Effects of channel spacers on direct contact membrane distillation

Yanbin Yuna,∗, Jianxin Wanga, Runyu Ma pamphlet, Anthony Gordon Fanec

aCollege of Environmental Science & Engineering, Beijing Forestry University, Beijing 100083, P.R. China
Tel. +86-13241730890; email: y.yanbin@unsw.edu.au
bCollege of Chemical Engineering, Beijing University of Chemical Technology, Beijing 100029, P.R. China
cSchool of Chemical Engineering, University of New South Wales, Sydney NSW, 2052, Australia

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ABSTRACT

The effects of spacers on flux enhancement of direct contact membrane distillation (DCMD) had been studied for high concentration NaCl aqueous solution. For DCMD experiments, spacers were filled in different channels of the module. The effects of spacers on temperature polarization and concentration polarization were demonstrated. By contrasting different modes of spacers filling channels, it was found that: (1) the coarse spacer enhanced fluxes up to 30% and heat transfer coefficients by approximately two times over the empty channels; (2) the effect of spacer filled in the hot-side channel on the flux was much bigger than that in the cool-side; (3) The sequence of the spacers effects on flux was: coarse spacer > fine spacer > without spacer.

Keywords: Direct contact membrane distillation; Spacer; Heat transfer; High concentration; NaCl solution; Mass transfer

1. Introduction

Membrane distillation (MD), a relatively new process, is an evaporation process of feeding volatile components through porous hydrophobic membrane. Compared with conventional desalination processes, e.g., reverse osmosis, distillation and flash evaporation, the main advantages of MD are: (1) production of a high purity distillate; (2) no limitations caused by osmotic pressure effects; (3) lower operation temperatures; (4) lower operation pressures; (5) lower membrane mechanical intensity demand; (6) lower energy expenditure; (7) no corrosion problems by using plastic equipments.

As a member of MD, the direct contact membrane distillation (DCMD) has liquid phases in direct contact with both sides of the hydrophobic membrane, which shows simple configuration and high permeate and is best suited for applications in which the major permeate component is water, such as desalination or concentration of aqueous solutions [1,2]. The heat and mass transfer mechanisms have been studied widely for low concentration solutions [3]. For high concentration (or close to equilibrium saturation), the complexity may be caused by changes in many operating parameters, such as: decrease of feed vapor pressure, increase of feed viscosity and so on, which lead to evaporation efficiency decrease. Moreover, temperature polarization and concentration polarization may become more severe. Attempts to reduce these effects have been made by improving the flow characteristics, i.e., enhancing flow rates or turbulent flow conditions. However, larger energy consumption by pumps is not appealing in economic viewpoint. An alternative method to use spacers has been proposed [4], which reduces concentration polarization and temperature polarization without increasing flow rates. For spiral ultrafiltration (UF) module and spiral reverse osmosis (RO) module, spacers or turbulence promoters are put into flow channels to promote wakes and eddy in laminar flow. Hence, mass transfer is enhanced. On average, feed channel spacers

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