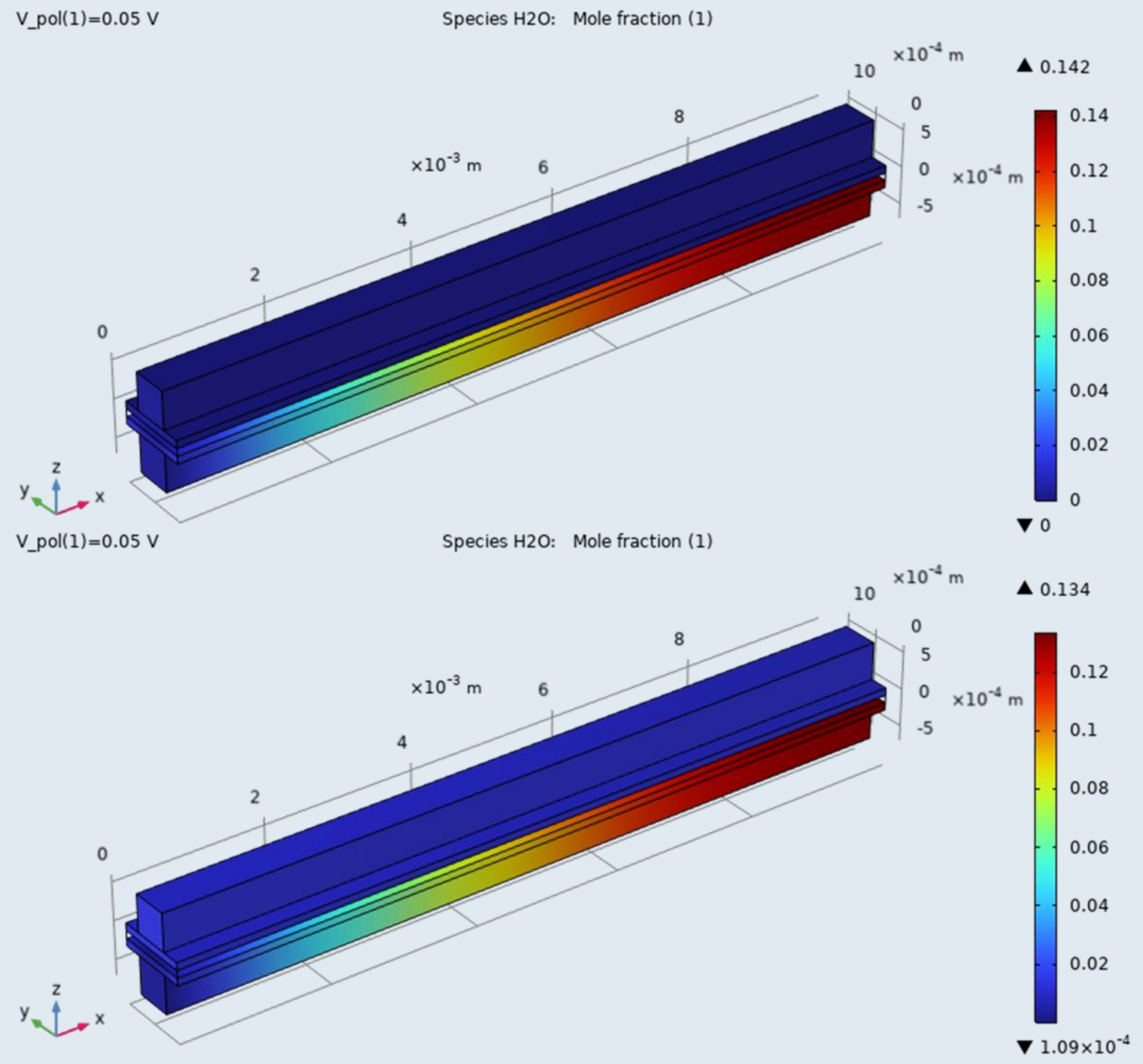

Bio-syngas fueled operation of a Solid Oxide Fuel Cell-Numerical simulations in COMSOL and experimental validation

COMSOL Multiphysics is employed to develop a numerical model of Solid Oxide Fuel Cell to study the intricate interactions

