Title:

Study of Enzymatic Covalent Immobilization Electrode in Biofuel Cells

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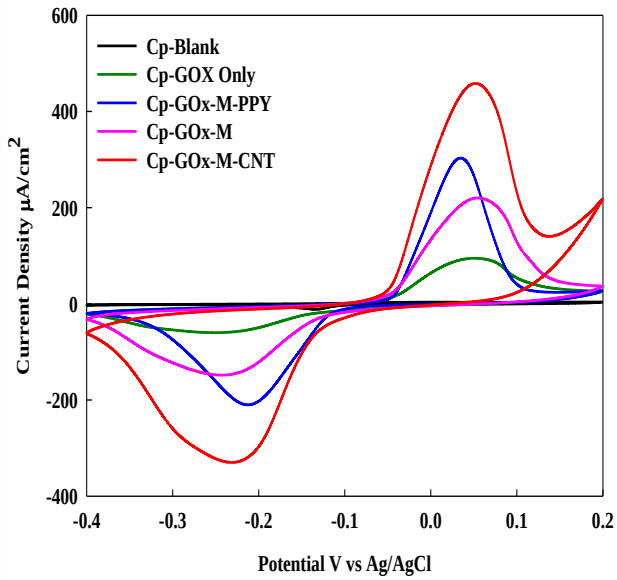
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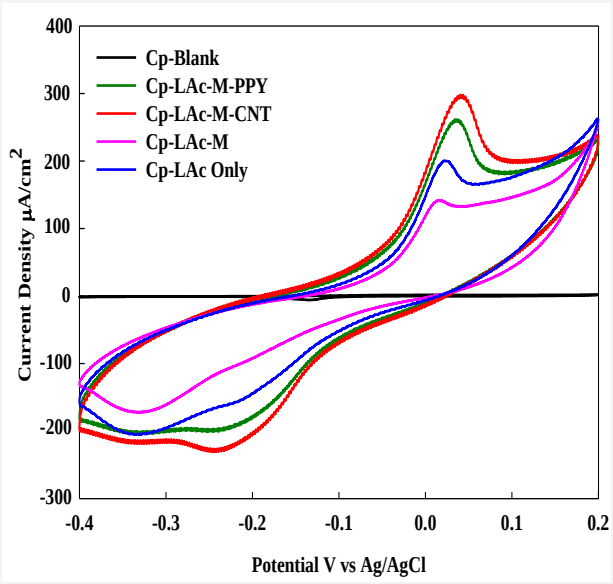
Enzymatic biofuel cell is a promising branch of biofuel cells that have application for low power devices (micro- to milliWatt). The main code of enzymatic biofuel cell is using enzymes as bioelectrocatalysts transforming chemical energy to electrical energy, as an alternative of metallic catalysts. This study, aims to progress the immobilization method of electrodes to increase electrical power and life duration for enzymatic biofuel cell using glucose oxidase in bio-anode, laccase in bio-cathode and glucose as the fuel. Mutually, these enzymes are immobilized onto carbon paper using covalent bonding method.

Electrochemistry deals with the acquaintances between chemical reactions and electricity. This includes the study of chemical changes caused by the passage of an electric current across a medium, as well as the production of electric energy by chemical reactions. electrochemical impedance spectroscopy, cyclic voltammetry and liner sweep voltammetry are fully utilized in this paper. EIS is an efficient, non-intrusive and semi-quantitative technique to characterize the performance of bio-electrochemical system such as enzymatic biofuel cell. Indeed, quantitative interpretation of impedance date can be obtained with the help of mechanistic models using meaningful equivalent circuits. The production of maximum power output is limited by their higher internal resistance in this case the combination of CNT with the enzyme (glucose oxidase and laccase) produce the maximum power output. Likewise, the cyclic voltammetry was used on a carbon paper electrode in aqueous solution containing phosphate buffer solution with glucose dissolve in it as supporting electrolyte. The purpose of the investigation was to carry out a quantitative detailed study of the electrochemical oxidation of glucose by glucose oxidase enzyme and reduction of O_2 by laccase enzyme in aqueous solution. The results of the study show that both the bioanode and biocathode enzyme produce maximum power density in combination with CNT plus the redox mediators ($K_3Fe(CN)_6$/ABTS). This can be observed from the peak separations which clearly indicates efficient mass transfer and high electrode kinetics.

