Multi-Step TPSR/QMS Technique to Study the Kinetics of NH₃-SCR

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1. What is NOₓ?

- Nitric oxides are reactive gases, primarily NO (>90 %) and NO₂.
- They are pollutants involved in many atmospheric processes e.g. formation of photochemical smog and acid rain.
- They are produced as a result of high temperatures during the combustion of fuels.
- Legislation is in place to reduce NOₓ emissions i.e. the European Waste Incineration Directive (WID) regulates activities that involve burning or gasification of waste (Figure 1).

2. DeNOₓ Process

- NH₃-Selective Catalytic Reduction (SCR) is an efficient, established method for NOₓ removal. The desired reactions are:
  \[ 4\text{NH}_3 + 4\text{NO} + \text{O}_2 \rightarrow 6\text{H}_2\text{O} + 4\text{N}_2 \]
  \[ 8\text{NH}_3 + 6\text{NO}_2 \rightarrow 12\text{H}_2\text{O} + 7\text{N}_2 \]
- BUT there are some disadvantages including:
  - Ammonia slip
  - Size of the installation
  - Thermal deactivation
- Structured reactors based on metallic short channel structures (Figure 2) demonstrate improved mass and heat transfer properties [1] and can remedy these issues [2].

3. Catlab

- Hidden Analytical CATLAB-PCS microreactor (Figure 3) with integrated quadrupole mass spectrometer (QMS) system.
- QMS is a convenient and powerful method for analysing complex reaction mixtures. However, careful calibration is required to obtain reliable, quantitative data.
- There are a number of factors to consider when optimizing the analysis system for a particular application, including: detector selection, ion fragment patterns and relative sensitivity values.

4. TPSR/TPD Studies

- Coupled with Temperature Programmed Desorption (TPD), Temperature-Programmed Surface Reactions (TPSR) can be used to gain new insights into the mechanism of NO reduction on copper-exchanged zeolites. Results may also shed light on the active centres of the reaction and relative reactivities of surface and gaseous species.
- TPD is used to study the adsorption/desorption of NH₃ and NO (Figure 4).
- TPSR can be used to investigate reactions between adsorbed and gaseous species (Figure 5).

5. Conclusions

- Initial results suggest a Eley-Rideal-type mechanism i.e. adsorbed NH₃ reacts with gaseous NO on Cu²⁺ active centres in the zeolite cavities.
- Obtained data was used for kinetic modelling [3].

REFERENCES