Directing filtration to optimize enzyme immobilization in reactive membranes

In this work, fouling principles in force in ultrafiltration were deployed to understand the role of selected variables—applied pressure (1-3 bar), enzyme concentration (0.05-0.2 g L⁻¹), pH (5-9) and membrane properties—on fouling-induced enzyme immobilization. The immobilization and subsequent enzymatic reaction efficiency were evaluated in terms of enzyme loading, conversion rate and biocatalytic stability. Alcohol dehydrogenase (ADH) was selected as a model enzyme. Lower pressure, higher enzyme concentration and lower pH resulted in higher irreversible fouling resistance and lower permeate flux. High pH during immobilization produced increased permeate flux but declines in conversion rates, likely because of the weak immobilization resulting from strong electrostatic repulsion between enzymes and membrane. The results showed that pore blocking as a fouling mechanism permitted a higher enzyme loading but generated more permeability loss, while cake layer formation increased enzyme stability but resulted in low loading rate. Low pH (near isoelectric point) favored hydrophobic and electrostatic adsorption of enzymes on the membrane, which reduced the enzyme stability. Neutral pH, however, promoted entrapment and hydrogen bonding of enzymes on the membrane, which improved the enzyme stability. This study suggests that a compromise between different fouling/immobilization mechanisms must be found in order to maximize the immobilization performance, both in terms of enzyme loading and also of enzyme activity.

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