SCR Catalyst for Simultaneous Control of NO_x, CO and NMHC Emissions from Gas-fired Power Plants

William B. Feaver, Harvey S. Rosenberg and Joseph A. Rossin
Guild Associates, Inc.
5750 Shier-Rings Road
Dublin, Ohio 43016
(614) 760-8007

Background

NO_x Emissions from Gas Turbines on the Order of 25 ppm

Although Emissions are Low, California has Targeted NO_x Emissions Levels be Less Than 2 ppm. Other States are Expected to Follow, and State Regulations may Tighten.

In Addition to NO_x, Gas Turbine Emissions also include CO and Unburned Hydrocarbons.

SCR is Leading Technology for Control of NO_x Emissions.

- **NO_x reduction limited by NH_3 slip**
- **Minimal CO, NMHC oxidation activity**

Objective:

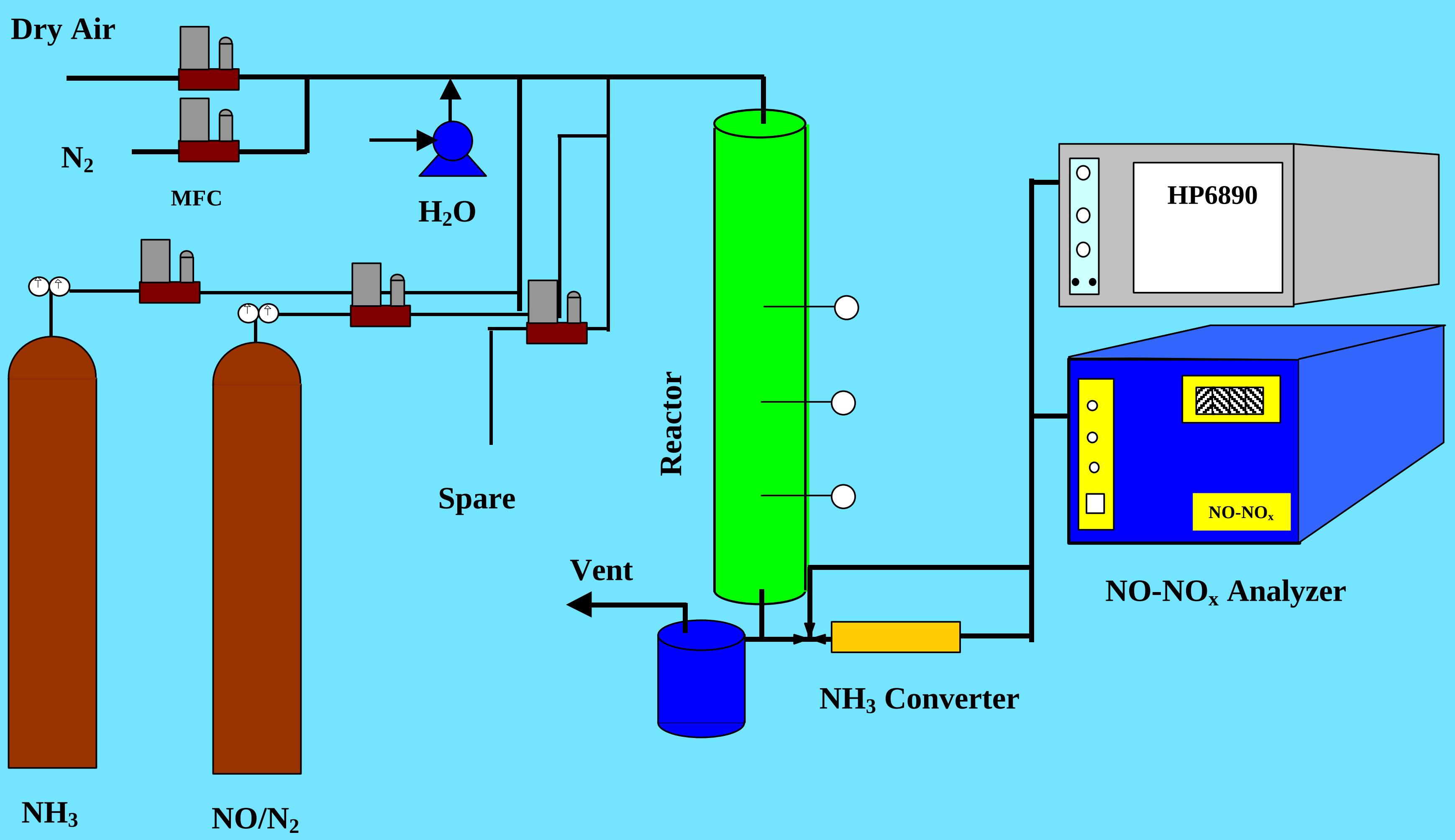
Develop a Monolithic Catalyst Capable of Controlling Gas Turbine Emissions

