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Enzymatic membrane reactor supported with ionic liquid as an efficient platform for removal of estrogens

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Considering the widespread issue of challenges in metabolizing certain medications, such as estrogens, the contamination of sewage with pharmaceutically active compounds is particularly noteworthy. There are four estrogens in sewage, three of them are natural steroids produced by living organisms: estrone (E1), 17β-estradiol (E2) and estriol (E3), while the fourth one is classified as synthetic: 17α-ethinyl estradiol (EE2).[1] Monitoring should mainly focus on 17β-estradiol, which has the greatest stability and toxicity. The following issues are of concern: endocrine disruption and negative effects on the reproductive and sexual functions of wild animals, fish, and humans. Some active pharmaceutical ingredients are resistant to traditional forms of pollutant removal used in sewage treatment plants, leading to the search for new environmentally friendly solutions.[2] Enzymatic degradation of estrogens can be considered a promising method compared to conventional physical and chemical oxidation processes. The introduction of ionic liquids in the immobilization of enzymes can influence enzymatic reactions by altering the structure, activity, enantioselectivity, and stability of the enzymes, thereby providing higher conversion rates.[3]

In the presented work, electrospun fibres made of polystyrene, polystyrene (PS) with the addition of MOF (PS+MOF), poly(methyl methacrylate) (PMMA) and poly(methyl methacrylate) with the addition of MOF (PMMA+MOF) were used as carriers for laccase immobilization by adsorption for use as a biocatalytic membrane in a continuous flow reactor. Then, a proof of concept was presented for the use of the produced biocatalytic system to biodegrade two estrogens: 17β-estradiol (E2) and 17α-ethinyl estradiol (EE2). An important part of the work was the use of ionic liquid as surface modifiers to bind the enzyme to the material surface more permanently and effectively. Additionally, differences in flow and permeability were examined between the tested membranes, both the clean membrane, the membrane after immobilization and after estrogen degradation by the produced biocatalyst. It has been discovered that the biocatalysts produced on presented polymer matrices could be a promising option for effectively degrading E2 and EE2 under various processing conditions. Moreover, membranes with immobilized enzymes, along with the addition of ionic liquid, exhibited higher activity compared to the other tested systems. This indicates the significance of using ionic liquids during the production of biocatalytic systems.

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