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Development of biocathodes with immobilized enzymes on mediator carboxylated carbon cloth for biocell fuel

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Abstract – This present study reports the developments of operational biocathode with fungal (laccase) and vegetable (peroxidase) extracts, from Shiitake (*Lentinula edodes*) and Brazilian zucchini (*Cucurbita pepo*), biocatalyst wired with methylene blue as mediator on carboxylated carbon cloth with binding and immobilization methods to better the electrons transference between cathode and biocatalyst molecules.

In recent years, there has been considerable interest in the development of non-precious metal catalysts as Pt substitutes for cathodes in polymer electrolyte membrane fuel cells (PEMFCs), due this metal is: a) very expensive, 2) poisoned very easy with CO and H2S, and 4) no renewable. Biofuel cells are similar to PEMFC, but use enzymes on place of platinum, however they are not electrons conductor in their whole molecule. So, an electron mediator plays an important role in the mediator-type biofuel cell.1-3

This present study reports the developments of operational biocathode with fungal (laccase) and vegetable (peroxidase) extracts, from Shiitake (*Lentinula edodes*) and Brazilian zucchini (*Curcubita pepo*)[1], biocatalyst wired (mediator/mediatorless) on carboxylated carbon cloth with binding and immobilization methods to better the electrons transference between cathode and biocatalyst molecules. The enzymatic activities showed that both crude extracts were actives with values of 278.2 and 400.7 $U.mL^{-1}$. At the anode, the cloth carbon was only impregnated with platinum nanoparticles. The electrochemical tests were carried out at 25°C in a PEMFC, in which cathode and anode were fed with oxygen and hydrogen, respectively. The maximum power density reached 342 $\mu W.cm^{-2}$ at a cell voltage of 0.171V with vegetable (peroxidase) extract adsorbed, bound, deposited and immobilized on carboxylated carbon cloth for 100h, at pH 7.0 in 0.1$mol.L^{-1}$ phosphate, and same conditions with fungal extract was 138$\mu W.cm^{-2}$ at a cell voltage of 0.108V and 25°C. Na presence of methylene blue adsorbed on carboxylated carbon cloth tissue this values were 522.8$\mu W.cm^{-2}$ e 426.3$\mu W.cm^{-2}$, respectively. When sprayed Nafion solution on first electrode with blue methylene, this value was to 895.1$\mu W.cm^{-2}$ (for peroxidase). These values showed that the peroxidase wired very well in this pH, due its molecules (pI near to 8.0) have net positive charge dislike carboxylated carbon cloth, while the laccase has pI near to 3.0 and has net negative charges. They also showed that methylene blue adsorbed on carbon cloths serve as mediator better to peroxidase than laccase. So, in these conditions, this work showed that it need ore contact between enzyme molecules and electrode and we need know very well each enzyme structure and electrode.

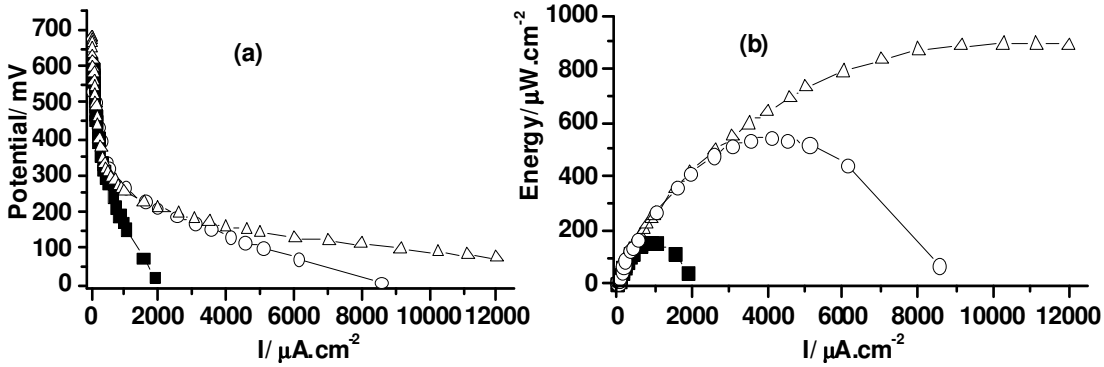

Figure 1: Curves of polarization (a) and power density (b) in PEMFC. Anode: 0,4 mg Pt cm^{-2}, and biocathodes with: peroxidase only adsorbed on carbon cloth carboxylated for 100h (-■-), and peroxidase adsorbed and immobilized on carbon cloth: carboxylated for 100h (-○-), and Nafion solution sprayed (-Δ-), at 25ºC.

References

[1] F. Colmati, S.A. Yoshioka, V.L.V.B. Siqueira, H. Varela, E.R. Gonzalez, *Int. J. Electrochem. Sci.,* 2 (2007) 195 - 202.