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Selective Catalytic Oxidation (SCO) of NH_3 to N_2 for Hot Exhaust Treatment

NexTech Materials Ltd.
Lewis Center, OH 43035

U.S. DEPARTMENT OF ENERGY
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DEARBORN
Directions in Engine-efficiency and Emissions Research Conference

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Background

NOx generation: combustion of fossil fuels

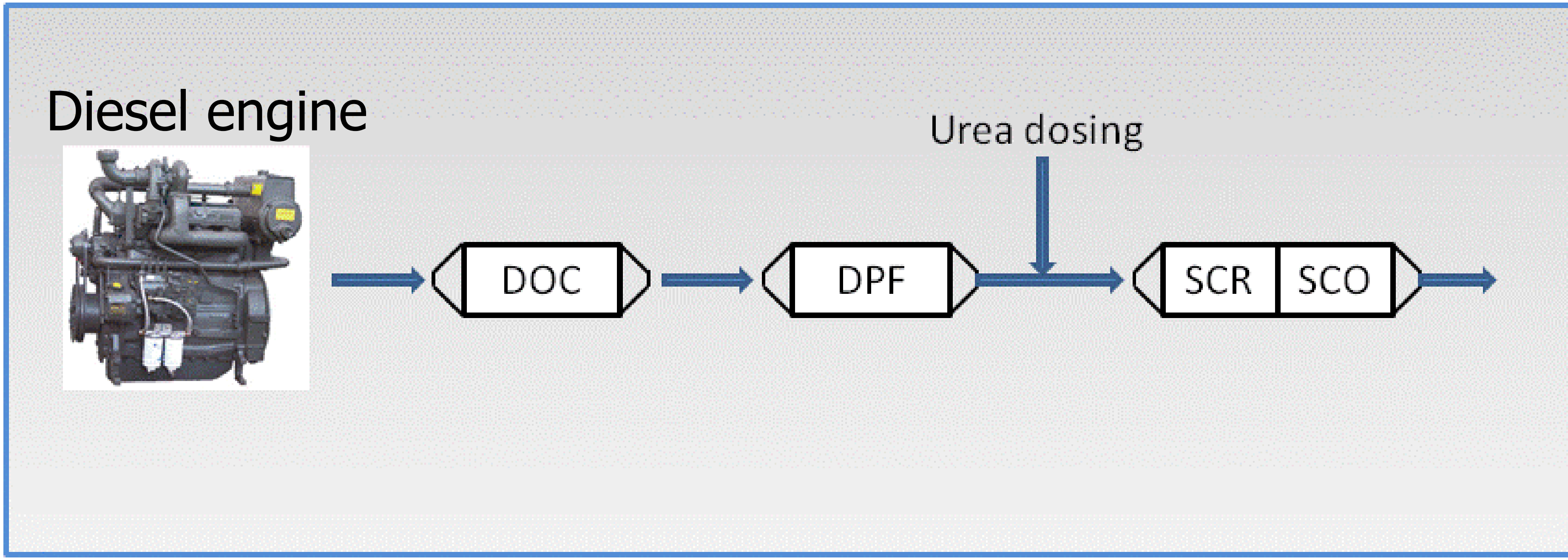
NOx is a major source for air pollution

Acid rain

Photochemical smog

Human's health

Diesel Engine Exhaust System



Urea-SCR: $CO(NH_2)_2 + H_2O \rightarrow 2NH_3 + CO_2$

$4NH_3 + 4NO + O_2 \rightarrow 4N_2 + 6H_2O$

NH_3 SCO Technology

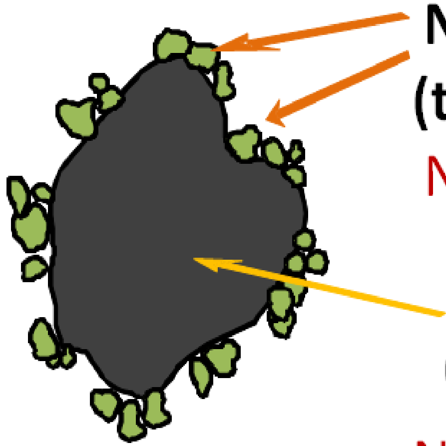
- **SCO for solving NH_3 slip problem in SCR system**
  - Incomplete NO conversion
  - Exhaust temperature upswings