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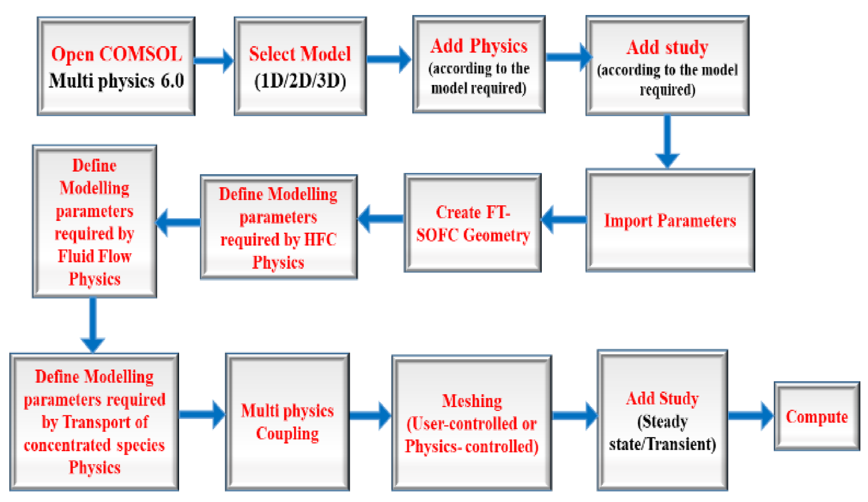
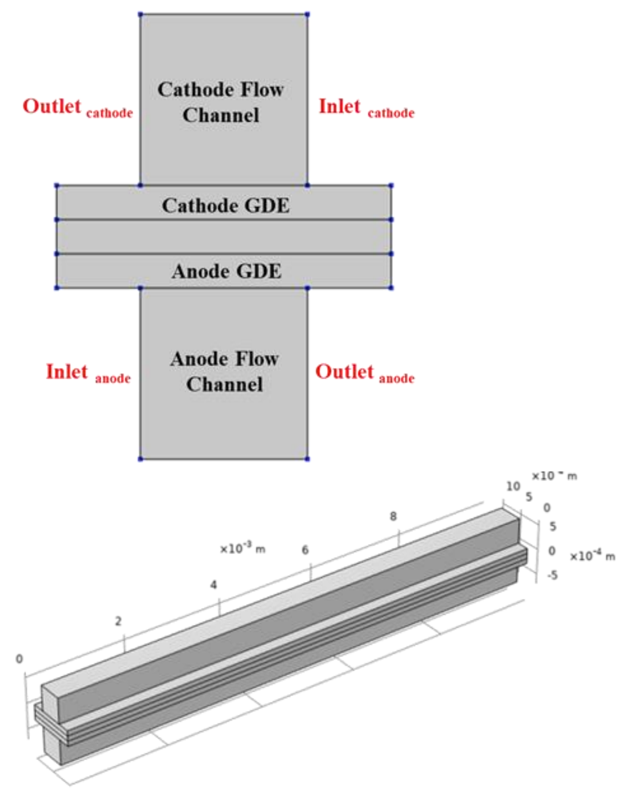
Abstract

This study focuses on modeling and analysis of an SOFC of flat tubular cell geometry, and between using air and oxygen as cathode fuels and explores two distinct bio-syngas compositions employed as the anode fuel. COMSOL Multiphysics is used to integrate various physical phenomena such as mass transport, charge-transfer kinetics, flow distribution in gas channels/ porous electrodes, electrochemical reactions and heat transfer. The current and power values of syngas and producer gas fueled SOFCs in an oxygen environment are 5724 A/m^2 and 1789 W/m^2 (syngas) and 3737 A/m^2 and 1369 W/cm^2 (producer gas), respectively. It is observed that syngas/producer gas operated with oxygen as cathode fuel resulted in a maximum current and power values than air as cathode fuel, due to the dilution effects Nitrogen in air. The study gives an understanding of syngas-fueled and producer gas-fueled SOFCs and the influence of cathode fuel selection on their performance.





Composition (%)	Syngas 1	Syngas 2
H_2	50	42.5
CO_2	32.5	26.5
CO	12.5	17.5
CH_4	5	3.5
N_2	0	10

Figure 1:Left - Fuel cell modelling steps in COMSOL Multiphysics. Right - Geometric representation of FT-SOFC Constructed employing COMSOL Multiphysics in 2D and 3D. Table 1: Composition of simulated Bio-syngas employed as anode fuel feed in a Flat-tubular SOFC model

Methodology

- COMSOL Multiphysics version 6.0 to create a numerical model for a Flat Tubular Solid Oxide Fuel Cell (FT-SOFC) is employed.
- 3-D model which includes various components such as the anode flow channel, anode Gas Diffusion Electrode (GDE), Ni-YSZ membrane, cathode GDE, and cathode flow channel is constructed.
- Performance of the model is studied using simulated bio-syngas of two different composition (Table 1) in an oxygen and air environment.
- Performance is assessed through polarization and power curves, distribution of species within the fuel cell, velocity profiles, pressure distribution, and electrochemical behavior of the FT-SOFC model

