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Prevention and management of silica scaling in membrane distillation using pH adjustment

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Abstract

Membrane scaling by silica is a major challenge in desalination, particularly for inland desalination of brackish groundwater or geothermal resources, which often contain high concentrations of silica and dissolved solids. Adjustment of feed pH may reduce silica scaling risk, which is important for inland facilities that operate at high water recoveries to reduce brine disposal costs. However, water recovery of reverse osmosis is also limited due to increased osmotic pressure with feed water concentration. Membrane distillation (MD) is a thermally driven membrane desalination technique that is not limited by increased osmotic pressure of the feed. In this investigation, pH adjustment was tested as a strategy to reduce silica scaling risk in the MD process. With feed water pH less than 5 or higher than 10, scaling impacts were negligible at silica concentrations up to 600 mg/L. Scaling rates were highest at neutral pH between 6 and 8. Cleaning strategies were also explored to remove silica scale from membranes. Cleaning using NaOH solutions at pH higher than 11 to induce dissolution of silica scale was effective at temporarily restoring performance; however, some silica remained on membrane surfaces and scaling upon re-exposure to supersaturated silica concentrations occurred faster than with new membranes.

Keywords

membrane distillation; membrane scaling; membrane fouling; membrane cleaning; silica

1. Introduction

Control and mitigation of silica scaling on membranes is a challenging problem in the treatment of impaired waters requiring desalination. Silica is present in most natural water resources, it has low solubility, and when concentrated beyond its solubility limit of approximately 120 mg/L [1], precipitation may occur and form a hard scale that is extremely difficult to remove. Silica scaling on heat exchanger surfaces in thermal desalination processes increases thermal resistance, which reduces process efficiency and requires costly chemical and mechanical cleaning. In membrane processes such as reverse osmosis (RO) or nanofiltration (NF), silica scaling reduces water flux [2-5], and is resistant to simple cleaning methods used to manage other types of mineral scaling such as acid washing. The