Optimization of gold nanoparticle-plasmonic membrane fabrication for membrane distillation process

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Abstract:

Membrane distillation (MD) process is being widely applied to desalination and wastewater treatment because of its several advantages: lower operating pressure, less membrane fouling and low-grade energy utilization. Although MD process requires low-grade energy comparing with other desalination processes, it still needs high energy consumption for heating the feed solution. In addition, temperature polarization (TP) on membrane reduces the MD performance. Hence, plasmonic membrane distillation (PMD) processes using plasmonic materials are being recently studied to overcome the limitation of conventional MD processes. The plasmonic materials are light to heat converting materials and absorb radiation at specific wavelength and then cause temperature rising. Among these materials, gold nanoparticles (GNP) are emerging material as high efficiency energy harvesting, chemically stability, scattering and absorption wavelength in visible region. Moreover, GNP has various optical and thermal properties depending on size. In this study, GNP as a plasmonic material selected to overcome TP as well as membrane fouling of conventional MD processes. Then, plasmonic effect of GNP size (20-60 nm) was evaluated. The fabrication condition for GNP embedded membrane was optimized and performance of PMD processes was investigated. Under optimal fabrication conditions for GNP-plasmonic membrane, performance of PMD process was evaluated in terms of permeate fluxes and rejection efficiencies. Furthermore, the effect of organic fouling mitigation in the PMD processes was evaluated by organic characterization and membrane surface analysis. The permeate flux was increased about ~40% by rising temperature of GNP-plasmonic membrane surface compared with conventional MD processes. Moreover, membrane organic fouling was effectively controlled by plasmonic effect of GNP. Therefore, PMD process is a promising strategy to reduce energy consumption and membrane fouling in the MD operation.

Keywords: Gold nanoparticle, Plasmonic membrane, Temperature polarization, Membrane fouling, Membrane distillation