Economical Oxygen Reduction Electrocatalysts: Alternatives to Platinum for Proton Exchange Membrane Fuel Cells

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Global warming is a significant threat to modern society caused by the burning of fossil fuels in order to meet everyday energy requirements. Renewable clean energy solutions such as solar and wind power are not as high-producing as carbon-based sources, but hydrogen-based electric energy is a viable alternative. Fuel cells are renewable, portable, efficient sources of hydrogen-based energy which do not add to carbon emissions; however, platinum is the primary material used as the catalyst which facilitates energy production. As a result of this, commercialization of fuel cell technology is prohibitively expensive. The goal of this project is to develop an economically viable cathode catalyst for proton exchange membrane fuel cells (PEMFCs). Three different metal catalysts (cobalt(III), iron(III), and copper(III)-based) with great potential are evaluated alongside three different nanomaterials (graphene, multiwalled carbon nanotubes (MWCNTs), and carbon black) in preparation of composites to replace platinum. After selecting the best-performing nanomaterial composite for each catalyst system, ratio and pH studies were undertaken in order to optimize ORR conditions. Polydopamine, a bio-inspired polymer was coated onto the best nanocomposite of each metal catalyst system to obtain more efficient catalyst with higher stability. Electrochemical techniques were used to perform the research. Cobalt-graphene nanocomposite (coated with PDA) was found to have the overall best peak potential at -105 mV. There was significant improvement in peak potential (51%, 55%, and 60% for copper, iron and cobalt respectively) after coating the nanocomposite with PDA. All three metal catalysts with nanomaterials and PDA demonstrate good activity for potential platinum replacements in PEMFCs

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