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Commentary

Application of Biocatalytic Membranes (BCMs) in Water Treatment

Saskia Baig*

Department of Science & Technology, University of Twente, Drienerlolaan, The Netherlands

DESCRIPTION

The use of enzyme immobilisation and reaction-separation integration in biocatalytic membranes has gained significant attention in online detection and biomanufacturing. However, the limited stability, poor comprehensive performance, and costly preparation costs restrict its applicability. In addition to enzyme immobilization, more efforts should be made to design biocatalytic membrane architecture specifically for a given application in order to maximise the synergistic effect of reaction, separation and increase its operating stability. Due to numerous anthropogenic activities during the past few years, the number of water contaminants has significantly expanded. There are several traditional technologies available for the treatment of wastewater. However, due to their action at trace concentrations and the limited removal effectiveness of the current treatment techniques, Micropollutants of Emerging Concern (MEC) pose a significant threat. MEC can be removed to some extent using cutting-edge technology like membrane technology. However, the efficiency can be impacted by various factors that include several chemical characteristics of MEC such as selectivity, and membrane fouling. Additionally, further processing may be necessary for the membrane filtering concentrate. One of the environmental friendly methods for eliminating various impurities from the water and reducing membrane fouling is the enzymatic degradation of pollutants and foulants. Enzymatic degradation and membrane separation are both benefits of Bio-Catalytic Membranes (BCMs), which immobilise enzymes on membranes.

The use of biocatalytic membranes in the food, pharmaceutical, and water treatment industries is promising and still, they are crucial step in making biocatalytic membranes is enzyme immobilization. Therefore, the question of how to lessen immobilization's detrimental impact on enzyme activity must be addressed. By immobilising five commonly used enzymes: laccase, glucose oxidase, lipase, pepsin, and dextranase on three commercially available membranes using three different immobilisation mechanisms: electrostatic attraction, covalent bonding, and hydrophobic adsorption. It was observed that, with the exception of dextranase, electrostatic attraction was the most effective method of immobilising enzymes. Covalent bonding and hydrophobic adsorption, on the other hand, had a negative impact on the conformation of the enzyme. Only lipase and dextranase could be immobilised using hydrophobic adsorption, whereas covalent bonding ensured high enzyme loading. Additionally, when choosing an appropriate immobilisation approach, the characteristics of the functional groups surrounding the enzyme active centre should be taken into account (i.e., avoid covering the active centre with a membrane carrier). This not only produced a flexible framework for the creation of biocatalytic membranes, but it also offered a cutting-edge way for assessing how immobilisation processes affect enzyme activity.

The majority of the pollutants, which include phenolic groups, colours, pigments, and antibiotics like painkillers and contraceptives, share certain chemical structural similarities. Many natural enzymes use a variety of phenolic and non-phenolic pollutants as substrates. They can also catalyse particular conversion reactions because of their individual selectivity, which makes them essential components for eliminating different pollutants, including MEC. Several enzymes have been used to break down a variety of organic pollutants. The enzyme-based treatments provide a number of benefits, such as a decrease in sludge production, catalytic activity, application to a variety of pollutants, and low energy requirements.

However, it is important to note that enzymatic degradation of harmful chemicals can only be utilised in processed wastewater, having reduced interferents and pollutants, due to the large levels of organic and inorganic materials in raw wastewater. Despite their high cost, restricted reusability, decreasing activity, poor stability, and potential to produce dangerous soluble byproducts, enzymes still have limited practical applicability despite their exceptional efficiency and environmental friendliness during water treatment procedures. Immobilizing enzymes on diverse substrates has been suggested as a potential remedy to these drawbacks. Immobilization increases the enzymes tolerance to the hostile environment while also

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Correspondence to: Saskia Baig, Department of Science & Technology, University of Twente, Drienerlolaan, The Netherlands, E-mail: baigsaskia@utwente.nl

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improving application convenience and selectivity. It has been difficult using traditional membrane technology to remove MEC and reduce fouling. Although improvements have been made to address the MEC issue, they continue to face challenges such as membrane fouling and retentate disposal requirements.