Nitride materials as possible electrodes for NH_3 reversible fuel cells

Vanessa C.D.Graça, Laura I.V.Holz, Maria A.Salvador, Sergey M.Mikhalev, Francisco J.A.Loureiro, Duncan P.Fagg

Centre for Mechanical Technology and Automation, Mechanical Engineering Department, University of Aveiro, Aveiro, 3810-193, Portugal

A principal aim of the EU 2030 climate & energy framework is the reduction of CO_2 emissions by the development of new technologies for industries and processes[1]. In this respect, ammonia (NH_3) is a key chemical that is produced in vast quantities worldwide as a precursor in a range of products that are vital to society, such as fertilizers and medicines. Moreover, due to its high energy density and the formation of only H_2O and N_2 upon its combustion, it also has been proposed as a potential carbon-free fuel [2].

The current industrial route for ammonia production is the Haber- Bosch process, which employs Fe-based catalysts to synthesize ammonia from nitrogen and hydrogen at high pressures (100-300bar) in the temperature range 300-550ºC [3]. Despite this prevalence, the process has a very high energy consumption, with low equilibrium conversion (10-15%) and produces 300 million metric tons of CO_2 per year due to its continued reliance on hydrogen produced from natural gas [3].

New greener concepts for NH_3 production and utilisation are, therefore, urgently needed.

The current work aims to offer potetnial materials for a highly attractive alternative to mitigate this problem, based on the electrochemical synthesis of NH_3 directly from H_2O and N_2,. with the input of renewable electricity, using a Proton Ceramic Electrolyser Cell (PCEC), Fig.1. Such a process can form NH_3 without CO_2 generation. Moreover, it can also provide a method for the chemical storage of renewable electricity, generating a route to balance renewable energy supply and demand, by the formation of a transportable chemical product of high energy density.

At this juncture, it is also important to highlight that the reverse operation of the electrochemical cell of Fig.1, would correspond to a fuel cell, where NH_3 would be combusted to form the products of H_2O and N_2, while also directly producing electricity and heat.

Despite this attraction, and the apparent similarity of these two devices, previous work on these concepts are scarce. For this reason, the current presentation aims to emphasise the challenges of these processes and the critical funcionalitites that are required in each case with respect the NH_3 electrode.

Discussion will then progress to decribe some recent work of our group on the development of a range of nitride materials as possible NH_3-electrodes for these devices.

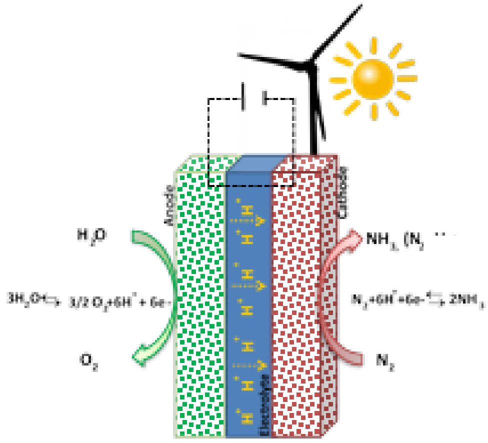

Figure 1. Electrochemical NH_3 production using a protonic membrane.

References

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Dr. Duncan Fagg is currently employed as a Principal Researcher in the University of Aveiro, Portugal. He obtained his B.SC in Chemstry and Materials science Nottingham University 1992 and Ph.D. in Chemistry Aberdeen University 1997. He has over 20 years of research experience with previous placements in CICECO Aveiro, Portugal, ICV Autonomous University Madrid, Spain, Dept.Chemical Engineering, Patras Greece, School of Chemistry, St-Andrews University Scotland, and Risø DTU National Laboratory for Sustainable Energy, Roskilde Denmark. He is the author of over 100 international scientific publications in areas covering Solid Oxide Fuel Cells (SOFC), Solid Oxide Electrolyser Cells (SOEC), Oxygen separation membranes, Hydrogen separation membranes, Hydrogen Storage..
Presentating author: Duncan Fagg, e-mail: duncan@ua.pt