High Rate Ammonia Synthesis by Intermediate Temperature Solid-state Alkaline Electrolyzer

Storagenergy Technologies Inc.: Feng Zhao, Jared Liao and Byron Millet
Subcontractors: Iowa State University: Wenzhen Li, Yifu Chen; Pennsylvania State University: Michael Janik, Yawei Lee
Technical & Business Contact: Feng Zhao, 801-386-8555, fzho@storagenergy.com

Introduction

- Ammonia Synthesis Methods
  (1) Haber-Bosch Process
    - N2 and H2 reacting at 15–25 MPa and between 400–500°C
    - Energy and capital intensive approach
  (2) Electrochemical synthesis
    - Low temperature, pressure, energy input, and emissions
    - Enables networks of distributed scale and near point-of-use
- Issues of Current Electrochemical Synthesis Methods
  - Only molten salt system operating at intermediate temperature range
  - Low ammonia production rate due to lack of highly active NRR catalyst
  - Low selectivity of nitrogen reduction due to HER
  - Poor stability using liquid based and proton-conducting electrolyte

Our Approach

We will develop a game-changing intermediate temperature (100–300°C) solid-state alkaline electrolyzer (ITSAE) for high-rate ammonia production from nitrogen/air and steam electrolysis based on following innovations:

(1) Cost-effective and intermediate temperature highly OH- conducting solid membrane
(2) Nanostructured Fe2O3-based bimetal oxide nitrogen reduction reaction (NRR) cathode catalyst
(3) Advanced solid composite electrode structure
(4) Noble metal-free oxygen evolution reaction (OER) anode catalyst

Work Plan

- Develop large ITSAE membrane with thickness of ≤50 µm and ASR of ≤0.125 Ω cm²
- Develop highly active and selective Fe based bimetallic oxide NRR cathode
- Use DFT methods to elucidate elementary reaction mechanisms and guide catalyst design
- Optimize MEA and ITSAE operation conditions
- Demonstrate ITSAE stack with productivity of 100 g/day
- Techno-economic- analysis and Technology to Market

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