Lignin-based nanomaterials: towards a new generation of electrocatalyst

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Abstract

Proton Exchange Membrane Fuel Cells (PEMFCs) are one of the key technologies in the sustainable energy landscape. To date, their large-scale implementation is limited by high costs, primarily attributed to the active catalyst phase, such as platinum, and issues related to durability and stability. To address the high platinum demands, research is focusing on alternatives such as the use of catalysts with lower platinum loads. Additionally, Vulcan XC-72, the most utilized conducting carbon employed as support material, typically derives from coal, lignite or polymers which can be expensive and non-renewable. For this reason, producing activated carbon from waste and by-products have gained attention due to the availability of low-cost precursors. These new catalyst materials must have a high specific surface area and porosity to utilize the full potential of the active phase and achieve significant activity at low loading thanks to a fine and homogeneous dispersion of the metals. Electrospinning and colloidal syntheses are promising techniques to produce materials that can feature the above-mentioned properties [1]. Electrospinning allows the production of nanofibrous structures with high surface area and tailored porosity, which are ideal for catalyst supports. On the other hand, colloidal synthesis involves the reduction of metal precursors in liquid media, producing nanoparticles with controlled sizes and shapes.

Lignin, a complex biopolymer and biowaste from lignocellulosic biomass, is a renewable and cost-effective alternative to conventional sources for the production of catalytic materials. Furthermore, lignin is rich in phenolic and polyphenolic groups, which are crucial for the complexation of metals such as platinum and its reduction [2].

In this work, design, preparation and characterization of novel lignin-based electrocatalyst for FCs application is carried out.

The resulting lignin-based materials show promising properties. SEM-EDX imaging indicates a homogeneous and wide dispersion of platinum, attributed to the metal-binding capabilities of lignin's phenolic groups. XRD analysis confirms the presence of platinum (0), and BET surface area analysis reveals a high surface area, with both micropores and mesopores. These findings suggest that lignin-based electrospun materials could offer a viable, scalable, and more sustainable alternative for PEMFC catalyst supports. Further investigations will explore their electrochemical performance using techniques such as electrochemical impedance spectroscopy, cyclic voltammetry, and polarization curves measurements.

Keywords: PEMFC; Hydrogen; Biowaste; Lignin.

References:

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