DTU Physics
Department of Physics

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Benchmarking Electrochemical Nitrogen Reduction and Ammonia Production

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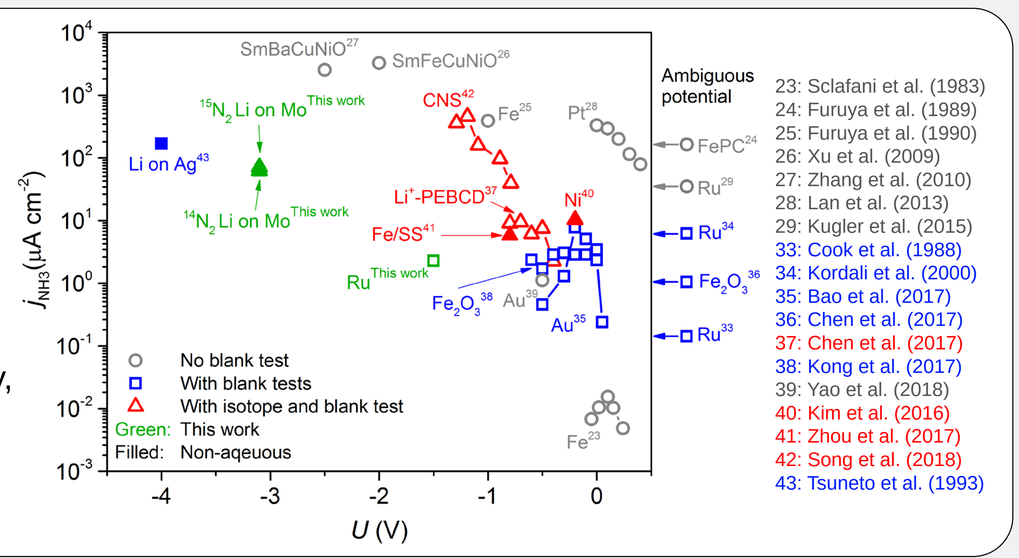
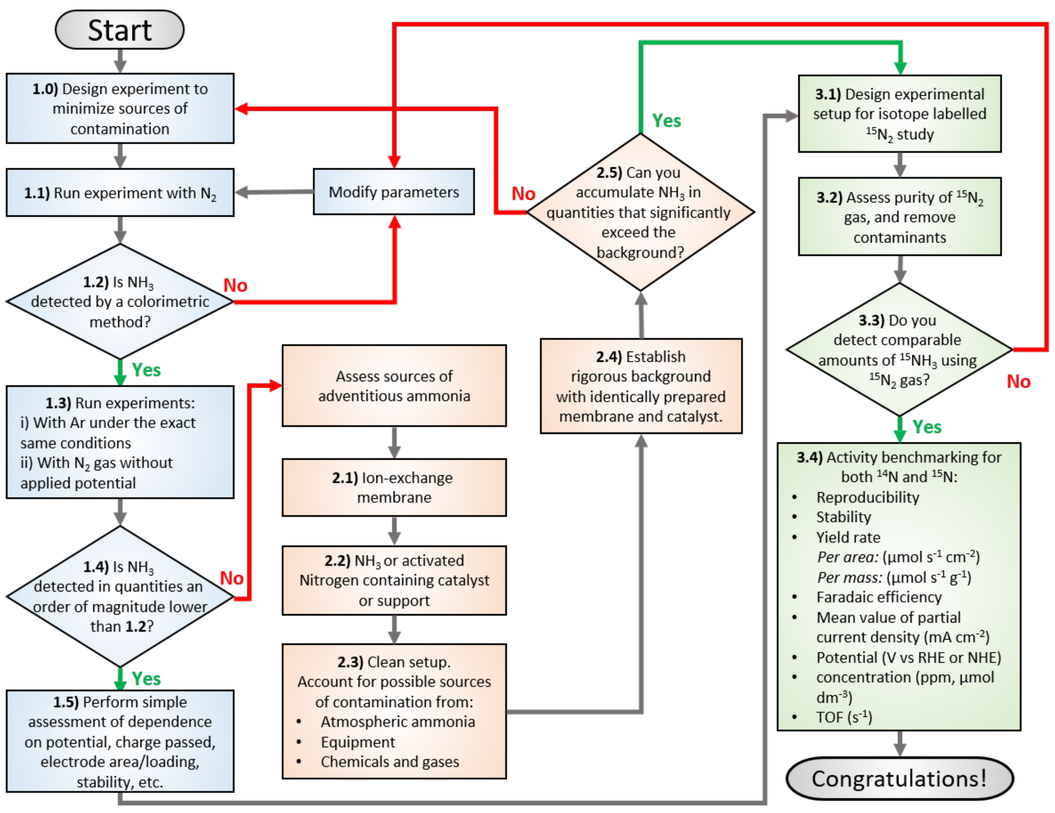
Introduction and State-of-the-Art

Industrial ammonia production via the Haber Bosch process uses ~1% of the global energy, requiring high temperatures (400-500 °C), high pressures (15-25 MPa), and steam reformed methane. An electrochemical approach to synthesizing ammonia could proceed under ambient conditions, needing only water and air as reactants.

