Catalyst System Design for the Control of NO\textsubscript{x} Using Hydrogen

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1. What is NO\textsubscript{x}?  
- Nitric Oxides - highly reactive gases; primarily NO (>90 %) and NO\textsubscript{2}  
- Pollutants, involved in many atmospheric processes e.g. formation of smog  
- Produced as a result of the high temperatures during combustion of fossil fuels  
- Legislation is in place to reduce NO\textsubscript{x} emissions

2. Current De-NO\textsubscript{x} Processes  
- NH\textsubscript{3}/urea-Selective Catalytic Reduction (SCR) is an efficient, established method  
  \[ 4\text{NH}_3 + 4\text{NO} + \text{O}_2 \rightarrow 6\text{H}_2\text{O} + 4\text{N}_2 \]
  \[ 8\text{NH}_3 + 6\text{NO}_2 \rightarrow 12\text{H}_2\text{O} + 7\text{N}_2 \]
- BUT it requires additional toxic chemicals:  
  - Intrinsic safety issues  
  - Extra system costs  
  - NH\textsubscript{3}/urea infrastructure necessary

3. H\textsubscript{2}-SCR  
- H\textsubscript{2} is already present in many systems e.g. diesel engines, biomass gasification combined heat and power (CHP) plants  
- Could replace NH\textsubscript{3}/urea processes:  
  Target Chemistry  
  \[ 2\text{NO} + 2\text{H}_2 \rightarrow 2\text{H}_2\text{O} + \text{N}_2 \]
  \[ 2\text{NO}_2 + 4\text{H}_2 \rightarrow 4\text{H}_2\text{O} + \text{N}_2 \]
- Removes the need for additional chemicals and their associated costs

4. Catalyst  
- Pd/Al\textsubscript{2}O\textsubscript{3} catalyst prepared using an incipient wetness impregnation technique  
- Supported on honeycomb monoliths (Figure 1)  
  - Outer diameter = 14 mm  
  - Channel size = 1 mm x 1 mm (x 80)  
- Compared to commercially available 1 wt\% Pd/Al\textsubscript{2}O\textsubscript{3} pellets (Figure 2)  
  - Diameter = 3 mm

5. Experimental Conditions  
- Gas composition supplied to catalysts:  
  - 1000 ppm NO  
  - 1000 ppm H\textsubscript{2}  
  - Air (12.5 % O\textsubscript{2}) or N\textsubscript{2}  
- Temperature varied from 50-250 °C (Figure 3)

6. Experimental Results

7. Conclusions  
- In the absence of O\textsubscript{2}, Pd/Al\textsubscript{2}O\textsubscript{3} catalysts can effectively reduce NO\textsubscript{x} using H\textsubscript{2}  
- However, Pd/Al\textsubscript{2}O\textsubscript{3} strongly promotes the reaction between H\textsubscript{2} and O\textsubscript{2}, even at low temperatures  
- Conditioning of the catalyst may be necessary to achieve maximum activity  
- Some selectivity of products was seen at varying temperatures