Functionalization of a Membrane Sublayer Using Reverse Filtration of Enzymes and Dopamine Coating

High permeability, high enzyme loading, and strong anti-fouling ability are the desired features for a biocatalytic membrane to be used in an enzymatic membrane reactor (EMR). To achieve these goals, the membrane sublayer was enriched with laccase by reverse filtration in this case, and the resulting enzyme-loaded sublayer was covered with a dopamine coating. After membrane reversal, the virgin membrane skin layer was facing the feed and the enzymes were entrapped by a polydopamine network in the membrane sublayer. Thus, the membrane sublayer was functionalized as a catalytically active layer. The effects of the original membrane properties (i.e., materials, pore size, and structure), enzyme type (i.e., laccase and alcohol dehydrogenase), and coating conditions (i.e., time and pH) on the resulting biocatalytic membrane permeability, enzyme loading, and activity were investigated. Using a RC10 kDa membrane with sponge-like sublayer to immobilize laccase with dopamine coating, the trade-off between permeability and enzyme loading was broken, and enzyme loading reached 44.5% without any permeability loss. After 85 days of storage and reuse 14 times, more than 80% of the immobilized laccase activity was retained for the membrane with a dopamine coating, while the relative activity was less than 40% without the coating. The resistance to high temperature and acidic/alkaline pH was also improved by the dopamine coating for the immobilized laccase. Moreover, this biocatalytic membrane could resist mild hydrodynamic cleaning (e.g., back-flushing), but the catalytic ability was reduced by chemical cleaning at extreme pH (e.g., 1.5 and 11.5). Since the immobilized enzyme is not directly facing the bulk of EMRs and the substrate can be specifically selected by the separation skin layer, this biocatalytic membrane is promising for cascade catalytic reactions.

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