Selective Catalytic Oxidation (SCO) of NH₃ to N₂ for Hot Exhaust Treatment

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Background

NOx generation: combustion of fossil fuels

NOx is a major source for air pollution

Acid rain

Photochemical smog

Human’s health
Diesel Engine Exhaust System

Urea-SCR:

\[ \text{Urea-SCR: } \text{CO}(\text{NH}_2)_2 + \text{H}_2\text{O} \rightarrow 2\text{NH}_3 + \text{CO}_2 \]

\[ 4\text{NH}_3 + 4\text{NO} + \text{O}_2 \rightarrow 4\text{N}_2 + 6\text{H}_2\text{O} \]
NH₃ SCO Technology

- SCO for solving NH₃ slip problem in SCR system
  - Incomplete NO conversion
  - Exhaust temperature upswings

- SCO Catalysts
  - Precious metal + zeolites: Pt/Fe-ZSM-5, Cu-SAPO-34
  - Precious metal doped oxides: Pt-CuO/Al₂O₃
  - Ion-exchanged zeolites: Fe-ZSM-5
  - Supported transition metal oxides: Fe₂O₃/TiO₂, V₂O₅/TiO₂
NexTech SCO Catalysts

- Pre-aged at 600°C for 2 hrs in flowing 10% steam

- **Catalysts**: transition metal oxides + zeolites

  - **NH₃ oxidation catalyst** (transition metal oxides)
    \[
    \text{NH}_3 + \text{O}_2 \rightarrow \text{N}_2, \text{NO} + \text{H}_2\text{O}
    \]

  - **SCR catalyst** (ion-exchanged zeolites)
    \[
    \text{NH}_3 + \text{NO} + \text{O}_2 \rightarrow \text{N}_2 + \text{H}_2\text{O}
    \]

**Testing conditions**

- 200-500 ppm NH₃, 5%O₂,
- 1 ppm SO₂ (when used), 1%H₂O (when used),
- balance He, GHSV = 100,000 ml/g/hr
Oxides improved low-T SCO activity
Effect of Oxides/Zeolite Ratio

Activity increased with oxides/zeolite ratio
Transition metal oxides showed higher performance than a conventional Pt catalyst.
Initial Lifetime

Initial conditions:
300°C, 500 ppm NH₃, 5%O₂, (1 ppm SO₂, 1% H₂O), balance He, GHSV = 100,000 ml/g/h

Stable activity demonstrated in SO₂ Oxides + Zeolites
Initial Lifetime

Transition metal oxides

Initial conditions:
300°C, 500 ppm NH₃,
5%O₂, (1 ppm SO₂),
balance He,
GHSV = 50,000 ml/g/h

Stable activity demonstrated in SO₂
200 ppm NO, 200 ppm NH₃, 1 ppm SO₂ (when used), 2% H₂O (when used) 5%O₂, balance He, GHSV = 30,000 ml/g/hr

Transition metal oxides showed excellent low-T SCR activity
• Transition metal oxide-based catalysts exhibited excellent SCO activity
  – Slightly better than a Pt based catalyst
  – 100% NH$_3$ conversion and >90% N$_2$ selectivity were achieved at ≥225°C at a space velocity of 100,000 ml/g/hr

• The oxide catalysts were tolerant to SO$_2$ and H$_2$O

• Transition metal oxide catalysts also showed superior low-temperature SCR activity
  – >90% NO conversion and >98% N$_2$ selectivity at 100-150°C
  – Tolerant to SO$_2$ and H$_2$O
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Thank You

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