Ing. Tullia Zucca
Chemical Process Engineer
Industrial Engineering Office
Via Goffredo Mameli, 2 26833 Comazzo (LO) – Italy
+39 3884420297 @: info@gandzsas.com www.gandzsas.com

Plasmammonia

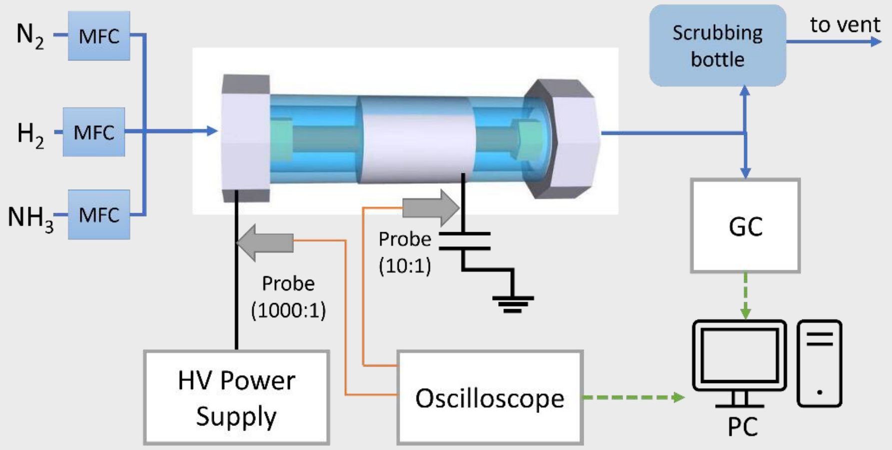
Ammonia decomposition is becoming a hot topic in the energy transition. The project looks at membranes and plasma reactors for ammonia decomposition to produce pure hydrogen.

THE CONTEXT

Existing ammonia production plants produce 100-3000-ton NH3/day with a worldwide production capacity estimated to 180 million tons per year, mainly used in agriculture as fertilizer (80% of the total production). However, ammonia could meet the transport n eeds of H2 for long distances due to its high hydrogen volumetric density, and thus enable the use of hydrogen in distributed applications. Estimations show that 500,000 tonnes per year of green hydrogen could be produced in 2037 from the cracking of green ammonia.

In recent years, Gallucci et al. and other authors have shown that the use of hydrogen selective membranes inside the reactor allow converting ammonia into pure hydrogen at lower temperatures compared to conventional reactors.

The invention of Tullia Zucca, uses a plasma source to split the ammonia into hydrogen and nitrogen, thus avoiding the use of a catalyst and allowing direct contact of ammonia with the thermal source.

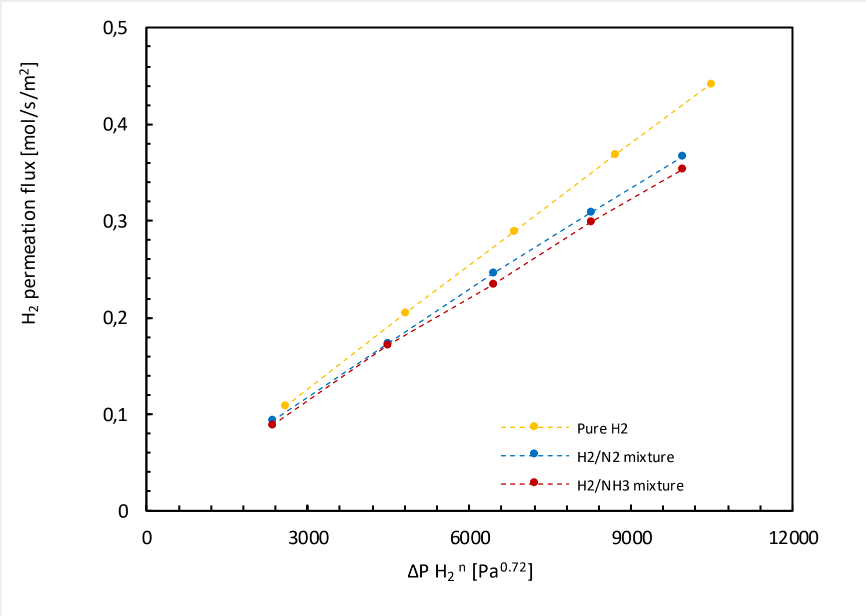


Scheme of the plasma reactor used for ammonia decomposition testing. The cold plasma reactor used is a DBD reactor packed with inert spheres of alumina..

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862330

THE CHALLENGE

The company of Tullia Zucca is expert in prototyping plasma systems. However, they need expertise in membranes and membrane reactors. The INNOMEM OITB brings together experts in membrane producers for hydrogen production such as Tecnalia and expert in membrane reactors design and testing such as TUE who also has expertise and setups for plasma reactors. This combination can accelerate the project of Tullia Zucca in the hydrogen production from ammonia decomposition with plasma.

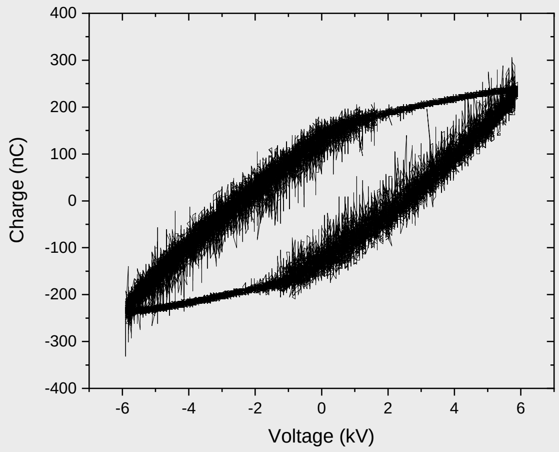


Hydrogen flux at different hydrogen partial pressure difference across membrane for pure hydrogen and binary H_2/N_2 and H_2/NH_3 mixtures containing 95 vol.% of H_2.

Results show no poisoning of membranes by ammonia remaining in the hydrogen.

THE RESULTS

In the project we have tested membranes with various mixtures of hydrogen ammonia and nitrogen, from bottles and from plasma reactors. We have shown that the membranes are capable at recovering hydrogen with purity above 99% and in some cases above 99.98%. The plasma reactor has also been tested. Unfortunately, cold plasma is not enough to completely convert ammonia. A warm plasma at about 450 °C is required for full conversion. This however is not a big problem because the membranes have to operate at high temperatures, thus a plasma at 450 °C would allow better heat integration in the reactor.



An example of the Lissajous figure for plasma tests.

CONCLUSION

Tecnalia has developed several membranes for the testing with ammonia hydrogen mixtures. Some of those membranes have shown very high selectivities above the target of the project.

The results show that membranes can be used downstream the plasma zone (provided that the reactor is hot enough) to separate hydrogen with high purity.

Pressure increases the membrane flux, thus the higher the pressure of the reactor the lower the amount of membranes to be used.

The plasma reactor can convert ammonia. However room temperature plasma can reach only 10-12% conversion. Higher temperatures can reach up to 99% conversion. High temperature plasma allows integration of membranes.

TECHNIQUES USED

Pd-based membrane production ad scale up

Plasma reactors

Integration of plasma reactor and membrane separation.

For more information, you can get in touch with us by sending an email to f.gallucci@tue.nl