Yeast surface display of oxygen reducing enzymes for microbial fuel cell cathodes applications

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Abstract:

Biofuel cells are electrochemical devices which convert chemical energy to electricity using biochemical pathways and redox enzymes. Microbial fuel cells (MFCs) are biofuel cells which use microorganisms to catalyze the release of electrons from organic matter and transfer them to various electron carriers that are electrochemically active. The possibility of self-sustaining and renewing systems and of extracting high percentage of the electrons from organic compounds increases the interest in MFCs, but the technology is not sufficiently developed yet and optimization efforts are essential.

Laccase and Bilirubin Oxidase (BOD) are broadly used in biofuel cells, as they catalyze the 4 electron reduction of molecular dioxygen to water and present the distinct advantage that partial 2 electrons reduction of the oxygen to hydrogen peroxide, which results in inferior performance, is avoided.

Yeast surface display (YSD) is a powerful tool for display and engineering of proteins. The yeast ER ensures that only properly folded proteins reach the cell surface. YSD simplifies the MFCs bypassing the necessity of adding purified enzymes to overcome the loss of activity during time, by providing the ability to induce the biosynthesis of new displayed enzymes when necessary, sparing expensive and yield decreasing purification processes. It was demonstrated that YSD of Glucose Oxidase (GOx) in the anode compartment has improved the performance of biofuel cells.

In this work, Laccase and BOD were successfully displayed on the surface of Saccharomyces cerevisiae, for the first time. Enzymes activity was determined by a biochemical colorimetric assay, and proper electron transfer with the electrodes was proved using cyclic voltammetry. Subsequently, these yeast cells were used in the cathode compartment of a novel MFC containing redox enzymes displaying yeast in both compartments, as the anode contained yeast displaying GOx. The performance of the fuel cells was studied and is presented.