Establishing Capabilities to Evaluate Reductants for NO\textsubscript{x} Adsorber Technologies

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Comparison of NO\textsubscript{x} Exhaust Levels and Emission Standards

- Typical Engine-Out NO\textsubscript{x} Level
- NO\textsubscript{x} Emission with Current Technology
- 2004 NO\textsubscript{x} Standard
- 2007 NO\textsubscript{x} Standard (Proposed)

- 35% Conversion Efficiency
- 90% Decrease in Standard

NO\textsubscript{x} (g/hp-hr)
**NO\textsubscript{x} Adsorbers Have Demonstrated High NO\textsubscript{x} Reduction Efficiencies for Lean-Burn Engines**

- NO\textsubscript{x} adsorbers operate in cyclic manner
  - **Adsorb** NO\textsubscript{x} during lean operation
  - **Regenerate** and **Convert** NO\textsubscript{x} during rich transient

- Necessary to optimize all three reaction steps to obtain maximum efficiency of system
Choice of Reductant Strongly Influences Overall Conversion of NO$x$

- Many studies employing precious-metal catalysts have revealed the overall NO$x$ conversion efficiency strongly depends on choice of reductant in “Lean-NO$x$” catalysis.

- NO$x$ adsorbers face complication that regeneration is also driven by reductant.

Ref: SAE 962043
Understanding the Impact of Reductant Chemistry is Necessary for System Optimization

• More practical to focus on classes of compounds rather than evaluate specific species
  – Effects of chemical characteristics (e.g., structure, bond order)
  – Effect of physical properties (e.g., boiling point, volatility)

• Necessary to understand reductant chemistry to achieve optimal reduction efficiency with lowest associated fuel penalty
  – Diesel fuel is comprised of a wide variety of species
  – Beneficial/detrimental effects of various reductant properties on overall controlling chemistry
Evaluation of Reductants on an Engine Application is a Very Daunting Task

- Extremely difficult to control operating parameters (e.g., exhaust concentrations and flow rate, temperature, etc..) independently during engine testing
  - Not possible to obtain kinetic rate information using engine

- Exhaust stream contains residual hydrocarbon and CO emissions which may interfere with data interpretation

- Use of engine test cell facility is expensive
Reactor System can be Used to Efficiently Evaluate Various Types of Reductants

- Possible to control operating parameters independently
  - Directly determine effect of parameters on reaction chemistry
  - Remove constituents (i.e., H₂O, CO, CO₂, etc…) from feed stream

- Implementation and operation of reactor system is much simpler than using an engine for testing
  - Lower quantity of operating variables to control
  - Reactor system designed to minimize data variability
  - Easier to make adaptations to system
  - Less expensive to operate
  - Lower quantity of reductant is necessary
Relative Trends for NO$_x$ Adsorption Following High Temperature Regeneration with Various Reductants
Relative Trends for NO\textsubscript{x} Adsorption Following Low Temperature Regeneration with Various Reductants
Summary

- NO\textsubscript{x} adsorber chemistry is complicated

- Choice of reductant is vital for high efficiency since reductant affects all three major reaction steps

- Reductant screening and reactor studies are necessary to obtain data which cannot be collected during engine testing
Summary (con’t)

• Reactor system has been constructed for rapid evaluation of various reductants for NO\textsubscript{x} adsorber technology

• Preliminary studies reveal different reductants alter the overall NO\textsubscript{x} adsorption phenomenon
  – Permits for improvement to overall system efficiency

• Reactor system can be used to evaluate various other NO\textsubscript{x} abatement technologies