Membrane Fouling during Microfiltration of Protein Solutions

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Abstract

Membrane fouling during cross-flow microfiltration (CFMF) of proteins is complex depending upon feed properties, operating conditions and membrane properties. Four different protein solutions (reconstituted whey protein, BSA, lactoferrin and ferritin) with a range of physicochemical properties were investigated at a variety of permeate fluxes under different solution conditions to elucidate fouling mechanisms during constant flux CFMF.

MF fouling usually occurs in three stages: i) adsorption ii) pore fouling (pore plugging or deposition near the pore entrance) and iii) formation of a surface layer. The importance of step (ii) depends upon whether a protein is completely or partially permeable through the membrane.

BSA probably fouled internally first by pore plugging followed by formation of a surface layer once all the pores were plugged. Prefiltration and the presence of SDS reduced fouling but did not prevent it, suggesting that aggregates present in the initial feed as well as those formed during MF contribute to pore plugging and so lead to severe fouling.

Fouling resistance curves for lactoferrin indicate an initial phase of slow fouling by plugging or deposition of aggregates. Mathematical modelling suggested that fouling was particularly severe at the pore entrance. As flux was increased, lactoferrin formed a concentration-induced surface layer.

Ferritin formed a concentration-induced gel layer even at relatively low fluxes (≥91 $L/m^2.h$) when the wall concentration of protein reached the "gel concentration". The gel layer was highly reversible to changes in hydrodynamic conditions such as cross-flow velocity and transmembrane pressure. Fouling was more severe with reconstituted whey than with fresh whey due to the presence of protein aggregates in the reconstituted whey.

The role of the physicochemical properties of proteins in aggregation and probable fouling mechanisms during CFMF are discussed. Protein-protein interactions under the influence of shear particularly at higher fluxes lead to aggregation and subsequent fouling.

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Table of Contents