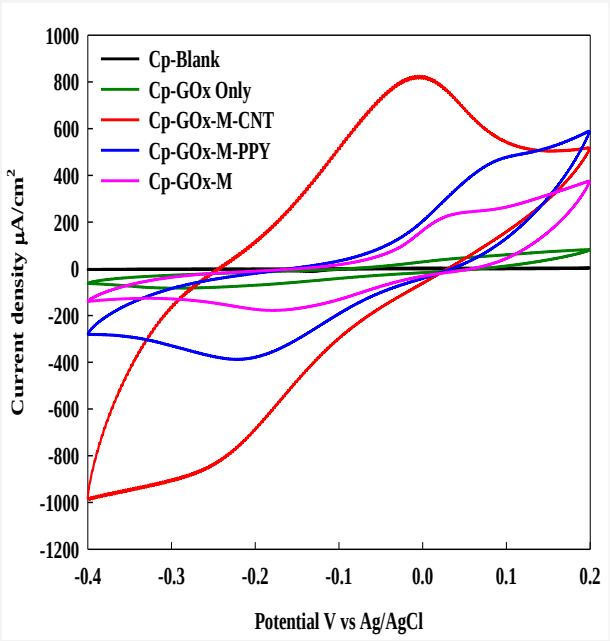
The maximum power density was 250 μW/cm2 at a voltage of 0.42 V. From the cyclic voltammograms, it shows that hydrophilic modify electrode has better performance. In summary, covalent immobization shows greater advantages than others in terms of enzyme leakage.

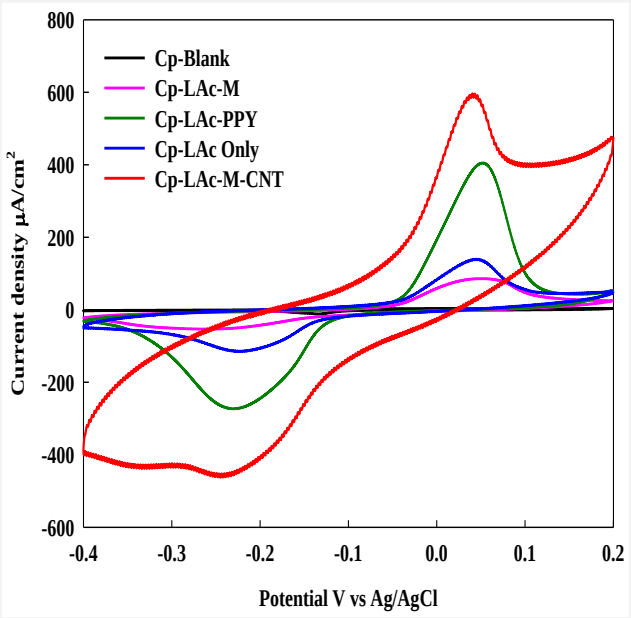
Bioanode **Effect of immobilization of hydrophobic carbon paper** **Biocathode**



