Long-term effects of chemical cleaning in the performance of ultrafiltration ceramic membranes

José E. Zapata-Montoya\textsuperscript{a}, Emilia M. Guadix\textsuperscript{b}\textsuperscript{*}, Antonio Guadix\textsuperscript{b}

\textsuperscript{a}Facultad de Química Farmacéutica, Universidad de Antioquia, Medellín, Colombia
\textsuperscript{b}Department of Chemical Engineering, University of Granada, Granada, Spain

email: eguadix@ugr.es

Received 25 October 2005; accepted 6 March 2006

1. Introduction

Ceramic membranes are more and more employed in the chemical and food industries when compared with organic membranes due to their resistance to extreme operating and cleaning conditions, which allows extended service lifetimes. An important research effort has been made in the last years on the design and optimisation of cleaning protocols in order to regenerate the ceramic membranes after the filtration of a wide number of materials (see, for instance [1]). However, studies about the effects in the long term of repeated operation and cleaning cycles on the performance of the membranes are scarce in the literature [2].

The aim of this work was to assess the evolution of a ceramic membrane employed in the ultrafiltration of milk in terms of permeate flux and transmission of protein. This process was selected since milk ultrafiltration is an important application in dairy technology.

2. Experimental

The ceramic module employed in this research was a 50 kDa tubular membrane from Tami (France) with a filtration area of 94 cm\textsuperscript{2}. A number of operational cycles (\(n = 50\)) were carried out. Each cycle comprised the following stages (Fig. 1):

- Milk ultrafiltration: Skim milk was ultrafiltered in the total recycle mode for 2 h at 50°C and at a transmembrane pressure of 150 kPa. The time evolution of permeate flux and protein transmission was monitored.
- Alkaline cleaning: A solution of 20 g/L \(\text{NaOH} + 2\) g/L SDS was recycled for 2 h at 50°C and 150 kPa.
- Acid cleaning: A solution of 0.3\% \(\text{HNO}_3\) was recycled for 15 min at 50°C and 150 kPa.

After appropriate water rinse, membrane resistances were evaluated at the end of each stage as the slope of the straight line that fits data of transmembrane pressure against water permeate flux.

3. Results and discussion

The evolution of both the initial and final milk permeate flux along the 50 cycles performed is represented in Fig. 2. It can be seen that the initial milk flux decreases slightly in the first 25 cycles and remains practically constant.
from then on. On the other hand, no significant differences are observed in the final milk flux during the whole 50 cycles.

Both initial and final protein transmission (Fig. 3) did not suffer important changes along the cycles, although final transmission values are always greater than the corresponding initial ones.

The membrane resistances after alkaline ($R_2$) and acid ($R_3$) cleaning steps are shown in Fig. 4. The values of $R_2$ are one order of magnitude lower than those obtained just after milk ultrafiltration ($R_1 = 2.5$ kPa/(L/m$^2$ h)), which are approximately constant in the 50 cycles. On the other hand, a further reduction in membrane resistance around 10% is achieved as a consequence of the acid cleaning. It can be seen, that the membrane resistances increase in the first operating cycles and do not show a clear trend in the last ones,
which could be related with the formation of irreversible fouling until equilibrium is reached.

4. Conclusions

The performance of a 50 kDa ceramic membrane was analysed along 50 cycles comprising milk ultrafiltration, alkaline and acid cleaning. The evolution of the measured values of permeate flux, protein transmission and membrane resistances suggest the formation to some extent of a residual fouling.

References
