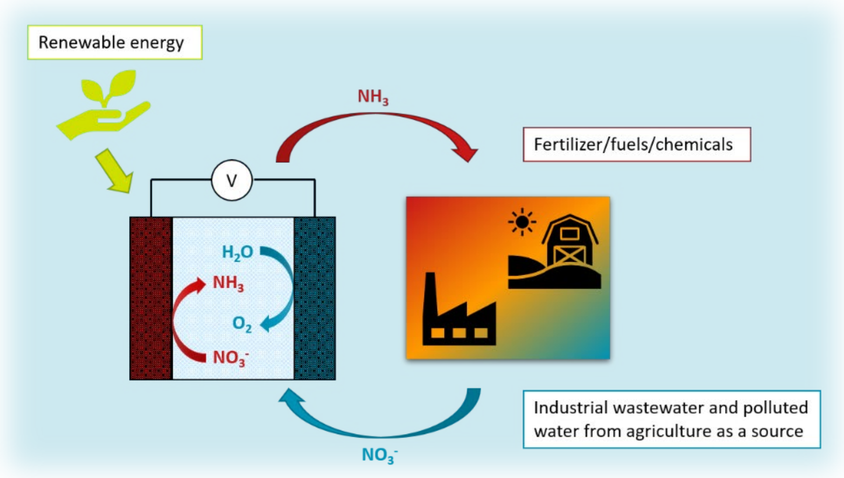
Inorganic Materials & catalysis
Electrocatalysis
Research Project – Emiel Hensen/Marta Costa Figueiredo/Yvette van Beek

INORGANIC MATERIALS & CATALYSIS

Electrochemical reduction of nitrate/nitrite for ammonia production

Background



Ammonia is widely considered to be an important building block for many chemical processes, e.g. fertilizers, fuels, and fine chemicals [1]–[3]. Until now the Haber-Bosch process has been considered as the major source for industrial ammonia production. It requires harsh conditions (200-300 bar and 400-500 ºC) and demands ~1.4% of the world energy supply, resulting in a carbon footprint of 1.5 ton CO_2 per ton of ammonia produced [4]. The electrochemical synthesis of ammonia recently gained interest because it allows a more sustainable and local production of ammonia, eliminating the large costs that come from inflexible Haber-Bosch plants and reducing environmental hazards associated with runoff and the use of hydrogen that leads to increasing CO_2 emissions [5]. A possible route towards NH_3 is the electroreduction of nitrates and nitrites (NO_3^-/NO_2^-) via an eight (1) and six (2) electron transfer process:

$$NO_3^- + 6\,H_2O + 8\,e^- \rightarrow NH_3 + 9\,OH^- \quad (1)$$

$$NO_2^- + 5\,H_2O + 6\,e^- \rightarrow NH_3 + 7\,OH^- \quad (2)$$

An increasing number of studies focusses on the electrochemical route towards ammonia [6]–[13]. Interest lies in NO_3^-/NO_2^- reduction since it is kinetically more accessible than breaking the triple bond in N_2. Additionally, electrochemical reduction of NO_3^-/NO_2^- seems a feasible route to reduce water pollution that jeopardizes our environment and health [14]. In line with this, the electrochemical reduction of NO_3^-/NO_2^- for ammonia synthesis is a promising route to restore the nitrogen cycle and creates an attractive route where ammonia production can be decentralized fuelled by renewable energy [15].

Techniques used:

- Preparation and characterization (e.g. SEM, XRD, XPS) of novel catalyst materials for the electroreduction of NO_3^-/NO_2^- to NH_3;
- Electrochemical techniques (e.g. CV, LSV) to study the reaction mechanism;
- Analytical techniques (e.g. NMR, GC-MS, HPLC, DEMS) to study obtained reaction products;
- Optimization of catalyst and reaction conditions for electrochemical cell configuration.

For further information:

Emiel Hensen (Helix, STW 3.33), Tel 5178, e.j.m.hensen@tue.nl
Marta Costa Figueiredo (Helix, STW 3.43), Tel 6310, m.c.costa.figueiredo@tue.nl
Yvette van Beek (Helix, STW 3.37), y.v.beek@tue.nl

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