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Incorporation of Co-based catalysts with structures similar to those of Prussian Blue on printed electrodes for application in a water oxidation study

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Abstract

The hydrogen gas is a clean source of energy, which can be obtained from the water decompositon. In order to minimize the thermodynamical and kinetical limitations of the water oxidation process, a catalyst was synthesized, the Cobalt (II) Hexacyanoferrate (III). The synthesed compund was incorporated in the filaments of Polylactic Acid (PLA) with graphene for further print of 3D electrodes and study of this process.

Key words: *Cobalt (II) Hexacyanoferrate (III), 3D Printed Electrode, Water Oxidation Reaction.*

Introduction

The main source of energy generation is based on fossil fuels, whose burning generates gases that have an impact on the planet's climate change[1]. Thus, the demand for new means of energy generation has been increasing and the hydrogen gas emerges as clean energy source whose reaction produces water vapor.

Hydrogen gas (H_2) can be obtained through the reaction of hydrogen and oxygen evolution, the water electrolysis. This reaction is thermodynamically and kinetically unviable in neutral pH without the presence of catalysts[2].

Thereby, a catalyst analogue to Prussian blue, able to decompose water and stable at neutral pH[3] was developed, the $Co_3[Fe(CN)_6]_2$. The incorporation of this catalyst in 3D electrodes allows the expansion of the method to large scales[4], since the production of 3D electrodes has a low cost.

Results and Discussion

The catalyst, Cobalt (II) Hexacyanoferrate (III) ($Co_3[Fe(CN)_6]_2$) was synthesized from the reaction between Potassium Hexacyanoferrate (III) ($K_3[Fe(CN)_6]_2$) and Cobalt Chloride ($CoCl_2.6H_2O$). The powder formed, Image 1A, was characterized by several techniques, such as Infrared Spectroscopy, X-ray Diffractometry, TG, DSC, Raman Scattering and SEM-EDS (Scanning Electron Microscopy - Dispersive Energy Spectroscopy).

Image 2 represents the characterization by SEM-EDS, Image 2A shows the irregular shapes of the nanoparticles created, and Image 2B shows that the nanoparticles have an irregular surface.

The heating process was applied to incorporate the catalyst in the PLA with graphene filament, resulting in a homogeneous mass. The modified polymer was transformed into a filament using an extruder, as squematized in image 1B. This filament was used in the production of the electrode in the 3D printer and also was characterized by several techniques, as well as the catalyst.

A linear voltammetry experiment using a reference electrode of calomel and a counter electrode of platinum, in a solution of phosphate (pH 7), was performed in order to verify the electrocatalysis of the printed electrode and the result is represented in Image 3A. Analyzing the Tafel plot, Image 3B, made from the values of the linear voltammetry, it is possible to infer that the reaction is favorable, as the Tafel slope is low[5].

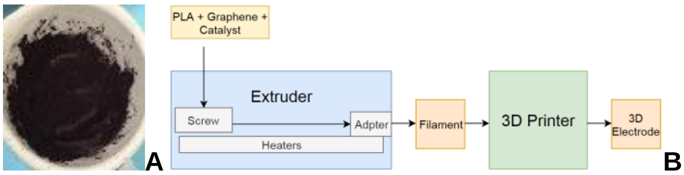

Image 1: (A) synthesized catalyst; (B) diagram of the extrusion process.

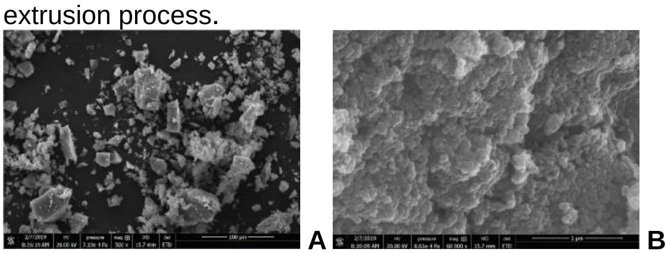

Image 2: Images obtained from the catalyst by SEM-EDS.

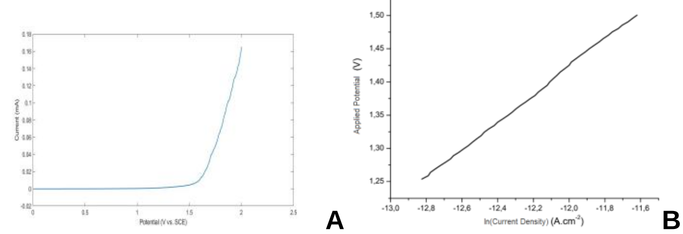

Image 3:(A) Linear voltammogram; (B) Tafel plot.

Conclusions

It is possible to observe that the catalyst, Cobalt (II) Hexacyanoferrate (III) ($Co_3[Fe(CN)_6]_2$), incorporated in the PLA with graphene filaments increases the conductivity of the electrode. This is observed by the current value obtained in the linear voltammetry and the low Tafel slope acquired, which allows the electrolysis of the water in neutral solutions. Thus, it is possible to obtain Hydrogen gas for the production of clean energy.

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