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Plasma Conversions

This research will focus on nitrogen fixation from air, water and electrical energy as a sustainable route to store renewable electricity in chemical bonds.

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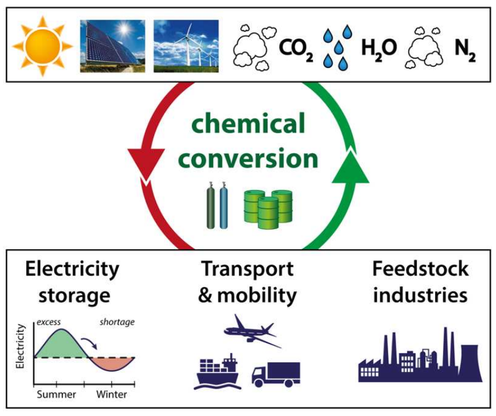
Partners DIFFER, Nouryon, OCI Nitrogen, University of Twente, Vopak, Yara

Budget 1 160 k€

Duration 2018-2020

Incentive

One of the greatest challenges of our era is the substitution of fossil feedstock as energy sources with renewable energy ones. However, due to their intermittent nature and the harvesting in the form of electricity, their direct introduction into the value chain of e.g. chemical industry remains challenging. Therefore, technologies based on renewable electricity that can transform base molecules (i.e. H_2O, N_2, CO_2) into energy or chemical rich ones have attracted tremendous interest.



Objective

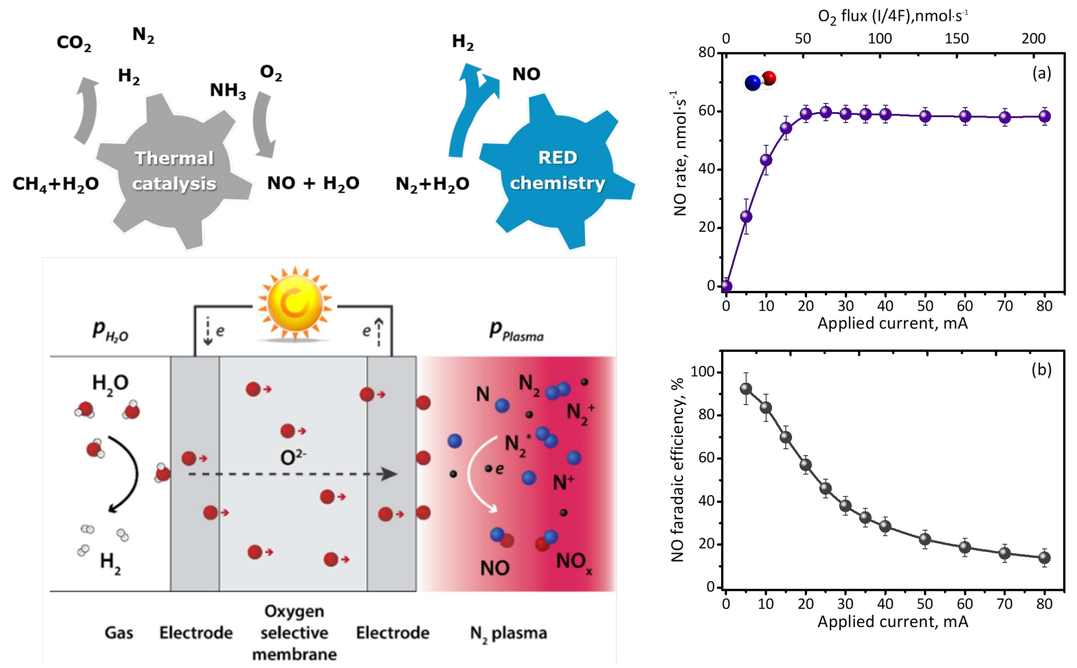
Among the three base molecules, N_2 is by far the least reactive since the N≡N triple bond is very strong and difficult to activate due to the absence of a permanent dipole. Consequently, even with the best catalysts known to date a substantial energy input is required to activate N_2. At industrial level nitrogen fixation is realized via ammonia and nitric oxide synthesis. Our objective is to develop renewable energy driven approaches for nitrogen fixation.

Approach

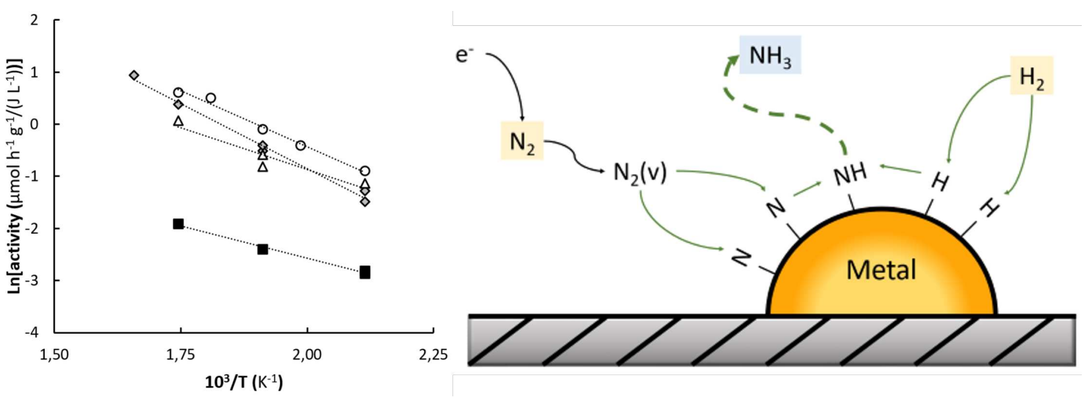
The novelty of our approach is based on the space (UTwente) or space (DIFFER) separation of reactants. Thus plasma activated nitrogen species are generated separately from the hydrogen (or oxygen) species for the ammonia (or nitric oxide) generation. Hydrogen (or oxygen) species are provided through a solid oxide membrane or at different time steps.

Results

DIFFER: We demonstrated that surface generated oxygen by means of a solid oxide electrolyte membrane is reacted with activated nitrogen gas for the first time, paving the way for an innovative all electric nitrogen fixation pathway. It is worthwhile to note the counter product of the electrolysis reaction i.e. hydrogen is also a commercially viable compound in addition to being a topic of research for the hydrogen economy (Patel et al, ACS Energy Lett. 2019).



UTwente: We demonstrated with experimental data that plasma-enhanced catalytic ammonia synthesis can occur via plasma-excited N2 molecules in a DBD reactor (Rouwenhorst et al., ACS Sustain Chem Eng. 2019), which was a postulate previously proposed by Mehta et al. Nat. Catal., 2018.



Recommendation

Plasma-assisted NOx synthesis shows better potential, due to the potential lower energy consumption, and the lower capital expenditure as compared to the Haber-Bosch process + Ostwald process. Therefore, future research should focus on enhancing the production rate and lowering the energy consumption for plasma-assisted NOx synthesis.

Institute for Sustainable Process Technology

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