Fungal oxidative enzymes to degrade organic micropollutants in novel bioreactors

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Introduction

About 300 million tons of synthetic compounds produced annually are partially released into natural waters[1]. Among these are the micropollutants, inorganic and organic substances present at low concentrations (pg to ng/l) in the environment. Some of them, namely endocrine disruptors (EDCs) modulate or disrupt the endocrine system of animals even at above mentioned concentrations. To date, an effective and sustainable strategy against this insidious contamination of aquatic environments barely exists. Physico-chemical treatments are unsuitable, e.g. due to high costs and "classical" wastewater treatment plants function only as partial barriers. A novel approach taking advantage of the remarkable catalytic potential of the terrestrial wood-rotting fungi (WRF) and emerging strategies of immobilization and insolubilization of enzymes for the removal of EDCs is presented.

Main Objectives

(i) Selection of WRF strains particularly effective for laccase production and characterization of their laccases

(ii) Stabilization of the laccase(s) by immobilization on nanoparticles and insolubilization by cross-linking (CLEAs)

(iii) Conception and modeling of suitable reactors for EDC degradation

Organisms

Wood-rotting fungi (WRF) are an ecophysiological group capable of mineralizing lignin using lignin-modifying enzymes: Several peroxidases and **laccases.**

Fig 1 *Pycnoporus coccineus*

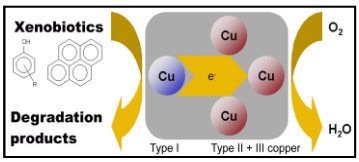


Fig 2: Catalytic mechanism of laccases

Laccases are copper-containing polyphenol oxidases that catalyze the one-electron oxidation of a variety of organic and inorganic substrates.

(i) Effective laccase production

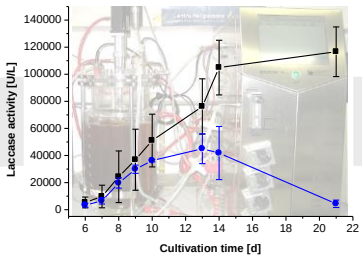
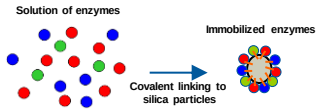


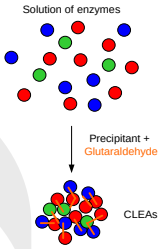
Fig 3: Laccase production profile of *Coriolopsis polyzona* in two different production media (mean ± S.D.)

(ii) Immobilization on nanoparticles



Laccases immobilized on nanoparticles with high specific surface area will result in intensified biocatalysts with increased stability.

(ii) Insolubilization as CLEAs



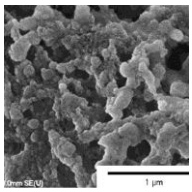
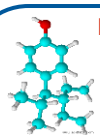


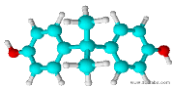
Fig 4: SEM of laccase CLEAs[2]

EDCs targeted

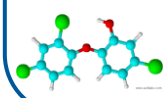


Nonylphenol (NP)
[NP] effluents up to ~ 400 µg/l;
Used in non-ionic detergents

Bisphenol A (BPA)
[BPA] effluents ~ 1 µg/l
[BPA] leachates ~ 15 mg/l
Leaching from plastics



Triclosan (TCS)
[TCS] effluents up to ~ 38 µg/l
Antimicrobial agent in personal care products



(iii) Novel and optimized reactors

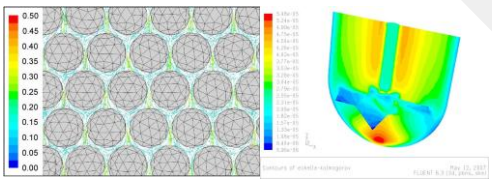


Fig 6: Visualizations of modeled fluid dynamics (B. Haut, ULB)

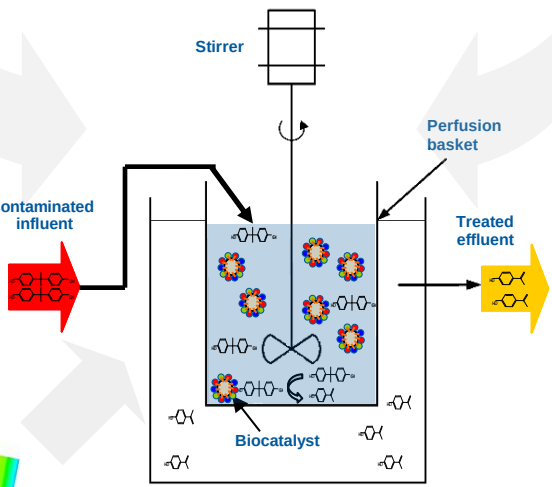


Fig 5: Experimental setup of a perfusion basket reactor, where the immobilized particles are retained inside the vessel and the treated effluent is separated by a membrane basket.

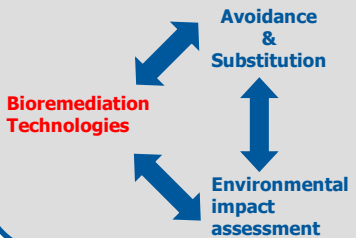
Conclusions and outlook

Enhancement of laccase production was achieved by selecting suitable strains and delimitation of physiological constraints.

Complete conversion of free laccase into CLEAs was accomplished. Further studies will focus on the improvement of functionalized nanoparticles and a comparison of both biocatalysts.

Novel reactor designs and models of those reactors will be used in combination with the presented biocatalysts.

The final aim is the development of a bioremediation process to contribute to the integrated approach of overcoming the problem of EDCs.



Taken from Hall *et al.* (3)

References:

1)Schwarzenbach *et al.* (2006), *Science* **313**:1072
2)Cabana *et al.* (2007), *J Biotechnol* **132**: 23
3)Hall *et al.* (2008), *JAMA* **300**: 1303

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