- **SCO Catalysts**
  - Precious metal + zeolites: Pt/Fe-ZSM-5, Cu-SAPO-34
  - Precious metal doped oxides: Pt-CuO/Al_2O_3
  - Ion-exchanged zeolites: Fe-ZSM-5
  - Supported transition metal oxides: Fe_2O_3/TiO_2, V_2O_5/TiO_2

NexTech SCO Catalysts

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

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



NH_3 oxidation catalyst (transition metal oxides)

$NH_3 + O_2 \rightarrow N_2, NO + H_2O$

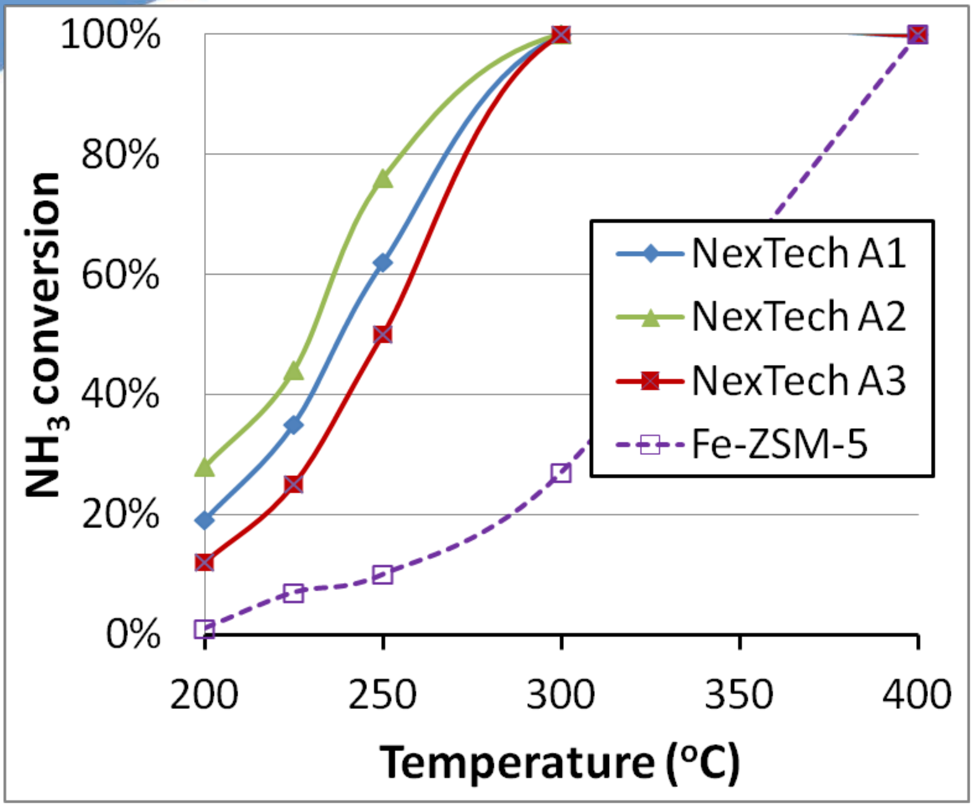
SCR catalyst (ion-exchanged zeolites)

