Biocatalytic Ceramic Membranes for Emerging Pollutants Transformation

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Biocatalytic Ceramic Membranes for Emerging Pollutants Transformation

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Biocatalytic nanofibrous membranes, integrating the benefits of membranes and enzymes, have drawn attention in wastewater treatment due to their high specificity and their operational catalytic stability. Polymeric membranes, as opposed to brittle ceramic membranes, are more commonly used as scaffolds for enzyme immobilization. However, polymeric membranes are typically non-biodegradable, which raises environmental concerns. Here, we report the fabrication of electrospun highly flexible SiO2 nanofiber membranes (NFMs) and the covalent immobilized of the green industrial biocatalyst, laccsase (EC 1.10.3.2). Several strategies for surface modification and functionalization of the NFMs were evaluated to improve the catalytic properties of the NFMs, in terms of enzyme load and apparent activity per membrane weight. Enzyme immobilization with the co-deposition of polydopamine (PDA) and polyethyleneimine (PEI) resulted in the best immobilization yield of 57.9±0.5% and apparent activity of 6.4±1.1 U g-1 membrane. Compared to the free enzyme, the fabricated catalytic membranes possessed good reusability, with 70% of their activity retained after five cycles. In addition, the immobilized laccase transformed the emerging pollutants diclofenac, mefenamic acid, sertraline, bicalutamide, and clarithromycin at >95% efficiencies. This is the first study to employs biocatalytic flexible ceramic nanofibers in wastewater treatment, thereby bringing novel insight into a previously less explored realm of biocatalytic membrane applications. Our work offers a technological platform for improving the sustainability of biocatalytic membranes, as compared with the end-of-life polymeric membranes modules.

References

[1] Xu R., Si Y., Wu X., Li F., Zhang B., Triclosan removal by laccase immobilized on mesoporous nanofibers: Strong adsorption and efficient degradation (2014), Chem. Eng. J. 255, 63–70
[2] Costa J.B., Lima M.J., Sampaio M.J., Neves M.C., Faria J.L., Morales-Torres, S., Tavares, A.P.M., Silva, C.G., Enhanced biocatalytic sustainability of laccase by immobilization on functionalized carbon nanotubes/polysulfone membrane (2019), Chem. Eng. J. 355, 974–985
[3] Shan H., Si Y., Yu J., Ding B., Facile access to highly flexible and mesoporous structured silica fibrous membranes for tetracyclines removal (2021), Chem. Eng. J. 417,129211