ON THE USE OF DEGRADATION PRODUCTS OF MILK AND VEGETAL OILS FOR BIO-CLEANING OF PES MEMBRANE FOULED BY MILK PROTEINS

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ABSTRACT

Skim milk ultrafiltration (UF) by polyethersulfone (PES) spiral membranes is widely used in dairy industries to standardize the milk protein content. The high fouling resulting reduces fluxes, thus limiting the productivity. Moreover, a twice daily cleaning operation is needed to restore membrane flux and insure hygienic safety.

The irreversible membrane fouling is due mainly to proteins, which are thus the target for cleaning [1]. From a set of cleaning tests performed with various alkaline solutions at pH 11.5 and 50°C we have proposed the use of interfacial energy (γL) as parameter to formulate an efficient alkaline cleaning solution: our extrapolation gives a target value of γL = 30 mJ m^{-2} [1]. Commercial formulated detergent solutions usually used for cleaning are based on surfactants derived from fossil resources. In this study, a proposal for bio-cleaning is made, using degradation products of milk components (proteins, butter, cream, skim milk and raw milk) and vegetal oils (olive, palm and coprah oils) as renewable resources, leading either to peptides with surfactant properties and/or to mixtures of fatty acid salts, in which palmitate and oleate sodium salts arise in various proportions according to the fat's origin. After an appropriate dilution at apparent CMC in soda, solutions from vegetal and animal fat degradation gave γL values ranging from 24 to 32 $mJ.m^{-2}$, whereas protein degradation products gave much higher γL values.

Physico-chemical analysis of residual fouling proved essential to avoid misleading efficiency interpretations obtained from flux recovery; the amount of residual proteins was measured directly on a flat membrane by FTIR-ATR [1].

Cleaning efficiency was studied in UF conditions (2 bar, 0.3 $m.s^{-1}$, VRR= 1, spacers, 315 $L.m^{-2}$) at pH 11.5, 50°C with a PES flat membrane (127 cm^2, HFK 131, 5-10 $kg.mol^{-1}$, Koch) fouled by skim milk. Bio-detergents removed between 50 % (non-fat origin) and 66 % (fat degradation products) of protein, indicating that soaps obtained from vegetal and animal fats are more promising than protein degradation components of lower efficiency, even if the latter performed better than fresh soda.

Transposition was then performed on a spiral membrane (6.5 m^2) with a cleaning solution volume to membrane surface ratio of 3.8 $L.m^{-2}$. This is comparable with industrial practice. Flux recoveries of spiral membrane ranged from 77% to 84%, which allowed the reuse of alkaline cleaning solution polluted by fat dairy components after UF treatment to be assessed. After three consecutive cycles of skim milk spiral UF and cleaning, a renewable surfactant gave 84% flux recovery and a commercial detergent (P3-Ultrasil 10 from Ecolab) 98% flux recovery. Despite the flux recovery for the former being 8% lower, the subsequent skim milk (production) flux appeared similar for both cleaning solutions (15 $L.h^{-1}.m^{-2}.bar^{-1}$ at 50°C). These results provide interesting insights for cleaning solution formulation and for recycling and reuse of dairy effluents containing fat.

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References: [1] M. Rabiller-Baudry, L. Bégoin, D. Delaunay, L. Paugam, B. Chaufer, *Chem. Eng. Process*. 47 (2008) 267–275