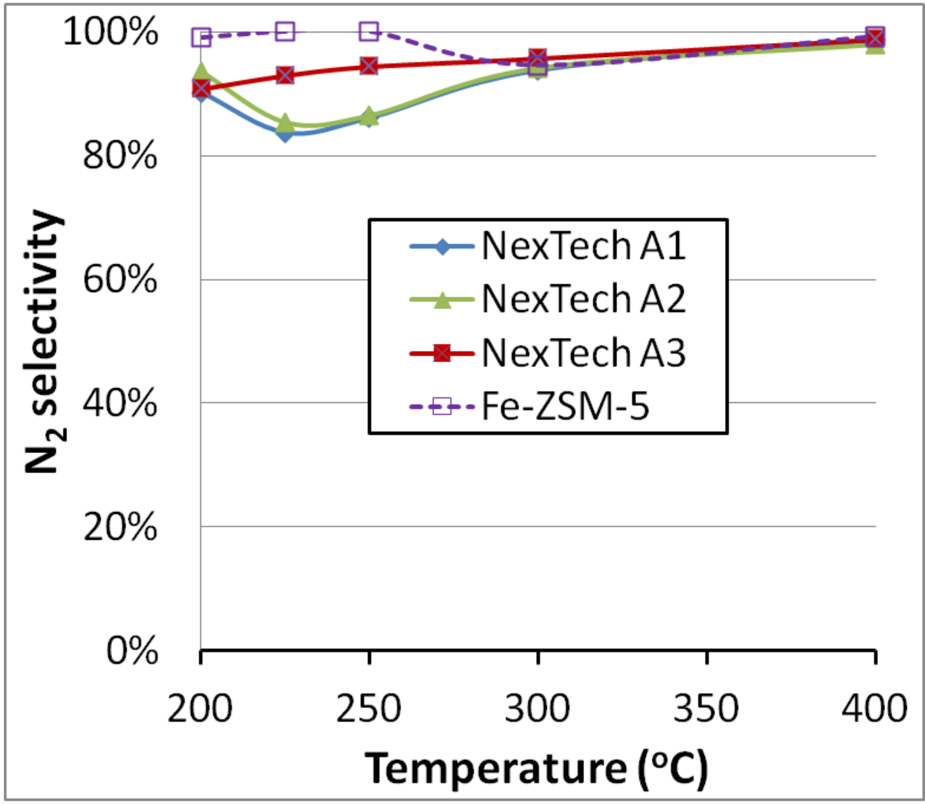
$NH_3 + NO + O_2 \rightarrow N_2 + H_2O$

- **Testing conditions**

  200-500 ppm NH_3, 5%O_2,
  1 ppm SO_2 (when used),1%H_2O (when used),
  balance He, GHSV = 100,000 ml/g/hr

