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Session 4
INNOVATIVE APPROACHES AND TOOLS FOR THE TRACKING AND BIOREMEDIATI ON OF EMERGING POLLUTANTS IN SOILS, SEDIMENTS AND GROUNDWATERS

Sub-session 4.1.
Detection and biodegradation of emerging pollutants

Main lecture

BIOCATALYTIC WEAPONS AGAINST MICROPOLLUTANTS

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Abstract

Emerging organic contaminants (EOCs) such as pharmaceuticals and personal care products (PPCPs) are present in areas of significant urbanization and affect treated and untreated wastewater, groundwater, drinking water as well as associated environmental matrices like sludges and sediments. The occurrence of these compounds at very low but environmentally relevant concentrations has earned them the collective term "micropollutants" while an important subgroup is causing concern because of their impact on organisms including humans via biological effects such as hormonal interference (endocrine disrupting compounds, EDCs) or bioaccumulation. Physicochemical techniques are not particularly effective for the removal of micropollutants. Conventional activated sludge systems are also relatively ineffective, but better PPCP removal has been observed by several teams to correlate with longer sludge retention time and/or more efficient nitrification. In the latter process a number of micropollutants including EDCs are (co)metabolized pointing to the active role of ammonia monooxygenase. This and other oxidative enzymes like cytochrome P-450 are involved in the transformation and removal of the biological effects of EDCs. Similarly, broad spectrum oxidative enzymes like fungal laccases and peroxidases are promising biocatalysts against PPCPs. 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). In our group, laccase-CLEAs have been successfully produced and applied for the treatment of micropollutants in adapted reactor systems. Furthermore, 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 EDC. An illustration of the powerful possibilities afforded by multi-enzyme biocatalysts involves our co-aggregation of laccases from *Coriolopsis polyzona*, with an acidic pH-optimum, and from *Coprinopsis cinerea*, with a neutral pH-optimum, in a single biocatalyst. The combi-CLEAs obtained 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 EDC removal based on laccase encapsulated by biomimetic titanification. The creative fusion of biocatalysis, chemical engineering fundamentals and nanotechnology opens up particularly attractive horizons towards sustainable treatment of micropollutant-contaminated water resources.