Results

- In O_2 environment, current and power values are recorded at 5724 A/m² and 1789.8 W/m², respectively for Syngas-1. These values are slightly lower, with a current of 5378 A/m² and power of 1735.7 W/m², for Syngas 2. But Syngas-2 showed higher values than Syngas-1 under air environment.
- Air as oxidizing medium has significant impact on various factors influencing SOFC performance – activation, ohmic, and mass transport losses and electrochemical performance.
- The electrolyte potential of FT-SOFC in an O_2 rich environment is higher than in air, due to the high oxide ion mobility from oxygen rich fuel for electrochemical reactions to takes place,

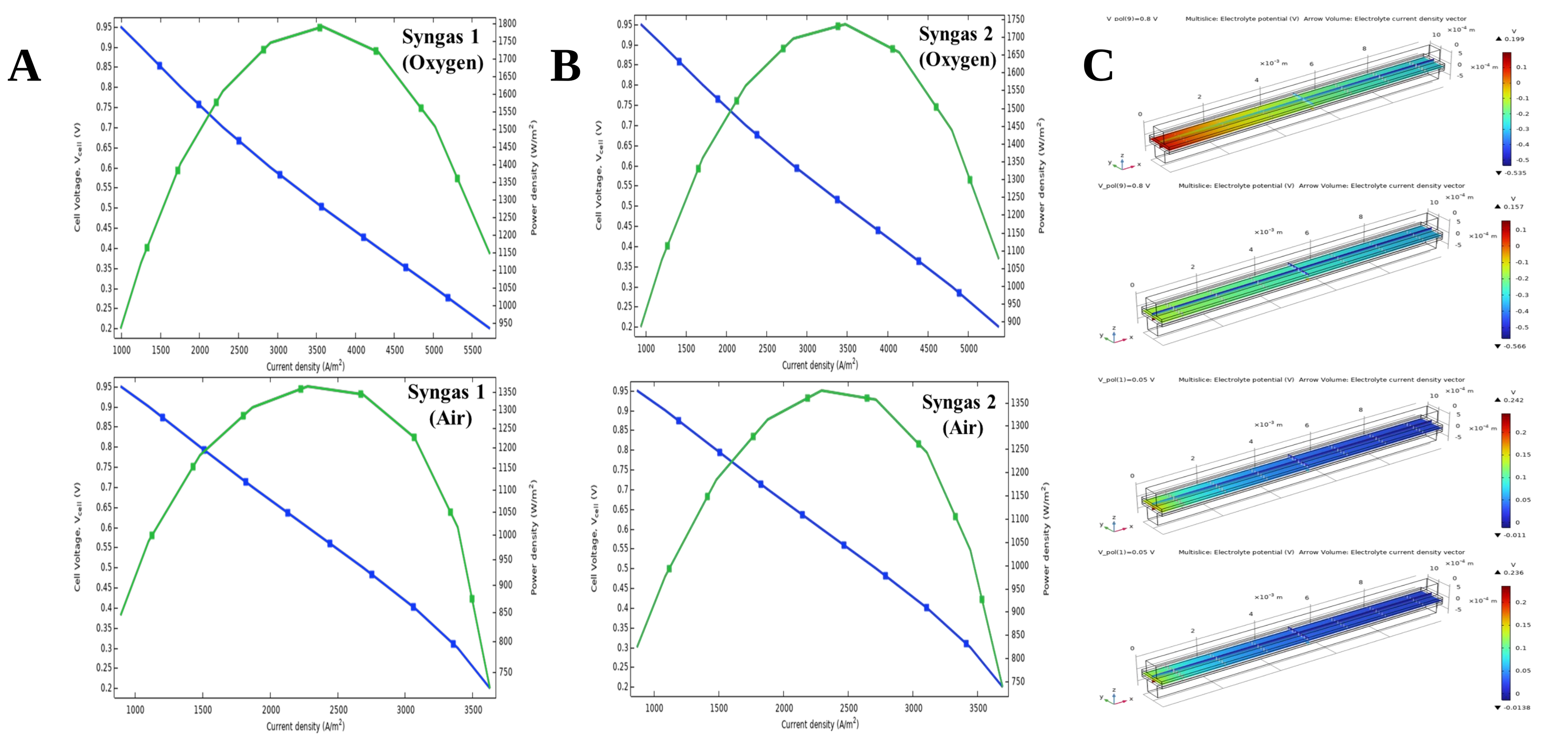


Figure 2: A - Polarization and Power Curves of Modeled FT-SOFC at syngas-1 composition in an Oxygen and air environment
B - Polarization and Power Curves of Modeled FT-SOFC at syngas-2 composition in an Oxygen and air environment
C - Distribution of electrolyte potential and electrolyte current density vector of syngas-1 in an air and oxygen environment simulated at 0.05 V & 0.8 V. Multislice: Electrolyte potential (V) & Arrow volume: Electrolyte current density vector

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