Copper Exchanged Zeolites for Ammonia Reduction of NO$_x$ from Biogas Gas Engines

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1. What is NO$_x$?

- Nitric oxides are highly reactive gases; primarily NO (>90 %) and NO$_2$.
- Pollutants, they are 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 NO$_x$ emissions i.e. the European Waste Incineration Directive (WID) regulates activities that involve burning or gasification of waste (Figure 1).

2. DeNO$_x$ Process

- NH$_2$-Selective Catalytic Reduction (SCR) is an efficient, established method for NO$_x$ removal. The desired reactions are:
  
  $$4\text{NH}_2 + 4\text{NO} + \text{O}_2 \rightarrow 6\text{H}_2\text{O} + 4\text{N}_2$$
  $$8\text{NH}_3 + 6\text{NO}_2 \rightarrow 12\text{H}_2\text{O} + 7\text{N}_2$$

- 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.

3. Catalyst

- Copper-exchanged zeolites are well known for their NO$_x$ reduction [2] and direct NO decomposition activity [3].
- Cu-Y and Cu-LZY 82 zeolites were prepared through three-fold ion exchange of the steamed form of LZY-82.

4. Experimental

- Gas composition supplied to catalysts:
  - 2000 ppm NO
  - 2000 ppm NH$_3$
  - 3 % O$_2$
- Temperature varied from 50-500 °C.
- Prepared zeolites compared to Cu-ZSM 5 standard.

5. Conclusions

- The copper exchanged zeolites retain the structure of the initial LZY-82 zeolite.
- Both prepared zeolite-Y catalysts demonstrate comparable DeNO$_x$ activity to the Cu-ZSM 5 standard.
- The production of unwanted side-products is negligible over the measured temperature range.

6. Future Work

- Prepare zeolite coated metallic sheets.
- Fully characterise both zeolite powders and the supported catalysts through techniques including SEM, Atomic Force Microscopy (AFM) and Raman spectroscopy.
- Repeat catalytic testing to obtain quantitative data for kinetic modelling.

References