- **Less than 1 ppm each NO_x, NH_3 and N_2O in Effluent**
- **Greater than 95% CO and NMHC Conversion (to CO_2)**
- **Operate at High Space Velocity**
- **Operate at Temperatures Below about 260°C**
- **Long Catalyst Life-time**
- **Low Cost**

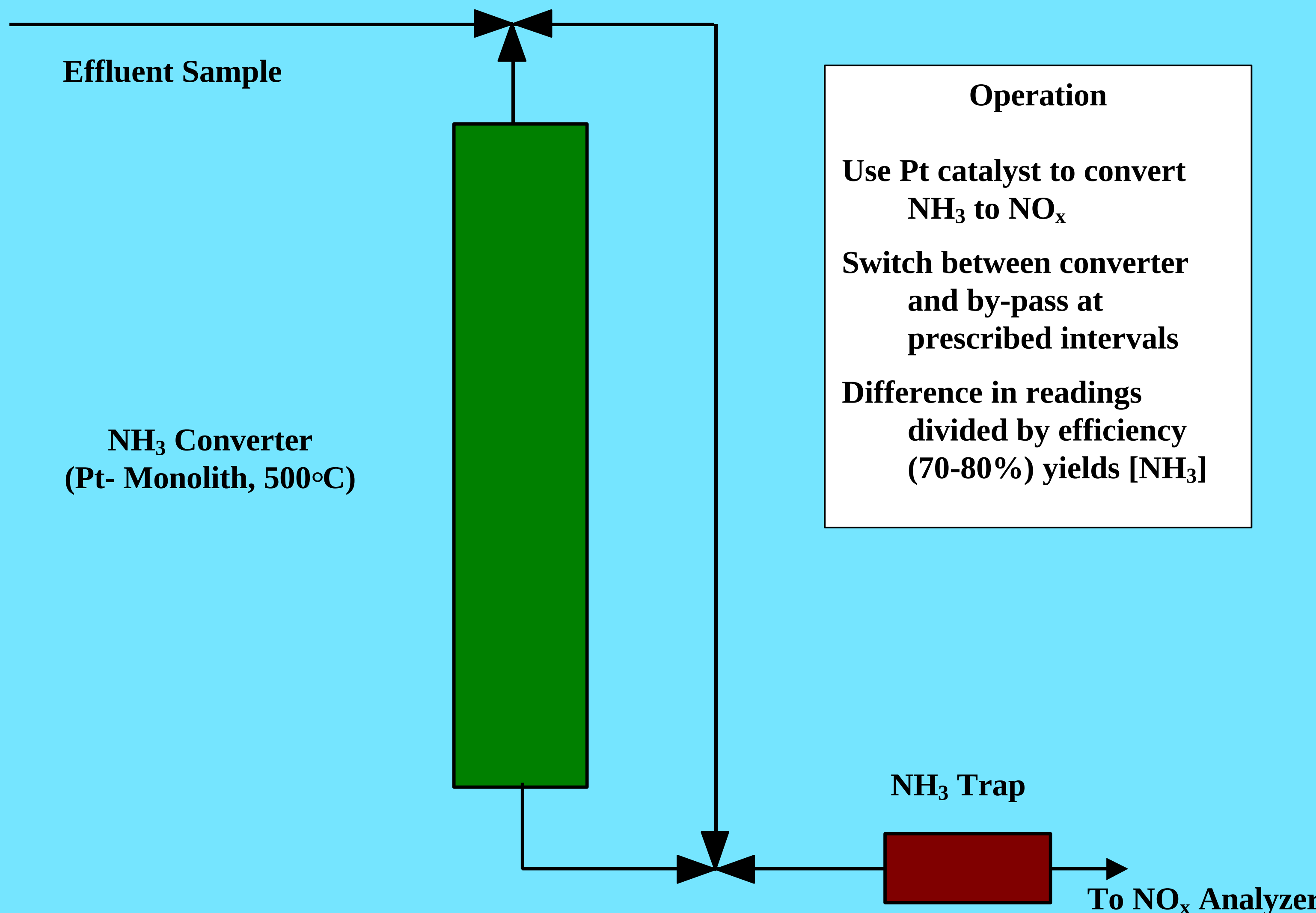
Strategy:

1. **Operate Process with Excess NH_3 for High NO_x Reduction.**
2. **Add Functionality to an SCR Catalyst to Decompose Ammonia.**
   - **Must decompose NH_3 to N_2 (minimal NO_x selectivity)**
   - **Activity must be balanced**
   - **Use NH_3 oxidation function to decompose CO, NMHC**
3. **Balance Activity of Two Functions for High NO_x Reduction while Minimizing NH_3 Slip.**

