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EFFECT OF IONIC CONDUCTIVITY AND EXCHANGE CURRENT DENSITY ON THE PERFORMANCE OF A DIRECT AMMONIA SOLID OXIDE FUEL CELL (DA-SOFC)

Brayn Díaz[a], Yuniel Martínez[a,b], Magdalena Walczak[a,b], Diego Celentano[a,b] and Loreto Troncoso[a,c]

[a]*Millennium Institute on Green Ammonia as Energy Vector (MIGA), Av. Vicuña Mackenna 4860, Macul, Santiago de Chile, RM, Chile, brayn.diaz@ug.uchile.cl, https://greenammoniainstitute.cl/en/*

[b]*Departamento de Ingeniería Mecánica y Metalúrgica, Escuela de Ingeniería, Pontificia Universidad Católica de Chile, Av. Vicuña Mackenna 4860, Macul, Santiago de Chile, RM, Chile, mwalczak@uc.cl, https://www.ing.uc.cl/mecanica-y-metalurgica/*

[c]*Instituto de Mecánica, Facultad de Ciencias de la Ingeniería, Universidad Austral de Chile, General Lagos 286, Valdivia, Chile, loreto.troncoso@uach.cl, https://ingenieria.uach.cl/*

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Abstract. Climate change has pushed researchers to seek alternatives to standard fossil fuel technologies. Fuel cells have grown in popularity as a way to convert fuels such as hydrogen, ammonia or methane into electricity, with solid oxide fuel cells (SOFCs) being noted for their potential to achieve high efficiency and power output. Direct ammonia SOFCs (DA-SOFCs) operate at high temperatures to crack ammonia into hydrogen at the anode, and use it on electrochemical reactions that produce energy and water. Improving the performance of these devices is an active area of research: from material design, to geometric configuration and operational parameters. In this context, mathematical modeling is an extremely useful tool once validated, as a given setup can be simulated and analyzed reducing the number of experimental measurements. This work uses a multiphysics model to study the effect of three different parameters related to electrode materials on the cell's performance: exchange current density and ionic conductivity at the cathode, and exchange current density at the anode. The model itself consists of algebraic and differential equations describing chemical reactions; ionic and electronic current; heat flow across gas, solid and porous domains; species transport, and fluid flow in porous media. The model is implemented in COMSOL Multiphysics® and solved using finite element methods. Polarization voltage sweeps for three different furnace temperatures are employed to capture performance under a variety of circumstances. For each temperature, polarization and power versus current curves are compared to experimental results with the goal to analyze the behavior of the studied parameters as well as the cell's response. Results show that the endothermic nature of ammonia cracking reactions affect temperature at the anode, emphasizing the importance of dependency of parameters on said variable.

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