrease surface roughness and improve permeability [2].

TFN membrane technology has been commercially introduced under the *Quantum*Flux trade name within the SWRO membrane market. However, work continues to extend this technology into other water treatment applications such as brackish water, industrial effluent and process streams, wastewater and groundwater. Enhanced permeability and selectivity are the primary features of the *Quantum*Flux SWRO product line. Additionally, several lab and field examples have shown promising improvements in flux stability. Such improvements to fouling resistance are widely considered to be critical for broader applications of RO membrane technology in low salinity waters and to improve established applications [3].

II. MATERIALS AND METHODS

2.1 Flat Sheet Fouling Tests

Testing of flat sheet membranes was performed on stainless steel cells with an active area of 20 cm^2 (3 in^2). Test benches were configured with two parallel sets of three cells in series. Fouling resistance was determined by the addition of sodium alginate feed (60 ppm) with calcium chloride (400 ppm) in a sodium chloride (32,000 ppm) solution. Membrane samples (three each) were made either with (labeled nanocomposite in Figure 1) or without added nanoparticles (labeled control in Figure 1) and allowed to run at 55 bar for 47 hours. Fabrication described in [2].

2.2 Module Construction

Nanocomposite BWRO and SWRO membranes, each measuring one meter (3.2 ft) wide, were produced on a continuous production machine and rolled into spiral-wound modules [20 cm x 1 m (3 in x 3.2 ft)]. These modules contained 37.2 m^2 (400 ft^2) of active area and used a 28 mil (0.71 mm) diamond feed spacer.

2.3 SWRO Module Testing

Performance was measured in an installation at the U.S. Navy Seawater Desalination Test Facility (SDTF) at Port Hueneme, California, USA. Feed water enters through an open ocean intake and is treated with a single stage media filter and 5 micron cartridge filter. To correct for daily changes in feed salinity, temperature and pressure, flux was normalized to a standard net driving pressure at 25° C (77° F) and 32,000 ppm according to established equations [4].

2.4 BWRO Module Testing:

BWRO testing is currently underway at several sites (an industrial waste stream, an industrial process stream, and a second pass SWRO site). Data will be forthcoming.

III. RESULTS AND DISCUSSION

3.1 Flat Sheet Fouling Tests

The resulting flux was normalized relative to one-hour values and is shown in Figure 1 below. Both membranes had approximately the same initial permeability (control = 52 LMH, nanocomposite = 54 LMH).

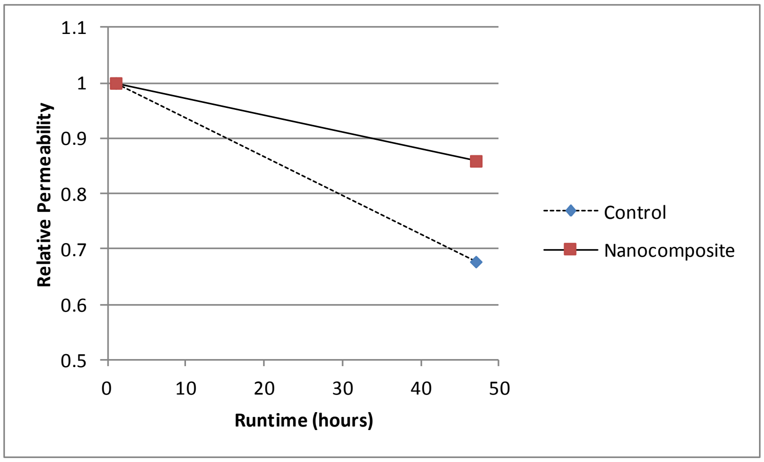

Figure 1: **Flat Sheet Fouling Test**

As shown above, the performance stability was improved by the addition of nanoparticles to the nanocomposite. While the control sample lost 32% of its permeability, the TFN membrane lost only 14% over the same time period and operational conditions.

3.2 SWRO Module Testing

During the course of the two week-long red tide event (2500-hour mark in Figure 2), the membrane permeability dropped 14.3%, a modest decline for the severity of the fouling event (SDI up to 6) and particle count (up to 30,000). A subsequent CIP [one hour of NaOH (pH 12) followed by two hours of pH 2 (citric acid)] led to a 95% recovery in permeability. The remarkably successful CIP suggests a low adhesive interaction between the deposited foulants and the membrane surface.

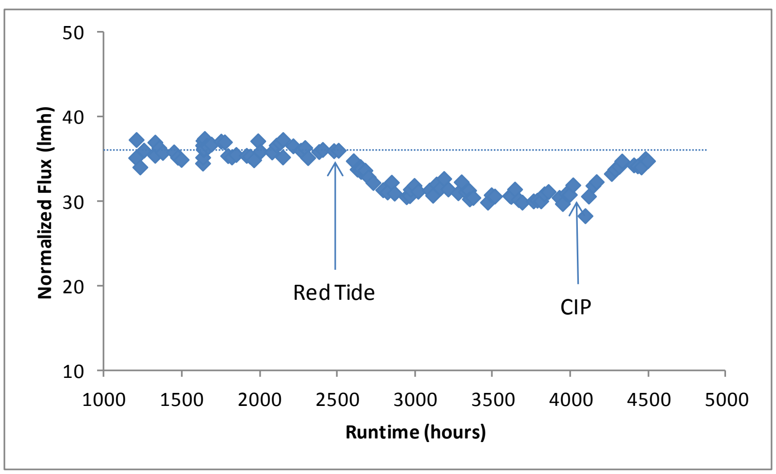

Figure 2: Flux loss experienced because of red tide and recovered flux after CIP

3.3 BWRO Module Testing

Results forthcoming.

IV. DISCUSSION

Discussion forthcoming.

V. CONCLUSIONS

In both seawater and low salinity water, fouling adds to the cost of water treatment through increased energy consumption, increased chemical usage and increased capital costs due to enhanced pretreatments and increased active area (to drop average flux). Although no technology will be uniformly low fouling, TFN membrane technology can, in some instances, decrease the effect of fouling on system level performance. This may result in increased flow over time, leading to either increased system production (or decreased system size) or reduced chemical costs and system downtime resulting from improved cleanability.

VI. REFERENCES

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