EXPERIMENTAL INVESTIGATION OF TRIODE ALCOHOL FUEL CELLS

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ABSTRACT

Alcohol fuel cells (AFCs) represent an environmentally friendly and efficient power generation technology converting alcohols chemical energy into electrical energy through electrochemical reactions. Renowned for their high energy density and reduced emissions, these cells find applications in transportation, portable power, and stationary power generation. However, challenges arise during alcohol electrooxidation, primarily associated with intermediate compounds like carbon monoxide, and reactive intermediates, causing catalyst poisoning and degradation, as well as undesirable cathodic side reactions due to intermediates crossover effects[1].

Studies focus on overcoming these drawbacks through catalyst development, improved membrane materials, and system design. AFCs triode operation is an alternative method, used to avoid the activation overpotentials that occur in an AFC due to the anode and cathode slow kinetics. This configuration includes a second circuit (through a third auxiliary electrode), which operates under electrolytic mode. Electrolytic operation of the auxiliary circuit has been found to enhance the overall power output. The successful application of triode operation has been reported recently[2] in Solid Oxide Fuel Cells (SOFCs), under hydrogen and steam reforming conditions, and H_2S poisoning conditions. Polymer Electrolyte Membrane (PEM) triode FCs have been also investigated under hydrogen and CO-poisoning conditions, leading to remarkable power output increase[3]. The enhancement was associated with catalyst work function change which leads to the chemisorption bonds strength modification of the reactants or other intermediates and thus in the catalytic rate modification[3].

Pt-Ru catalysts are by far the most appropriate choice for AFCs but with a prohibitive cost. Thus, a partial replacement of the quantity of these noble metals by cheaper active metals, such as Sn in conjunction with a high specific surface area (SSA) support utilization, such as Graphene nano-platelets (GNPs), could lead to novel low-cost electrocatalysts with high metal dispersion.

The present study is related to the utilization of triode operation in conjunction with the development of novel, nanodispersed, trimetallic Pt-Ru-Sn catalysts, supported on Vulcan and GNPs, as anodes in triode Direct AFCs. The widespread usage of AFCs especially those using fuels that can be potentially produced by waste by-products would contribute to the development of green technologies based on a circular economy.

KEYWORDS: fuel cells, alcohols, Pt-Ru-Sn, triode operation

REFERENCES

[1] Fadzillah DM, Kamarudin SK, Zainoodin MA, Masdar MS. (2019). Int. J. Hydrogen Energy, 44, 3031–3054.

[2] Caliandro P, Diethelm S, Nakajo A, Van herle J. (2015). ECS Trans, 68, 2387–2396.

[3] Martino E, Koilias G, Athanasiou M, Katsaounis A, Dimakopoulos Y, Tsamopoulos J, Vayenas CG. (2017) Electrochim. Acta, 248, 518–533.

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