Unfortunately most electrochemical studies report low selectivity and activity, and these low quantities of measured ammonia can easily be contaminated. We therefore propose a rigorous benchmarking protocol, which enables reliable detection and quantification of electrochemically produced ammonia.



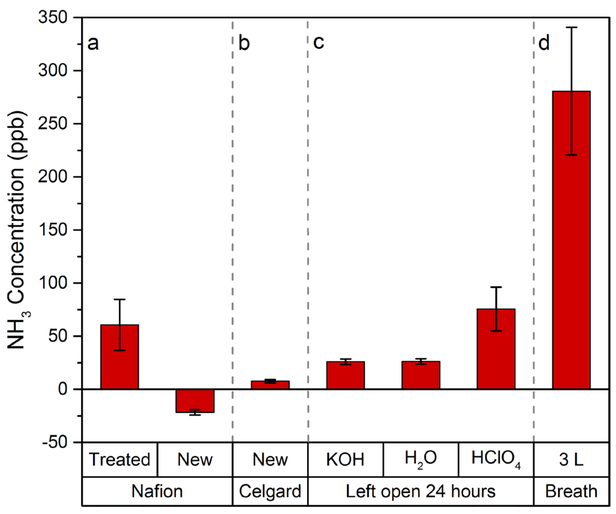
The Benchmarking Protocol



1.0 Potential Contamination Sources

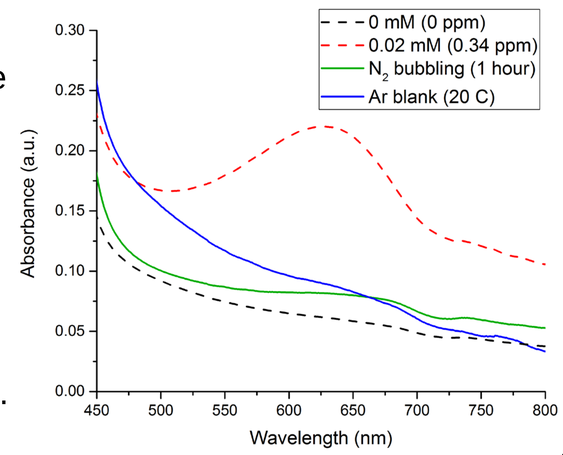
Common sources of adventitious ammonia:

- The setup itself
- Nitrogen containing electrolyte, electrodes, cleaning procedures, etc.
- Ion exchange membrane
- The researcher
- Laboratory air
- N_2 gas bottles



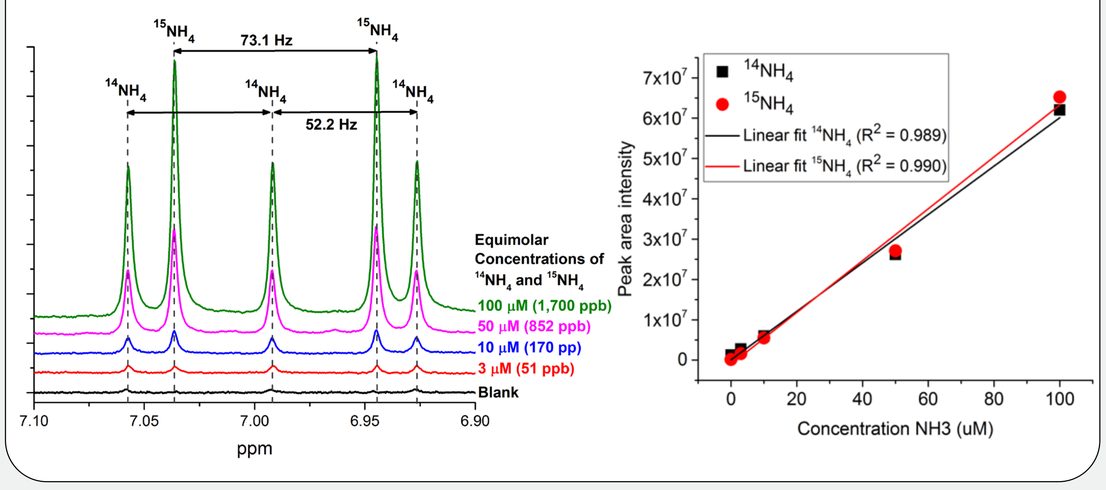
1.3 Background measurements

- Background measurements provide an initial estimate of the level of contamination.
- Run measurements with:
  - Ar gas, similar potential
  - N_2, no applied potential
- These tests should give negligible amounts of ammonia.



3.1 NMR Isotope Labelled Measurements

- A crucial proof for successful N_2 reduction is done by utilizing $^{15}N_2$ and measuring $^{15}NH_3$ as the main ammonia product.



Conclusion and Outlook

- Utilizing the protocol minimizes or eliminates spurious results.
- Isotope labelled experiments is a crucial and necessary step.
- It allows scientists to distinguish false positives from real breakthroughs, and provides the field with a benchmarking standard.

References

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