Impurities Contributing to Catalysis: More Efficient and Low Cost Fuel Cells

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Project Publications

1. Gumaa A. El-Nagar: Efficient Direct Formic Acid Fuel Cells (DFAFCs) Anode Derived from Seafood waste: Migration Mechanism. Scientific Reports 2017, 7, 17818-17829.
2. Gumaa A. El-Nagar, Auspicious Metal-Doped-Cu2O/Cu Dendrite Catalysts for Direct Alkaline Fuel Cells: Effect of Dopants, ECS Transactions 2017, 80, 1013-1022.
3. Gumaa A. El-Nagar, Enhanced electrooxidation of glucose at nano-chitosan-NiOOH modified GC electrode: fuel blends and hydrocarbon impurities. Physical Chemistry Chemical Physics 2017, 19, 2537-2548.
4. Gumaa A. El-Nagar, A promising N- doped carbon-metal oxide hybrid electrocatalyst derived from crustacean's shells: Oxygen reduction and oxygen evolution. Applied Catalysis B: Environmental 2017, 214, 137-147.
5. Gumaa A. El-Nagar, One-pot synthesis of a high performance chitosan-nickel oxyhydroxide nanocomposite for glucose fuel cell and electro-sensing applications. Applied Catalysis B: Environmental 2017, 204, 185-199
6. Gumaa A. El-Nagar, Impurity-Induced Electrocatalysis: Unpredicted Enhancement Effect of Ammonia Impurity towards Formic Acid Electro-Oxidation. ChemistrySelect 2016, 1, 5706-5711.

Project Summary

The global commercialization of fuel cells (FCs) is obstructed by the high cost of their Balance-of-Plant (BOP) components and commercial Pt-based electrodes, in addition to the low performance of their Pt-based commercial electrodes. See Figure 1 which is a diagram summarizing the project.

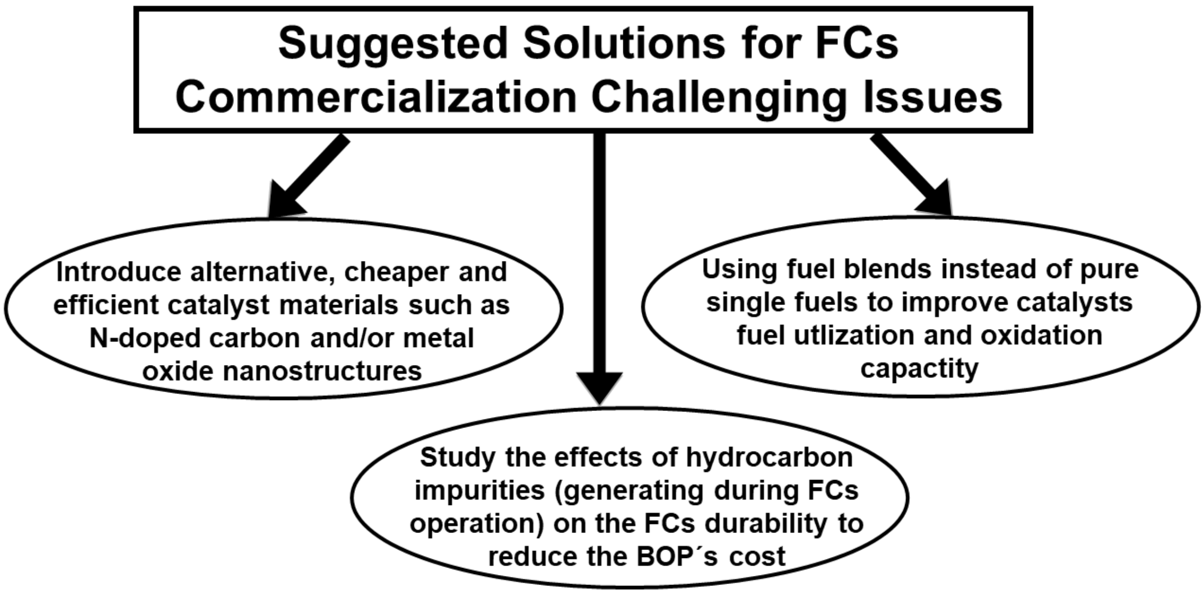

Figure 1: Diagram Summarizing the Project

Thus, this project is aiming to reduce the FCs cost without sacrificing their performance via:

1. Using Pt-free catalyst materials (non-PMG) such as metal oxide nanostructures and/or nitrogen-doped carbon materials as alternative, efficient, cheap electrodes for commercial Pt-based electrodes. For example, we used chitosan obtained from crustacean’s shells to create a nitrogen-doped graphitic structure with superior activity and durability for oxygen reduction reaction (see above article No. 4). Additionally, the chitosan matrix is also used for reducing the Pt nanoparticles amount concurrent with enhancing their active surface area, utilization and performance (activity and stability) for direct formic acid fuel cells (DFAFCs, see above article No. 1).

2. Reducing the balance-of-plant (BOP) components of FCs by investigating the effects of hydrocarbon impurities in-situ generated during FCs operation on the performance (activity and durability) of as-prepared non-precious metal

catalyst materials compared to commercial Pt-based electrodes. Recently, we reported the unexpected enhancement effects of some selected hydrocarbon impurities produced during FCs operation on the Pt-based electrodes of DFAFCs (see above article No. 6 and our previous publications in J Power Sources 265, 2014, 57-61, Electrochimica Acta 180, 2015, 268-279 & J Physical Chemistry C 118, 2014, 22464). Based on the obtained results in the above-mentioned articles, we could reduce the cost of BOP´s components along with enhancing the FCs performance.

3. Increasing the performance of FCs via using fuel blends (i.e., mixtures of two fuels) instead of single pure fuel. For instance, blending glucose with different molar ratios of methanol, ethanol and ethylene glycol results in a significant enhancement in the fuel utilization, NiOOH oxidation capacity and turnover number of oxidized glucose molecules compared to the pure fuels (see above article No. 3).