

Characterisation of Nickel Catalyst used in Urea Steam Reforming

Andrew N. Rollinson^{1*}, Jenny Jones¹, Valerie Dupont¹, and Martyn V. Twigg²

¹Energy and Resources Research Institute, School of Process, Environmental and Materials Engineering, University of Leeds, Leeds, LS2 9JT, England

²Johnson Matthey Plc, Orchard Laboratories, Orchard Road, Royston, SGE 5HE, England

*ear3anr@leeds.ac.uk

Introduction

Urea is a safe and sustainable substance that is identified as being an attractive energy carrier for hydrogen [1]. Hydrogen could replace fossil fuels as an energy source by its utilisation in fuel cells [2]. Steam reforming of urea has recently been achieved and a syngas rich in hydrogen (H_2) was produced [3]. The catalyst used in steam reforming of urea was nickel on alumina. Characterisation of this catalyst in terms of its physical nature and its efficacy at urea steam reforming is hereby reported.

Experimental

An experimental catalytic urea steam reforming parametric study was completed in a fix bed reactor at a range of temperatures between 500°C and 700°C. A range of steam to carbon ratios (S:C) from 2:1 to 8:1 were attempted. 20 grams of 18wt% nickel oxide on alumina catalyst was used. Syngas composition was measured by a series of online analysers, and compared against thermodynamic modelling predictions calculated using EQUIL software [4]. Condensate was analysed offline for NH_4^+ content. Catalyst characterisation used was determined by assessment of syngas composition over time, digital microscopy, SEM, TEM, EDX, and BET adsorption.

Results/Discussion

H_2 yields close to the theoretical maximum of 3 were achieved at temperatures of 600°C. Catalyst efficiency for steam conversion and therefore H_2 production reduced significantly below 600°C. At lower temperatures, the catalyst performed less well for ammonia (NH_3) dissociation with experimental NH_3 values found to be higher than equilibrium predictions.

No deactivation of the catalyst was observed with five stages of repeated steam reforming, oxidation and reduction. No catalyst deactivation was observed over the run time of the

experiments (≥ 2 hours). The catalyst did not exhibit evidence of carbon deposition, increase in surface area, or the conversion of Ni to NiO during steam reforming (see Table 1 and Figure 1).

Table 1. BET results of catalyst surface area at different stages in urea steam reforming process

Condition	Surface Area
Post steam reforming	2.971 m ² /g
Post steam reforming, oxidation and reduction	2.775 m ² /g
Fresh oxidised (as supplied)	3.262 m ² /g
Fresh reduced	3.720 m ² /g

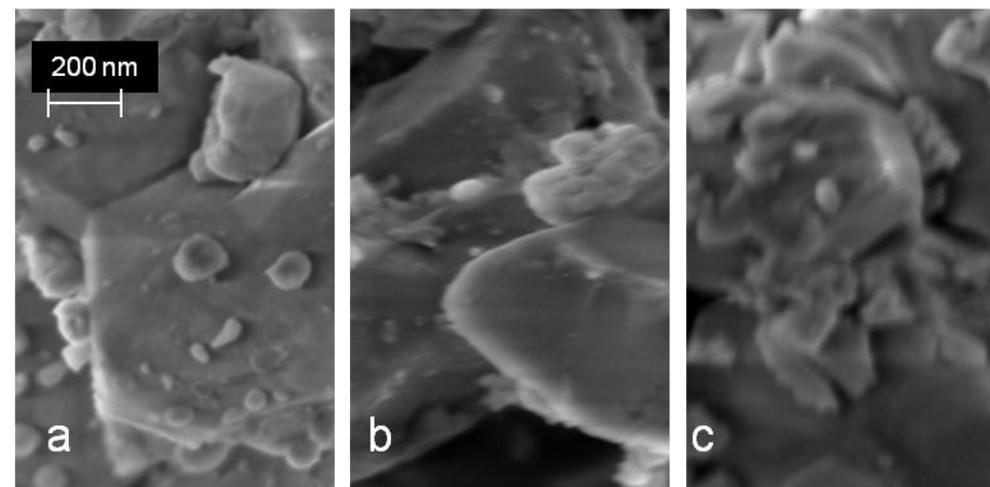


Figure 1. SEM of nickel oxide catalyst post urea steam reforming (a), reduced (b), and fresh as supplied oxidised (c).

References.

1. A.N. Rollinson, et.al., *Energy Environ. Sci.*, 2011, DOI: 10.1039/C0EE00705F
2. C.J. Winter, *Int. J. Hydrogen Energy*, **34** (14), Supp 1, 2009, S1-S52.
3. A.N. Rollinson, et.al., *Hydrogen production by catalytic steam reforming of urea*, 5th International Ege Energy Symposium, 27-30 June 2010, Denizli, Turkey.
4. A.E. Lutz, F.M. Rupley and R.J. Lee, *Chemkin Collection Release 3.5*, Reaction Design Inc, San Diego, pp.2-20, 1999.