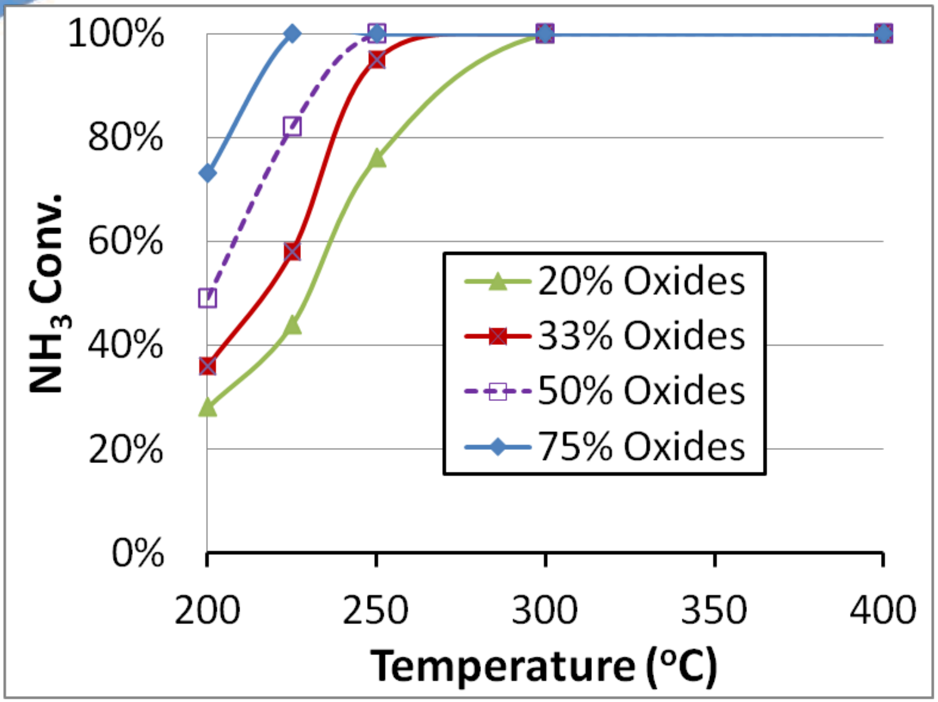
SCO Performance

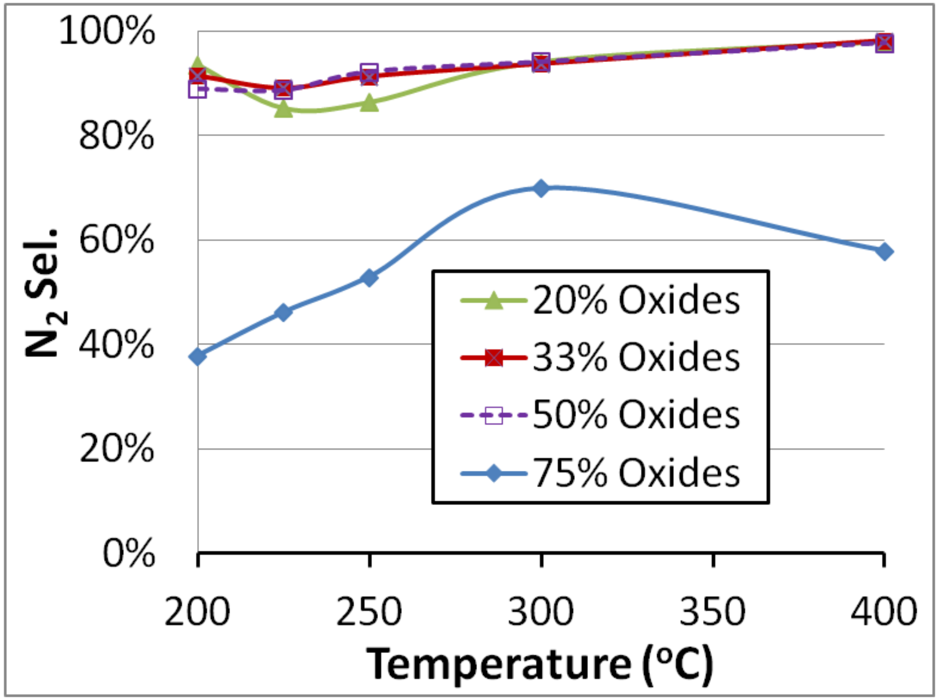




Oxides improved low-T SCO activity

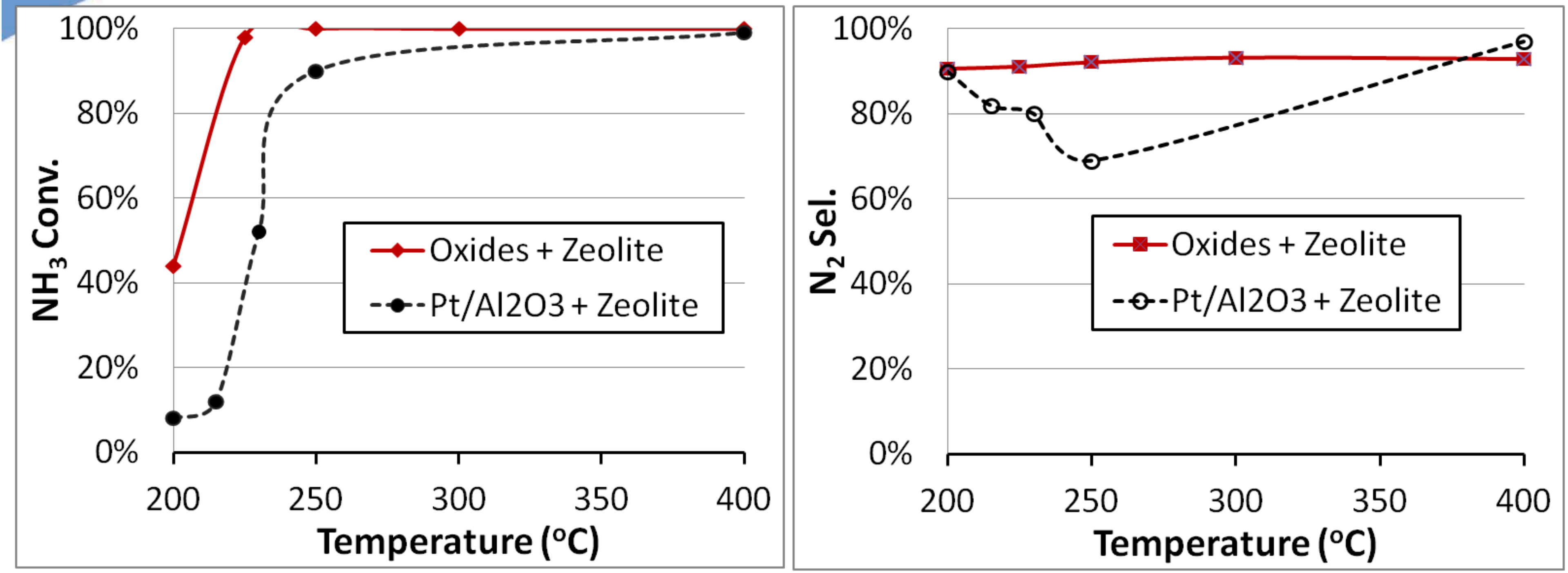
Effect of Oxides/Zeolite Ratio





Activity increased with oxides/zeolite ratio

Transition Metal Oxides vs. Pt



Transition metal oxides showed higher performance than a conventional Pt catalyst

