



16th INTERNATIONAL CONFERENCE ON CARBON DIOXIDE UTILIZATION

“Blue-Urea”: Sustainable AgriChem

Peter Styring,^{1,2,3*} Justin Driver,^{2,3} Rhodri Owen,^{2,3} Terrance Makenyire,^{2,3} James McGregor^{2,3}

¹Department of Chemistry, The University of Sheffield, Dainton Building, Brook Hill, Sheffield S3 7HF, United Kingdom

²UK Centre for Carbon Dioxide Utilisation, Department of Chemistry, The University of Sheffield, S3 7HF, United Kingdom

³Chemical & Biological Engineering, The University of Sheffield, Sir Robert Hadfield Building, Sheffield S1 3JD, United Kingdom

*Corresponding author: p.styring@sheffield.ac.uk

Keywords: Low Carbon Ammonia, Urea, Process Engineering, Integration

Urea is often lauded as the biggest user of CO₂ in a utilization process [1]. However, it is in fact a net CO₂ emitter as the hydrogen required in the conventional Haber-Bosch process is produced by steam methane reformation (SMR). It is the CO₂ generated in the SMR process that is used to form the urea, not emissions from industry. In our process, a small pilot reactor receives hydrogen from an ITM-POWER PEM electrolyser unit which produces the hydrogen from water. The pilot reactor is a single channel stainless steel tubular reactor operating at high temperature and pressure. The unit is contained in a polycarbonate blast-proof booth (Figure 1) with service access points.



Figure 1. Pilot plant for the novel low-carbon Haber-Bosch synthesis of ammonia.

The reactor is packed with a Johnson-Matthey low pressure Haber-Bosch catalyst. The nitrogen and hydrogen feeds pass through a Haskell hydrogen-resistant pressure amplifier and then heated to reaction in a Carbolite cylindrical furnace. Further heating is applied directly to the reactor body using trace heaters. The conversion was determined using

a calibrated ammonia monitor. The ammonia can be quenched using nitric acid solution to yield ammonium nitrate (AN) which can also be used as a fertilizer.

Urea is produced by contacting the concentrated ammonia product with carbon dioxide in *iso*-propanol solution. The ammonium carbamate intermediate is filtered using a Doctor M continuous cake filtration unit and then decomposed under pressure in a Parr autoclave to yield urea (Figure 2).

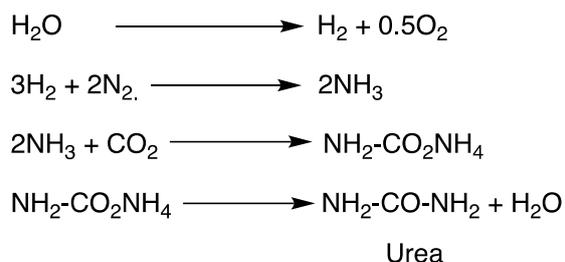


Figure 2. Urea synthesis without SMR.

In this paper we will present details of the process evaluation and conditions employed to optimize yield and conversion.

Acknowledgments

We acknowledge financial support from BBSRC (EP/K001329/1).

References

[1] K. Armstrong and P. Styring, *Front. Energy Res.*, **2015**, 3, 8. doi: 10.3389/fenrg.2015.00008