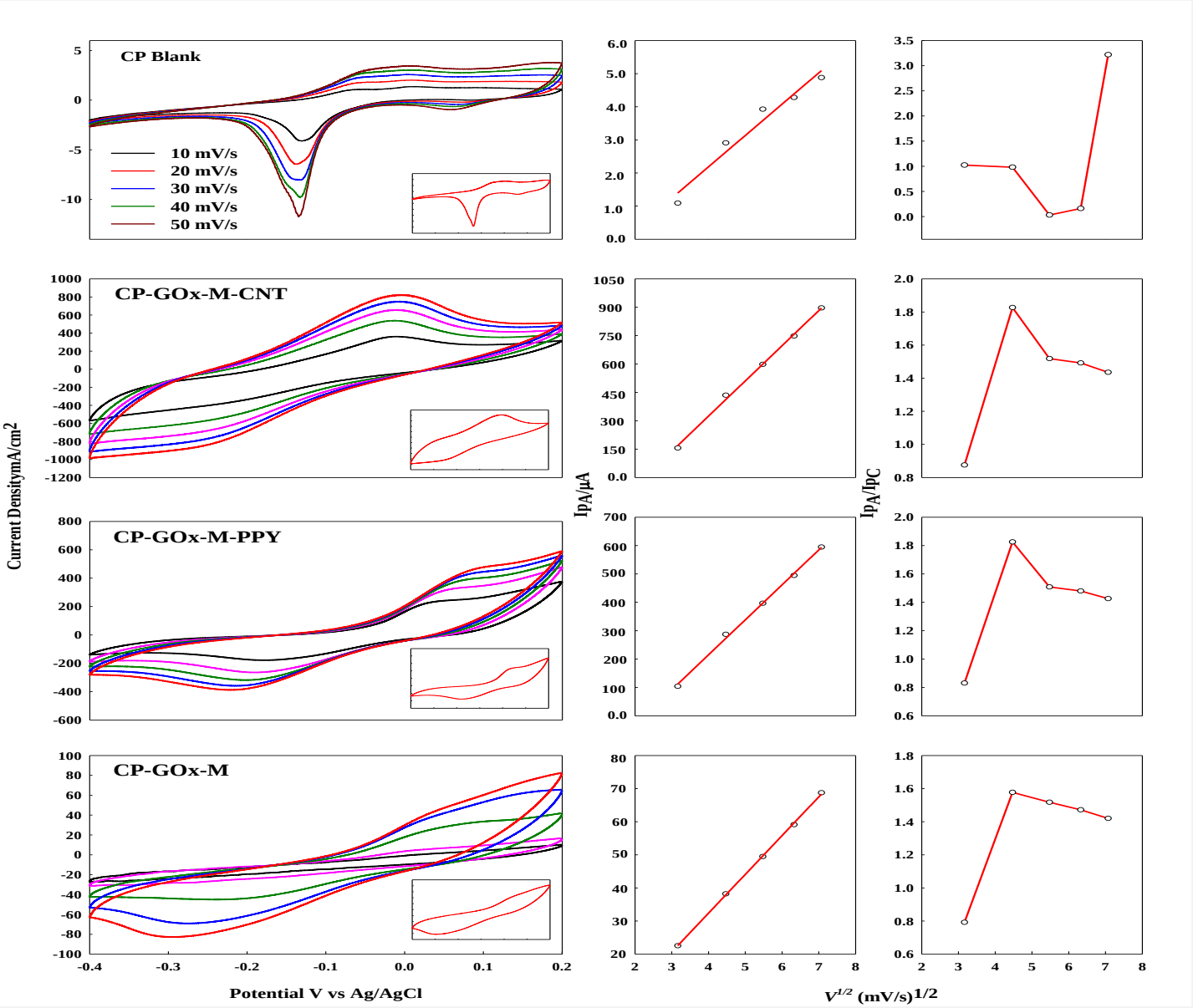


Bioanode **Effect of immobilization on hydrophilic carbon paper** **Biocathode**

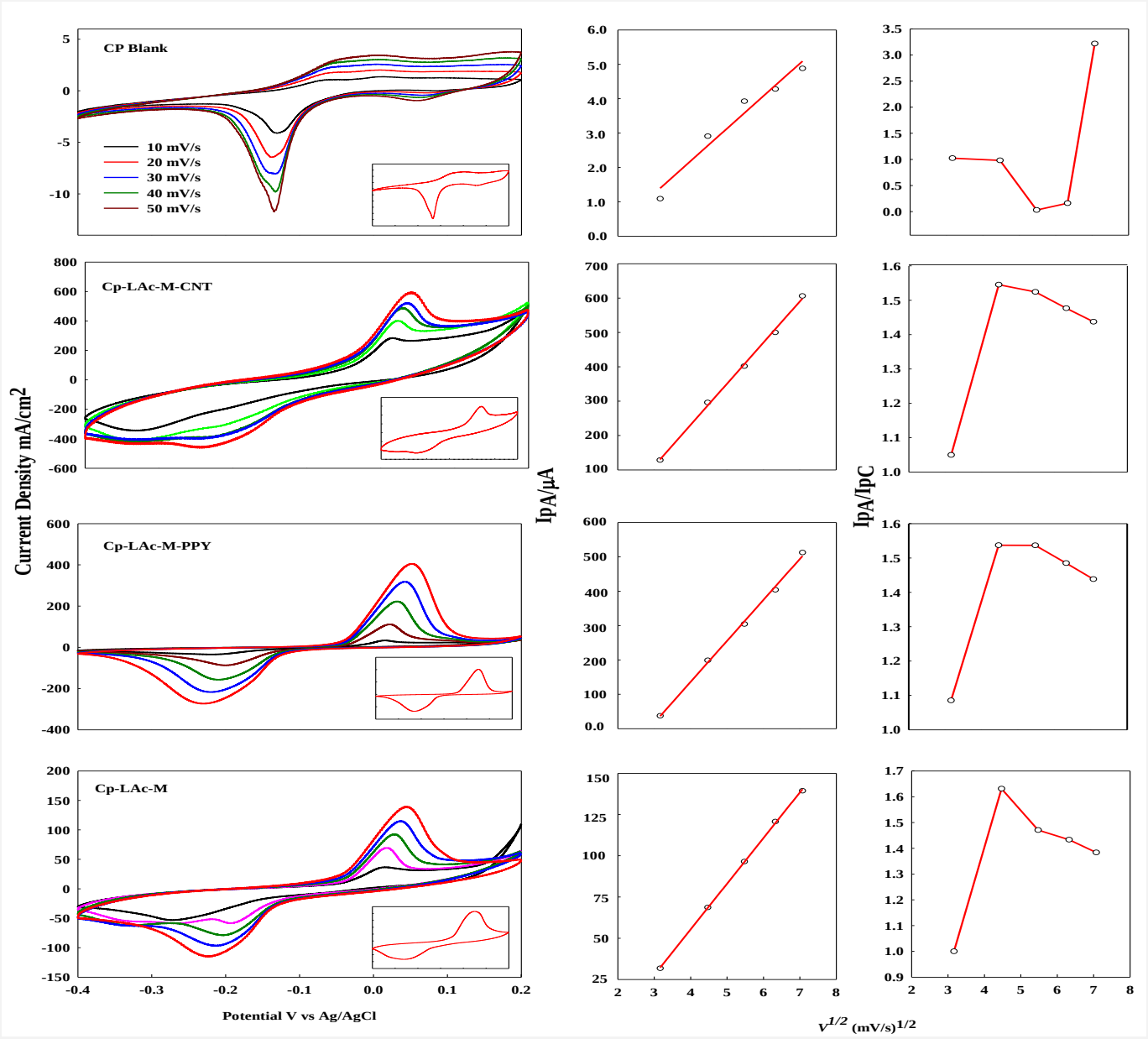




Effects of scan rate



cyclic voltammogram for the blank electrode and Bioanode electrode with different combinations at different scan rates (10-50) mV/s and with their corresponding diffusion coefficients and current ratio vs scan rate plot



cyclic voltammogram for the blank electrode and Biocathode electrode with different combinations at different scan rates (10-50) mV/s and with their corresponding diffusion coefficients and current ratio vs scan rate plot

Table 3-1 calculation of Bioanode and Biocathode voltammogram

Electrode	Epa (V)	Epc (V)	Ipa (A)	Ipc (A)	Slope cm/v s^{-1}	Scan rate V/s	Diffusion Coefficient (cm^2/s)
Blank	0.005	-0.147	7.17×10^{-6}	-3.141×10^{-6}	0.1891	0.02	7.02×10^{-6}
GOx-M-CNT	0.082	-0.256	5.798×10^{-4}	-3.174×10^{-4}	0.2479	0.02	9.2×10^{-6}
GOx-M-PPY	0.073	0.255	5.740×10^{-4}	-3.145×10^{-4}	0.2464	0.02	9.3×10^{-6}
GOx-M	0.064	-0.194	5.644×10^{-4}	-3.579×10^{-4}	0.2342	0.02	8.8×10^{-6}
LAc-M-CNT	0.044	-0.233	2.171×10^{-4}	-1.519×10^{-4}	0.2395	0.02	9.0×10^{-6}
LAc-M-PPY	0.049	0.234	2.434×10^{-4}	-1.793×10^{-4}	0.2384	0.02	8.9×10^{-6}
LAc-M	0.054	-0.203	2.563×10^{-4}	-1.889×10^{-4}	0.2314	0.02	8.7×10^{-6}

Note this results are calculated from different scan rate (10-50 mV/s) and the slope of the plot of Ip_a vs. $V^{1/2}$ (scan rate) and the slope corresponds to the diffusion coefficient.