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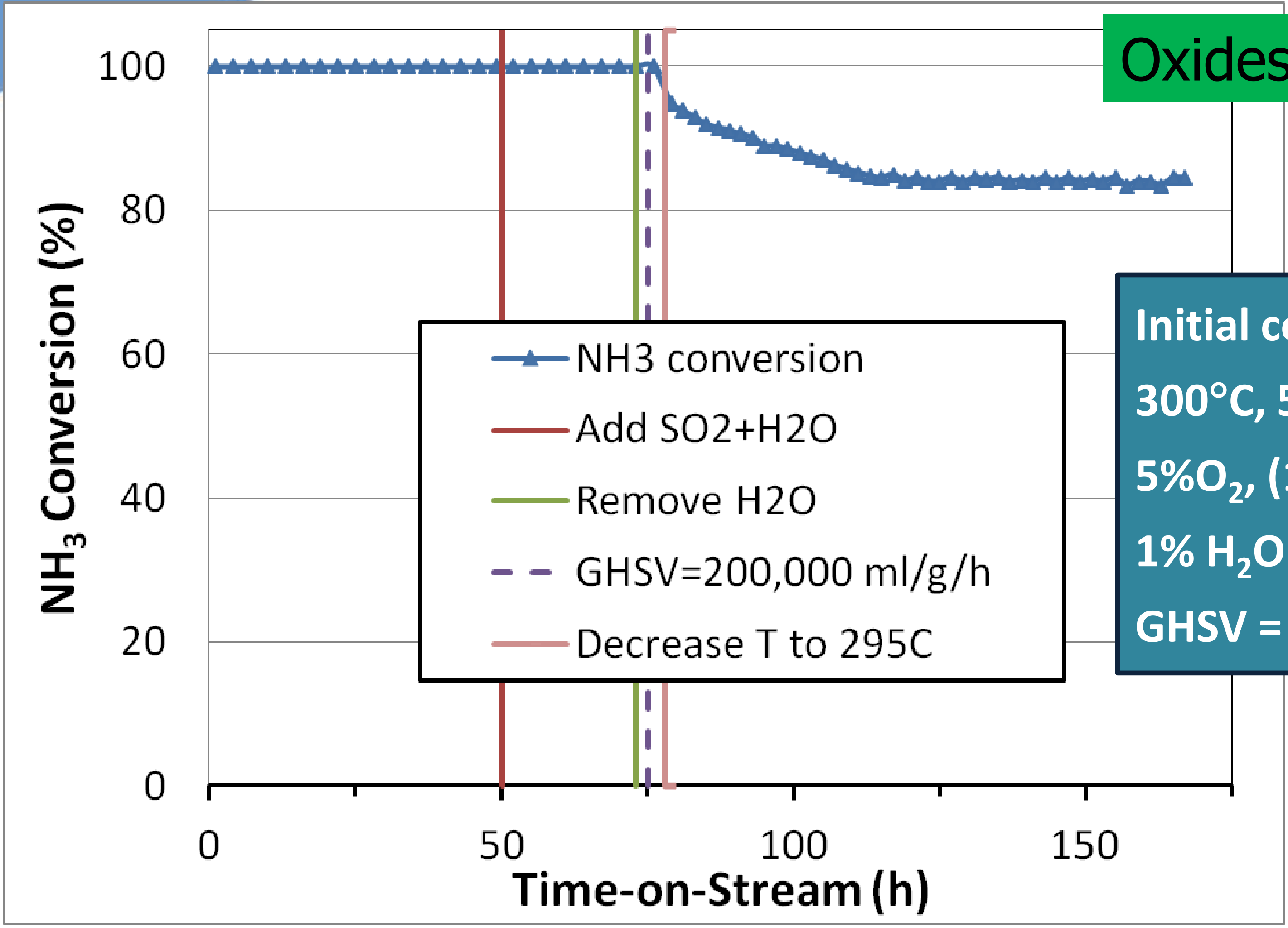
Initial Lifetime



