Ru-SUPPORTED ANODE FOR IMPROVING CATALYTICAL PROPERTIES IN MOLTEN CARBONATE CO-ELECTROLYSIS FOR EFFICIENT E-FUELS SYNTHESIS

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The objective is to demonstrate a new fuel electrode solution for the innovative Molten Carbonate Electrolysis. The innovative material is a Ru-supported fuel electrode for Molten Carbonate Electrolysis, which aims to enhance the catalytic property of the standard fuel electrode and accelerate the reactions associated with the production of synthetic fuel. Molten Carbonate Electrolysis is a technology capable of converting a mixture of water and carbon dioxide into hydrogen, carbon monoxide, and various hydrocarbons in a single step using the co-electrolysis principle. This technology's advantage over other electrolyzers is its ability to produce fuel with a high energy density that contains hydrocarbons. The addition of a catalyst to a new fuel electrode is intended to accelerate the hydrocarbon conversion reaction, thereby enhancing the final fuel mixture. In this project, it is envisioned that a prototype of a new electrode will be manufactured with Ru proportions of 5%, 10%, and 15% in standard Ni-based slurry. The performance enhancement of the new electrodes for Molten Carbonate Electrolysis will be investigated by testing them in the lab. At the conclusion of the project, the prototype with the best performance will be prepared as the demonstrator and selected for future research.

Keywords: MCFC, MCE, electrolysis, electrodes, hydrogen

Introduction. Molten carbonate electrolysis is an innovative process, and the purpose of this project is to demonstrate a new fuel electrode solution for it. The novel substance is a Ru-supported fuel electrode for molten carbonate electrolysis. Its purpose is to improve the standard fuel electrode's catalytic property and to speed up the reactions associated with the production of synthetic fuel. Using the co-electrolysis principle, molten carbonate electrolysis is a process that can, in a single step, convert a mixture of water and carbon dioxide into hydrogen, carbon monoxide, and a variety of different hydrocarbons. The ability of this technology, in comparison to that of other electrolyzers, to produce fuel with a high energy density that also contains hydrocarbons is one of its primary advantages. The addition of a catalyst to a new fuel electrode has the purpose of accelerating the reaction that converts hydrocarbons, which in turn improves the fuel mixture that is produced in the end.

A new fabrication method based on tape casting is proposed to produce microporous electrodes with a support as a nickel foam layer. An alternative to traditional anodes, these new materials were tested for power density and compared against current state-of-the-art standards. The expected results of utilization of catalytically active metals for high temperature fuel cell electrodes is advantageous from a technological standpoint, particularly when mass production is involved. Additionally, having a new component as reaction support provided an increase in fuel cell power density.

It is projected that during the course of this project, a prototype of a new electrode will be fabricated using Ru with different concentrations in a slurry that is primarily composed of nickel. The potential for the newly developed electrodes to improve the performance of the Molten Carbonate Electrolysis process will be investigated through laboratory testing. At the conclusion of the project, the prototype that has demonstrated the highest level of performance will be chosen to serve as a demonstrator and will be the focus of subsequent research.

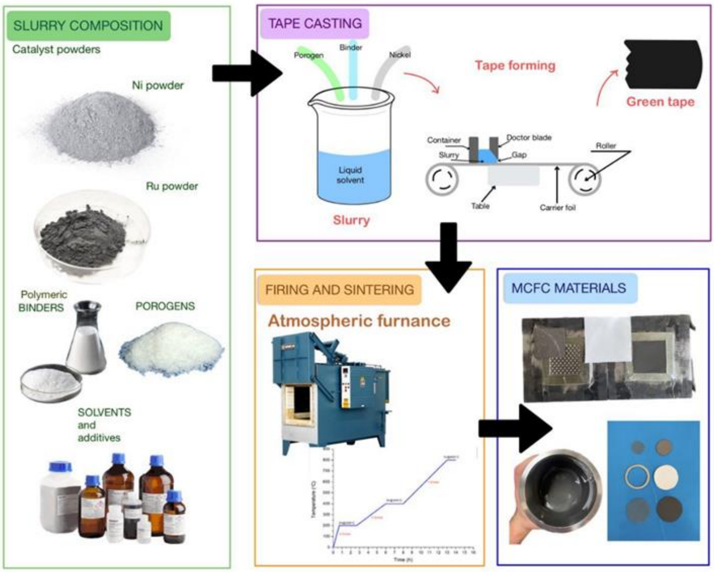

Fig. 1. The manufacturing plan for novel Ru-supported fuel electrodes.

The research plan is to manufacture and test Ru as an additive for anode electrode in portion of 1%, 5%, 10% and 15%. The fabrication of MCFC electrodes involved a tape casting process, beginning with the preparation of a slurry containing nickel and ruthenium powder, solvents, binders and other additives. This mixture is then dried and fired to form the green tapes, which are used to form the anodes and cathodes (as shown in Fig. 1).

In the initial phase of creating anodes in the manufacturing of fuel electrodes, cyclohexanone, polyethylene glycol, fish oil, and polyvinyl butyral are combined. The mixture is then agitated at 250 rpm for 2 hours under vacuum conditions. Later, pure Ni powder (99.9% purity with average particle size e6 mm) together with Ru powder are added as solid content. The slurry is churned again under comparable time and vacuum circumstances before being distributed on flat glass substrates using tape casting with a 1.5 mm 'doctor blade' gap; it must then be dried at 80°C for 8 hours. The resultant green tapes are then sintered under a hydrogen/nitrogen reducing environment at 900°C for 1 hour.

In order to investigate performance of new material, the electrodes are then assembled with other MCE components and tested in a single-cell testing rig where voltage, current density and power density are measured under real conditions. The cells are conditioned for 21 hours in air at temperatures of 25-450°C, followed by heating for 13 hours in an H_2/CO_2 rich atmosphere at temperatures of 450…650°C in order to melt the carbonates.

The electrodes will be examined for their energy efficiency and electrochemical performance using MCE. After conditioning, four series of tests are conducted at 650°C while feeding the fuel gas $(H_2)80/(CO_2)$ 20% and the oxidant gas (Air)70/(CO_2) 30%. The reference gas fluxes for this experiment are hydrogen at 2.2 ml/cm^2/min and carbon dioxide at 0.55 ml/cm^2/min at the anode, and air at 6.2 ml/cm2 /min and carbon dioxide at 2.66 ml/cm^2/min at the cathode. The cell resistance is monitored with an HIOKI 3560 AC mU HiTESTER (four wires, 1 kHz), while the gas composition and flow rates are regulated by Brooks 5850E Digital Mass Flow Controllers because of their high levels of precision, which could be operated through software via serial PC ports. A DC electronic load (SAE Electronic Conversion SRL) is used to provide load demand. LabVIEW® software is utilized to administer and monitor all common control systems. During charging, the cell voltage is measured directly at the electrodes. The scan rate is set to 0.1 percent of the maximum current value per second, and measurements are taken at least every 10 seconds.

The investigation based on comparing different amounts of Ru added will indicate which manufacture sample is promising for the manufacturing and scale-up. This single selected sample will be demonstrated as a novel material protype as the result of the project. Its manufacturing procedure will be described in detail and analyzed for scale-up feasibility. As a beneficial point of this solution can be mentioned that mostly classic production methods remain unchanged which means that new equipment is not needed therefore such a solution is cost-effective.