

ROBUST BIOCATALYSTS FOR POLLUTION CONTROL AND ENVIRONMENTALLY BENIGN BIOPROCESSING

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Increasing awareness of the finite resources of the planet, including its environmental quality, constitutes a powerful driver for industries and governments not only to fight the effects of pollution but to avoid it at the source. Demands are mounting to replace conventional industrial processes by less- or non-polluting ones. During this gradual shift the treatment of wastes from current human activities and as a legacy of our industrial history remains a challenge. As these treatments merge with environmentally benign industrial processes a truly sustainable economy will become a reality. Enzymes or whole-cell biocatalysts in industrial processes are linked to lower consumption of energy and chemicals and are thus "green" agents. Enzymes catalyze specific reactions under moderate conditions hence they are instrumental for the selective removal of pollutants from waste streams. Enzyme specificity also precludes undesired side-reactions, while in some cases the pollutants treated could be transformed into added-value products, as illustrated in the waste biorefinery concept. The power of such biocatalysts is demonstrated in the case of emerging organic contaminants (EOCs) such as pharmaceuticals and personal care products (PPCPs), which affect treated and untreated water and associated matrices like sludges and sediments at very low but environmentally relevant concentrations ("micropollutants") through unwanted biological effects like endocrine disruption. Oxidative enzymes like fungal laccases and peroxidases are promising biocatalysts for the transformation and removal of the biological effects of EOCs. The re-usability of such enzymes and their separability from reactants and products can be ensured by carrier-based immobilization or by formation of cross-linked enzyme aggregates (CLEAs) which are applied for the treatment of EOCs in adapted reactor systems. We have identified key factors for the production of CLEAs of laccases alone or of combined oxidoreductases (e.g. versatile peroxidase coupled to glucose oxidase), and we have improved these novel biocatalysts by applying rational experimental design and optimization methodologies, as shown in the degradation and detoxification of bisphenol A, a ubiquitous endocrine disruptor. Multi-enzyme biocatalysts co-aggregated in combi-CLEAs showed activity over a broad pH range implying their suitability for the treatment of micropollutant-contaminated real wastewaters of varying pHs. Finally we have prepared novel robust biocatalysts for EOC removal based on laccase encapsulated by biomimetic methodologies. The creative fusion of biocatalysis, chemical engineering fundamentals and nanotechnology opens up attractive horizons towards both

sustainable treatment of micropollutant-contaminated matrices and, more generally, multiplies our options for environmentally relevant industrial processes.

keywords : enzyme; oxidoreductase; laccase; micropollutant; nanoparticles