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REMOVAL OF PHENOLIC POLLUTANTS FROM MUNICIPAL WASTEWATER THROUGH IMMOBILIZED LACCASE ENZYMES

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Abstract

Endocrine disrupting compounds (EDCs) can cause adverse health effects like developmental disorders, birth defects or cancer. One major pathway for EDCs to be released into the environment is through wastewater treatment plant effluents. Consequently, removal of EDCs from wastewater is of concern. Many EDCs in wastewater are phenolics e.g. bisphenol A (BPA). It has been proposed that laccase–an enzyme using molecular oxygen as substrate to oxidize phenolic moieties–could be utilized for the removal of phenolic contaminants from wastewater. In the present work laccase of a *Thielavia* genus has been immobilized on fumed silica nanoparticles. The stability and activity of the resulting biocatalysts regarding the removal of bisphenol A from biologically treated wastewater was assessed and compared to the activity and stability of free laccase enzymes. Stability of the immobilized laccase was considerably higher than that of the free enzyme. After 7 days the conjugates retained 81.1±0.4% residual activity while the free laccase was virtually inactive after 1.5 days. Activity of biocatalysts regarding the removal of BPA was tested at concentrations usually measured in wastewater streams (ng-µg L^{-1}). At initial bisphenol A concentrations of approximately 5 µM both immobilized as well as free laccase were able to eliminate 95% of the initially present BPA within 5 hours. Initial BPA transformation rates were higher for the free (7.87±0.45 mU mg^{-1} protein) compared to the immobilized (1.03 ± 0.15 mU mg^{-1} protein) enzymes. This might be due to mass transfer limitations for BPA with the immobilized enzymes since the laccase-nanoparticle conjugates showed increased activity compared to the free enzymes towards ABTS (2,2′-azino-bis(3-ethylbenzthiazoline)-6-sulfonic acid)–a commonly used substrate to assess laccase activity–and was therefore not inactivated by the immobilization procedure. Additionally, transformation experiments with the laccase-nanoparticle conjugates at initial ^{14}C-labeled BPA concentrations of 86 nmol L^{-1} were performed in biologically treated wastewater. Approximately 75% of the initial BPA was transformed within 2 hours. The ability to significantly eliminate BPA at environmentally relevant concentrations as well as the increased stability of the immobilized over the free enzymes shows the large potential for laccase-nanoparticle conjugates in municipal wastewater treatment for the elimination of phenolic contaminants.