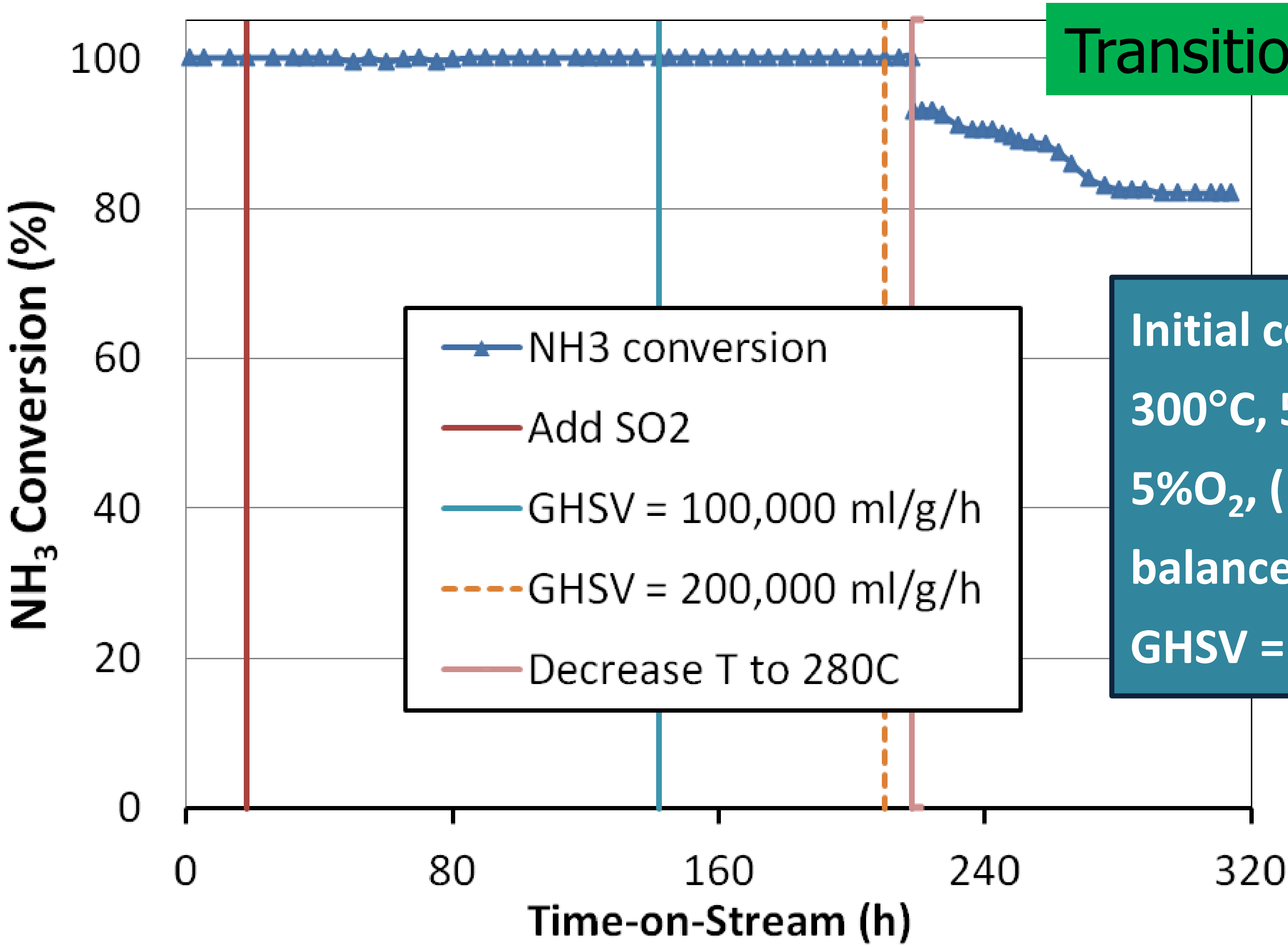
Oxides + Zeolites

Initial conditions:

300°C, 500 ppm NH_3, 5%O_2, (1 ppm SO_2 1% H_2O), balance He , GHSV = 100,000 ml/g/h

Stable activity demonstrated in SO_2

Initial Lifetime



Transition metal oxides

Initial conditions:

