ENHANCING THE LIFETIME OF LACCASE-BASED BIOFUEL CELL CATHODES BY SEQUENTIAL RENEWAL OF ENZYME

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We present a novel bio-inspired approach to enhance the lifetime of enzymatic biofuel cell electrodes. Due to limited enzyme stability the lifetime of such fuel cells is at present only in the order of weeks or months [1]. While current research approaches to overcome this problem focus on enzyme stabilization by immobilization [2], living organisms separate enzyme lifetime from system lifetime by the continuous regeneration of fresh enzyme. We transfer this principle to biofuel cells by sequentially exchanging the electrolyte to re-supply active enzyme to the electrode. Since this concepts demands reversible adsorption of the enzyme, we chose a mediator-less graphite felt cathode with adsorbed laccase as biocatalyst, operating in oxygen saturated 100 mM citrate buffer (pH = 5) [3].

In a first step the adsorption kinetics of laccase were studied. Within a concentration range up to 8×10^{-2} g l^{-1} Langmuir-type behavior was identified, the adsorption and desorption constants being $k_{ads} = 9.4 \times 10^{-3}$ ml s^{-1} mg^{-1} and $k_{des} = 6.5 \times 10^{-3}$ l s^{-1}, respectively. This means that in less than two minutes 63 % of the enzyme adsorbed to the electrode can be replaced by fresh enzyme from the electrolyte solution.

The performance of corresponding electrodes was studied at a constant load of 24 µA cm^{-3} (Fig. 1). Over a period of 340 hours the electrode without enzyme re-supply exhibits an average potential decay of 1.6 mV h^{-1}. In contrast, regular re-supply of active enzyme drastically reduces performance degradation to a value of only 0.4 mV h^{-1}. The bio-inspired enzyme renewal is thus a promising approach to significantly extend the lifetime of enzymatic biofuel cells.

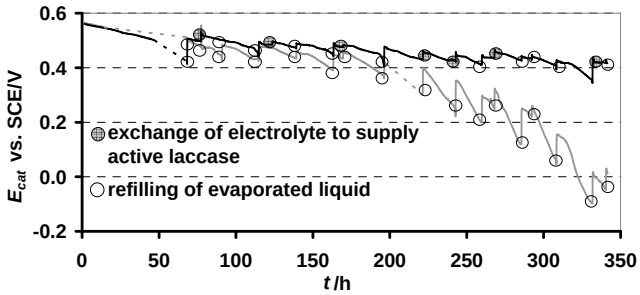

Fig. 1: Time-dependent development of cathode potential E_{cat} for cathodes with (black line) and without (grey line) sequential renewal of laccase catalyst.

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