MEMBRANE CONTACTORS IN INTEGRATED SYSTEMS

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ABSTRACT

In the present work, results of simulation studies carried out for the water carbonation process are presented and compared with experimental data obtained for the same system. Furthermore, the use of membrane contactors in integrated membrane operations is proposed and discussed as a mean to enhance the performance of processes.

INTRODUCTION

Membrane contactors are new systems in which microporous hydrophobic membranes are used to promote the mass transfer between phases. Being the membranes hydrophobic, the aqueous solutions don't go through pores and the mass transfer occurs at the pores entrance.

Todate, several have been the studies carried out with these systems like liquids degassing (e.g. water deoxygenation for ultrapure water production), adding gases into liquids (e.g. water ozonation), liquid-liquid extractions, CO_2 removal from fuel gases etc. that evidenced their potentialities in terms of higher surface areas and better mass transfer coefficients with respect to conventional systems. The possibility to rationalise industrial productions with integrated membrane systems is also attractive. For example, a hybrid plant where UF/RO and OD are integrated has been realized in Melbourne (Australia) for the concentration of grape juice [1]. It consists of UF and RO pretreatment stages, an OD unit and a single-stage brine evaporator. This plant concentrates fresh juices up to 65-70 °Brix. Some interesting results obtained by using membrane contactors also in integrated membrane processes are now presented and discussed.

RESULTS AND DISCUSSION

The potentialities of membrane contactors have been tested for water carbonation [2] and for increasing the recovery factor in desalination processes [3].

In the first case, a hollow fiber membrane contactor has been used to promote the gas-liquid transfer during the experimental tests. The CO2 flowed in the lumen side while the water was fed in the shell side and flowed perpendicularly to them. Several parameters have been analysed in order to determine the best operating conditions. By working at the right ones, it has been possible to produce an over-saturated water. In particular, the highest degree of carbonation (11 g/l) has been reached at PCO2=2.4 atm; T=6°C; Pwater=2.9 atm; Qwater=92 ml/min; QCO2= 315 ml/min. The performance of this system has been also theoretically analysed. A mathematical expression in which the mass transport of CO2 through the membrane pores is function of the temperature, water and CO2 flow rate, CO2 pressure, trans-membrane pressure, has been derived for the experimental system used. The correlation found to predict the mass transfer coefficient refers to the liquid phase, the resistance to the transport at the gas phase assumed negligible. The parameters which are in the correlation have been determined on the basis of the experimental results. From this expression, it has been possible to determine the CO2 concentration into the water for several operating conditions. Preliminary data show an interesting agreement with the experimental results as it is reported in Table1.

Table 1. Comparison between experimental and theoretical results.
Operating conditions: T= 17°C, Pwater = 1.1 atm; Pgas =1 atm.

QH_2O (ml/min)	QCO_2 (ml/min)	C_{CO2} (g/l) exp.	C_{CO2} (g/l) theor.
92	88.2	1.3	1.3
	211	1.73	1.79
	315	1.83	1.94
180	88.2	0.887	0.885
	211	1.6	1.7
378	211	1.03	0.9
	315	1.1	1.11

For the desalination process, the membrane contactor device has been used to carry out the membrane distillation of a RO brine (75 g/l). By feeding in a countercurrent flow mode the distillate (T=15°C) and the brine (T=35°C) a MD brine of 320 g/l (saturation value) has been reached. The recovery factor of the MD unit was of 77%.

From the studies made, membrane contactors seem to offer interesting potentialities. Their integration in several processes could lead to an improve of the performance of the overall system. For example, in seawater desalination, by using a MD unit operating on the RO brine, it is possible to obtain higher recovery factors (87%) with respect to the RO unit alone (40%). (see Fig. 1). This means lower brine production with consequent reduction of the environmental impact (brine disposal or treatment) and more pure water achievable. Membrane contactors can be used also for the pre-treatment step of the desalination operation. The presence of a membrane contactor unit before the RO one could serve, for example, for the elimination of the gases into the water to be treated or for the ozonation for water disinfection (see Fig. 2).

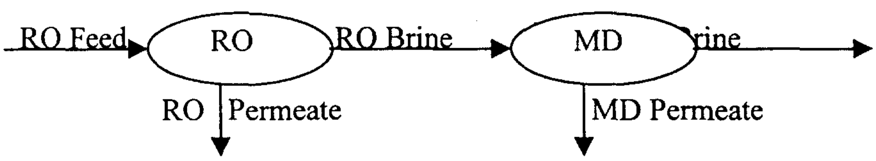

Fig. 1. Reverse osmosis/Membrane distillation integrated flow sheet

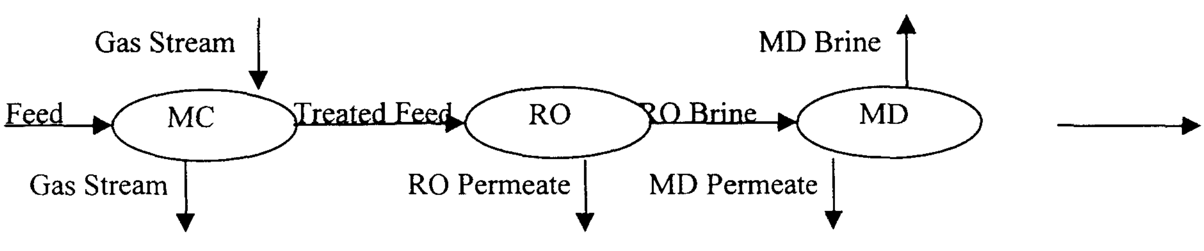

Fig. 2. Membrane contactor/Reverse osmosis/Membrane distillation integrated flow sheet

CONCLUSIONS

The use of integrated membrane systems might help in the optimization of several processes of industrial interest. An intelligent combination of the several membrane units, lead, in fact, to the rationalisation of the industrial productions.

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