300°C, 500 ppm NH_3, 5% O_2, (1 ppm SO_2), balance He , GHSV = 50,000 ml/g/h

Stable activity demonstrated in SO_2

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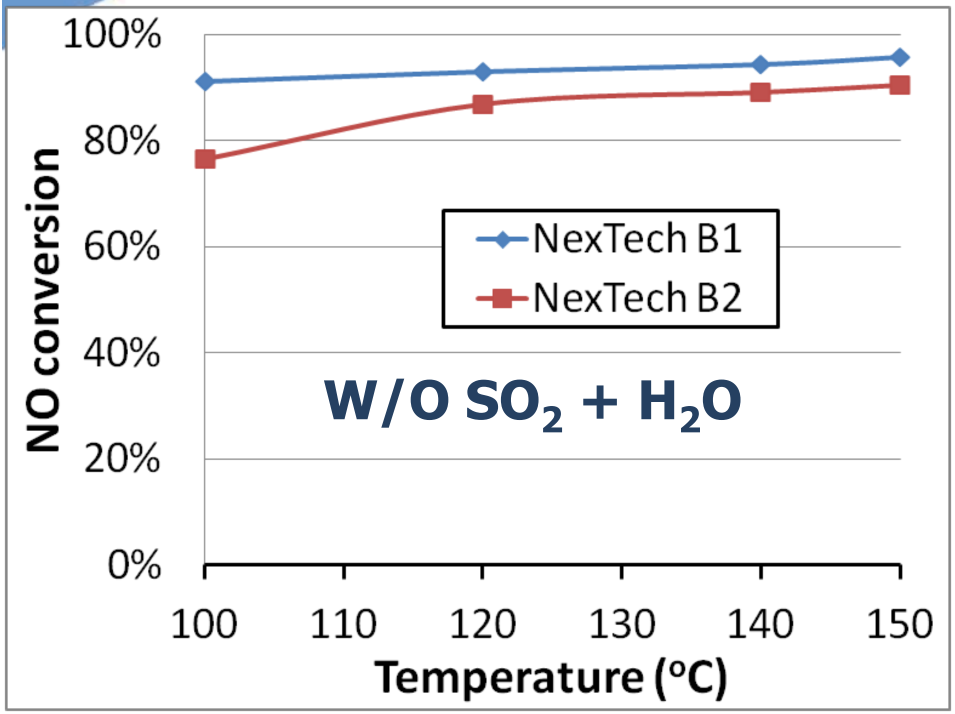
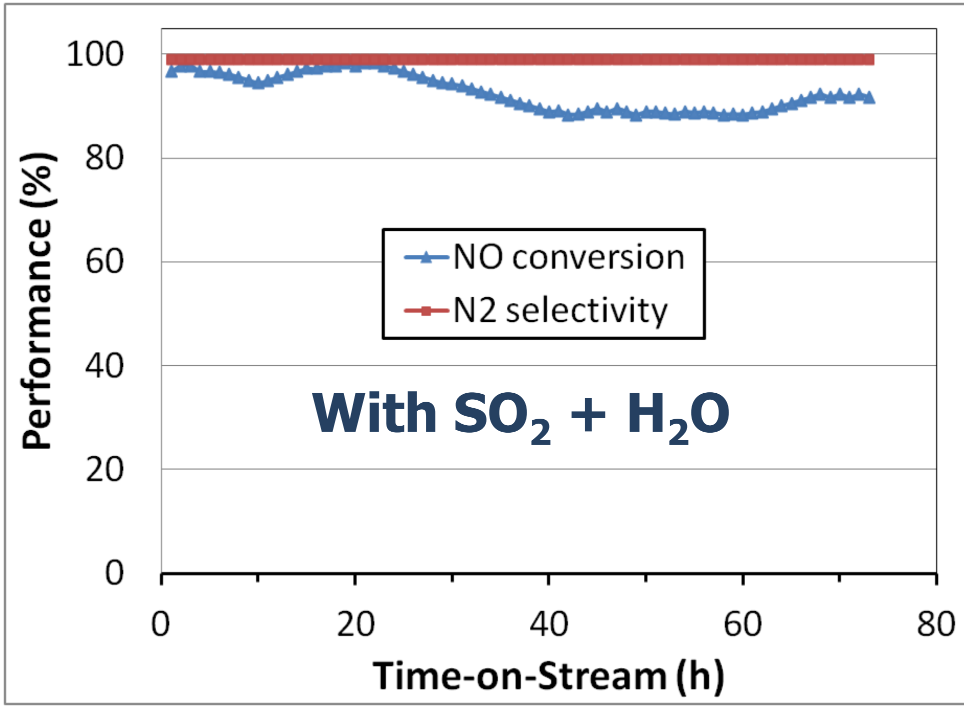
Low-T SCR Activity





200 ppm NO, 200 ppm NH_3, 1 ppm SO_2 (when used), 2% H_2O (when used)
5%O_2, balance He, GHSV = 30,000 ml/g/hr

Transition metal oxides showed excellent low-T SCR activity

Summary

- 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_2O
- 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_2O

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Acknowledgement

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- Team members

  Rich Long, Pradeep Kanakarajan, Buddy McCormick, Matthew Seabaugh, Scott Swartz

Thank You

For further information, please visit www.nexceris.com or contact Dr. Matthew M. Seabaugh: (614) 842-6606 ext. 107; matt@nexceris.com