Ammonia to electricity: performance and stability of a Solid Oxide Fuel Cell

Semester Project (10 ECTS)

Administrative

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Remarks: If interested, please send your CV, with a short motivation letter, to Cedric Frantz and Michele Bruno

Project description:

Ammonia is an essential chemical commodity that is increasingly recognized as a promising energy carrier for a sustainable energy transition. When synthesized from renewable hydrogen and nitrogen, it provides an efficient means of storing and transporting hydrogen, helping to overcome the challenges associated with hydrogen's low volumetric energy density. In this context, Solid Oxide Fuel Cells (SOFCs) offer a particularly advantageous route for ammonia utilisation. Operating at high temperatures, SOFCs can internally crack ammonia into hydrogen and nitrogen ($2\mathrm{NH_3} \rightarrow \mathrm{N_2} + 3\mathrm{H_2}$), enabling direct conversion to electricity with efficiencies exceeding 70%. This integrated process minimises energy losses compared to systems relying on external ammonia cracking or low-temperature fuel cells.
The proposed project, within the framework of *AMON EU project*, will investigate the direct use of ammonia in SOFC systems for stationary power generation and maritime applications. The study will focus on SOFC electrochemical performance, stability, and degradation mechanisms, contributing to the broader objective of enabling efficient and scalable technologies for the renewable ammonia economy.

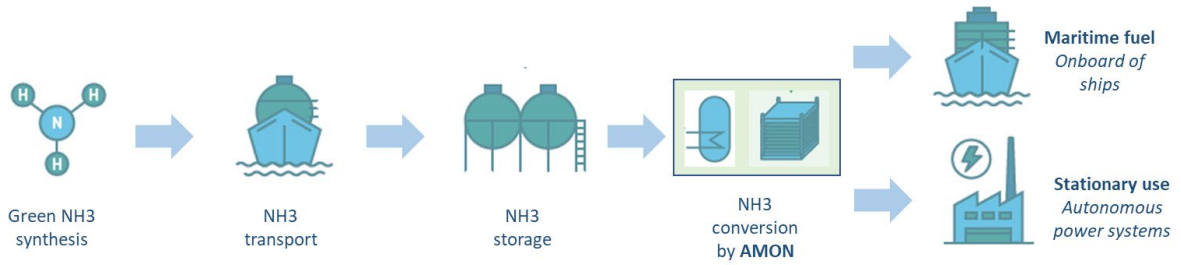

Figure 1 - Ammonia as a hydrogen carrier and relevant end uses (AMON EU project).

Your tasks:

The objective of this work is to conduct an initial screening of a single SOFC cell by varying key operating parameters, temperature, fuel utilization, and gas composition, to assess the influence of ammonia on cell performance and degradation. The student will gain hands-on experience with essential electrochemical techniques, including cyclic voltammetry and Electrochemical Impedance Spectroscopy (EIS), and will learn how to interpret and analyze the resulting data. Additionally, the student will acquire practical skills in handling ammonia-containing gas mixtures and conducting gas analysis. The work will include the following tasks:

a) Literature review on high-temperature ammonia reactions, with emphasis on ammonia cracking.
b) Introduction to the laboratory and the experimental stations.
c) Experimental work, including variation of SOFC operating conditions, execution of cyclic voltammetry, EIS measurements, and gas analysis.
d) Data analysis, involving EIS interpretation using Distribution of Relaxation Times (DRT) and Complex Nonlinear Least Squares (CNLS) fitting with internally developed software.