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CLEANING EFFICIENCY AND IMPACT ON PRODUCTION FLUXES OF OXIDIZING DISINFECTANTS ON A PES ULTRAFILTRATION MEMBRANE FOULED WITH PROTEINS

Lydie Paugam*[12], David Delaunay[12], Murielle Rabiller-Baudry[12]
[1] *Université Rennes 1, UMR "Sciences Chimiques de Rennes"- CNRS, CS 74205, case 1011, 35042 Rennes Cedex, France. * lydie.paugam@univ-rennes1.fr*
[2] *Université Européenne de Bretagne*

ABSTRACT

Cleaning and the disinfection are key steps in membrane processes, particularly in food industry. They take place daily and successively to both restore membrane performances, by eliminating the fouling originated by the product filtration (alkaline + acid cleaning steps), and to prevent micro-organism development (disinfection). 45% of membranes processes established in the food industry are in the dairy industry. In this field, the ultrafiltration (UF) of skim milk is one of the biggest membrane applications. When using the HFK131 system (PES, Koch, MWCO: 5-10 $kg.mol^{-1}$) which represents 70% of the world market for this application, the resulting irreversible fouling was identified (using FTIR-ATR, SEM-EDX) as being due to proteins alone [1]. Analysis of cleanser action on this protein fouling has also shown [2] that nitric acid, usually used after a first alkaline step, can lead to a misleading increase of fluxes: the higher the amount of protein on the membrane, the higher the resulting increase of the flux, that is the worse the previous alkaline cleaning, the higher the over-estimation of the global cleaning efficiency.
Questions arise, including what are the consequences of a partial cleaning of a skim milk UF PES membrane on the following disinfecting step?, and what is the action of disinfection products on a residual protein deposit? We study the action of various disinfectants on a HFK 131 fouled with milk proteins. Hypochlorite solution (from bleach, 200 ppm, pH 11.5) is the most commonly used disinfectant. The results obtained depend strongly on the ratio of volume of disinfectant to membrane surface. A sufficiently high ratio [hypochlorite volume/membrane surface] gives complete protein removal. In these conditions, when the previous alkaline cleaning is not properly done, the hypochlorite both finishes the cleaning and disinfects. Moreover, a high [volume/surface] ratio (11.5 $L.m^{-2}$, 6.5 m^2 spiral membrane) leads to an increase of the following skim milk flux of 13 % compared to that obtained after an efficient cleaning (flux recovery, protein removal) with a commercial product (P3-Ultrasil 10, Ecolab) without any disinfection. In contrast, if the hypochlorite quantity is not sufficient to remove the overall residual protein deposit, this leads to reduced fluxes during the following skim milk UF. For a similair residual protein deposit (after cleaning), fluxes in skim milk are lower after an 'insufficient' treatment by ClO^- (-13 % with 3.8 $L.m^{-2}$) than without any contact at all, *i.e.* without any disinfection. PVP-iodine (200 ppm, pH 4.6), a halogen oxidising reagent like hypochlorite, does not show any protein removal; worse, it leads to a significant decrease in water flux after treatment. The difference with hypochlorite could arise from the working pH range. At acidic pH, the amine groups will be preferentially oxidised whereas at basic pH the reaction would concern SH groups on cysteine [3]. Oxonia active (Ecolab, hydrogen peroxide + peracetic acid, 1 %, pH 3.2) and peracetic acid (200 ppm, pH 3.8) does not give any protein removal but a strong decrease of water fluxes (up to -47 %). In contrast, sodium perborate ($1g.L^{-1}$, pH 10.0), which also releases hydrogen peroxide, gives 40% protein removal.
In conclusion, if a protein deposit still remains on the membrane at the start of the disinfection step, the following product flux can be strongly decreased or enhanced, depending on the nature of the oxidising agent and on its conditions of use (volume/membrane surface at fixed concentration, pH). Consequently, cleaning and disinfecting steps have to be studied in synergy.

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