Influence of feed and draw solution concentrations on the performance of desalination process using forward osmosis (FO)

Razieh Ahmadizadeh, Soheila Shokrollahzadeh*, Seyed Mahdi Latifi
Department of Chemical Technologies, Iranian Research Organization for Science and Technology (IROST),Tehran, Iran
*corresponding author: shokrollahzadeh@irost.org, telephone number: +98 2156276624

ABSTRACT

Forward osmosis (FO) is a novel membrane separation process that potentially can be used as an energy-saving alternative to conventional membrane processes. In this work, to investigate the feed salinity effect on the desalination by employing FO process, the feeds with various salinity were prepared. The results indicated that increasing salinity from 0 to 30 g/l NaCl (draw solution: 1M) and 15 to 30 g/l NaCl (draw solution: 2M) results in about 60 and 18% water flux decrease, respectively. In addition, the difference between theoretical and experimental obtained flux decreases by increasing feed salinity. Also, the increasing of draw solution concentration from 1M to 2M leads to a distinct increase in this diffrentce. This phenomenon confirms the prevailing influence of internal concentration polarization (ICP) in the process.

Keywords: desalination, Forward osmosis (FO), internal concentration polarization

1. INTRODUCTION

The world population growth has increased exponentially in recent years. In the face of this enormous population growth, one of the most critical concerns is to meet the increasing demand for potable water at low-energy cost. Also in many regions where surface water and groundwater is not sufficient and available (especially in coastal areas), Freshwater scarcity is more severe. As a result, technologies of seawater or brackish water desalination and impaired sources reclamation have the potential to produce high-quality water for both industrial and domestic usage [1, 2]. But it must be noted that the most desalination methods for production of clean water are still energy-intensive and, therefore, the development of a low-energy process for this purpose is essential. At the present time, membrane technologies have widely applied to produce freshwater from alternative water resources and from among them, high-pressure reverse osmosis (RO) is the most common technology used for desalination. Although RO process uses up considerably less energy compared to previous decades, it is still an energy-intensive process due to high hydraulic pressure utilization [3].

One of the main obstacles of employing RO process is membrane fouling which extremely can cause flux decline in long-term performance. In this situation, the system may require raising hydraulic pressure or sometimes may need intensive chemical cleaning or membrane replacement. These mean that the operational costs will increase. On the other hand, due to present highly concentrated organic and inorganic compounds in RO concentrated brines, the management of this saline water discharge is a consequential environmental problem. Therefore, in the last decade, there are very interests in the investigation of other new and affordable technologies, which are capable of reclaiming high-quality water from saline and impaired sources (sea and wastewater) and as well providing low energy cost compared to the RO desalination [3,4].

The forward osmosis (FO) process has emerged as novel membrane technology for generation of freshwater that can be applied in processes such as desalination [5], wastewater treatment [6], power generation [7], food processing [8] and concentration or dilution of RO brine [9]. This process employs the osmosis phenomenon for the water transport from a saline feed solution (with low osmotic pressure) to a greater concentrated solution as draw solution (with high osmotic pressure) across a semi-permeable membrane and not requires any external hydraulic pressure [10].

Recently, several review papers explained extensive account of advantages and disadvantages of forward osmosis process. The comprehensive applications of FO especially in comparison to RO process are due to its two significant advantages: lower energy consumption and lower fouling propensity. In fact, the absence of hydraulic pressure in the FO process has resulted in minimal irreversible fouling and lower operating costs [11, 12].