Using microorganisms to harvest electricity -Towards a self-regenerating enzymatic cathode

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The advantage of microbial biofuel cells (mBFCs) is that microorganisms continuously reproduce and thus lifetimes of up to five years have already been reported [1]. While these cells have a lower power density (e.g. 188 µW/cm^2 [2]) than enzymatic biofuel cells (eBFCs; e.g. 1450 µW/cm^2 [3]), enzyme degradation limits the lifetime of eBFCs to only a few weeks and therefore hinders their long-term use [4].
The aim of our research is to improve the long-term stability of efficient, but currently short-lived enzymatically–catalyzed fuel cell electrodes [4]. We aim to continuously supply catalytically-active enzymes at the electrode using living microorganisms that grow in an electrode-integrated micro-bioreactor. In this way, the advantages of eBFCs and mBFCs would be combined by establishing a fully self-regenerating eBFC.
In the present work, we demonstrate the feasibility of using the crude culture supernatant of the fungus *Trametes versicolor*, which produces laccase as an extracellular enzyme, to supply a biofuel cell cathode. During culturing, aliquots of the supernatant were regularly removed and replaced by fresh medium. The aliquots, containing approximately 2.2 U/mL laccase activity, were transferred to the cathode compartment of a BFC. To record the loadcurve, the current was incrementally increased (steps of 5.6 µA/cm^2*h) and the cathode potential was measured against a reference electrode (SCE). This resulted in a current density of 74 µA/cm^2 at a cathode potential of 0.4 V vs. SCE. The same activity of commercial laccase (Sigma) in SC medium produced a current density of 78 µA/cm^2 at the same cathode potential (Figure 1). Hence, we could show that it is possible to use the crude culture supernatant of *T. versicolor* at the electrode, and that the current density obtained is comparable to the current density recorded with commercial laccase. Our work is thus a first step towards the aim of constructing a self-regenerating enzymatic biofuel cell.

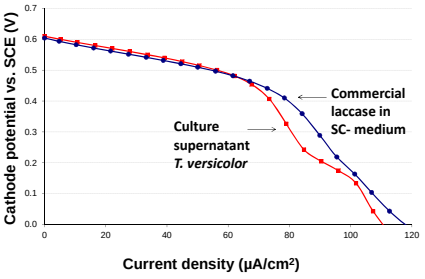

Figure 1: Cathode loadcurves under continuous air purging.

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