Schematic of Fixed Bed Catalytic Reactor System



NH_3 Analysis



Operation

Use Pt catalyst to convert NH_3 to NO_x

Switch between converter and by-pass at prescribed intervals

Difference in readings divided by efficiency (70-80%) yields [NH_3]

Experimental

Catalyst: All Tests Performed using Catalyst Washcoated onto a Monolith with a Cell Density of 230 cells/in^2

Analysis:

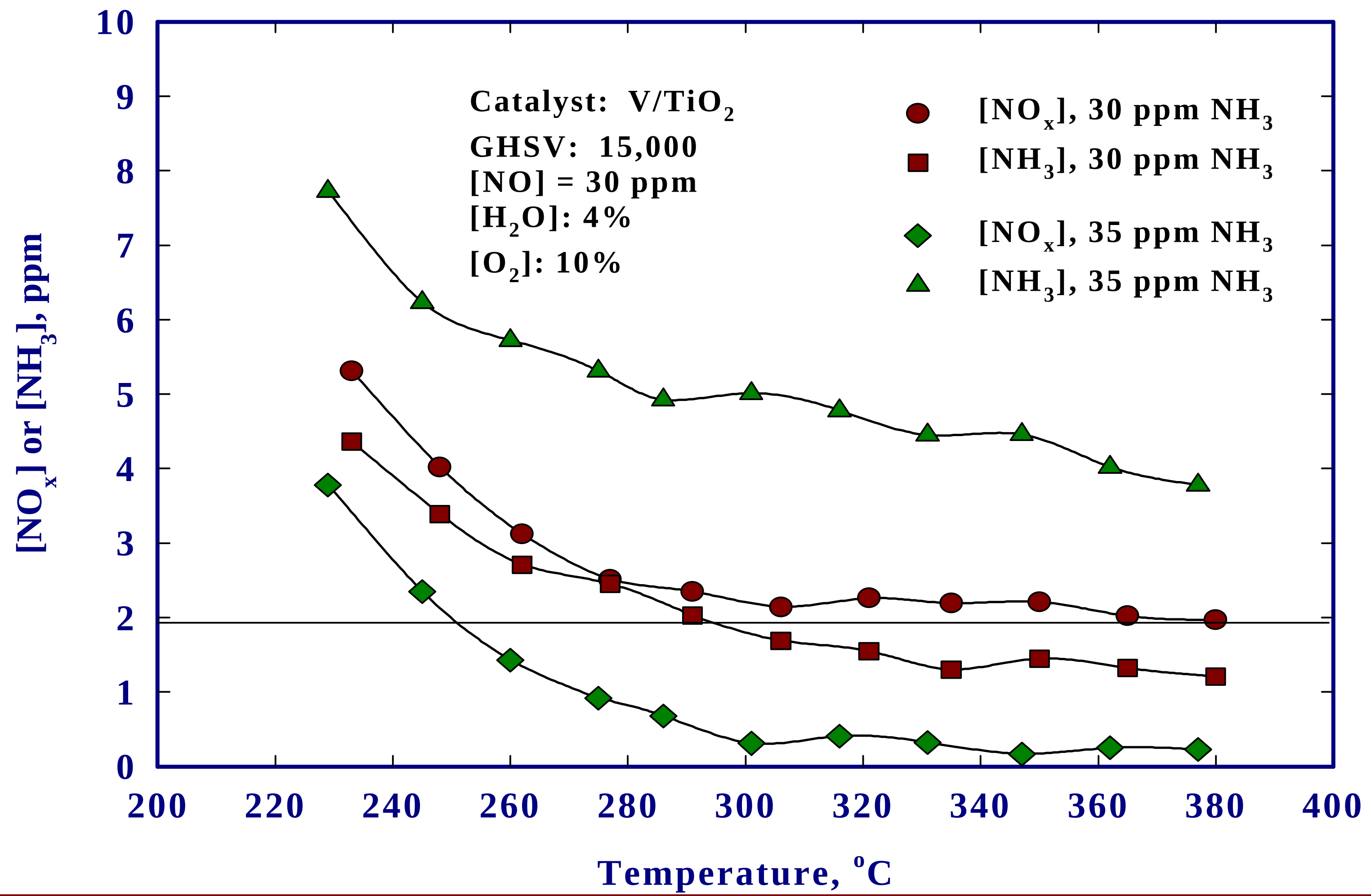
NO_x: NO-NO_x Analyzer (Chemiluminescence)
NH_3: Catalytic Converter ($NH_3 \rightarrow NO_x$)
N_2O, CO, HC: Gas Chromatograph (TCD, FID)

Procedure:

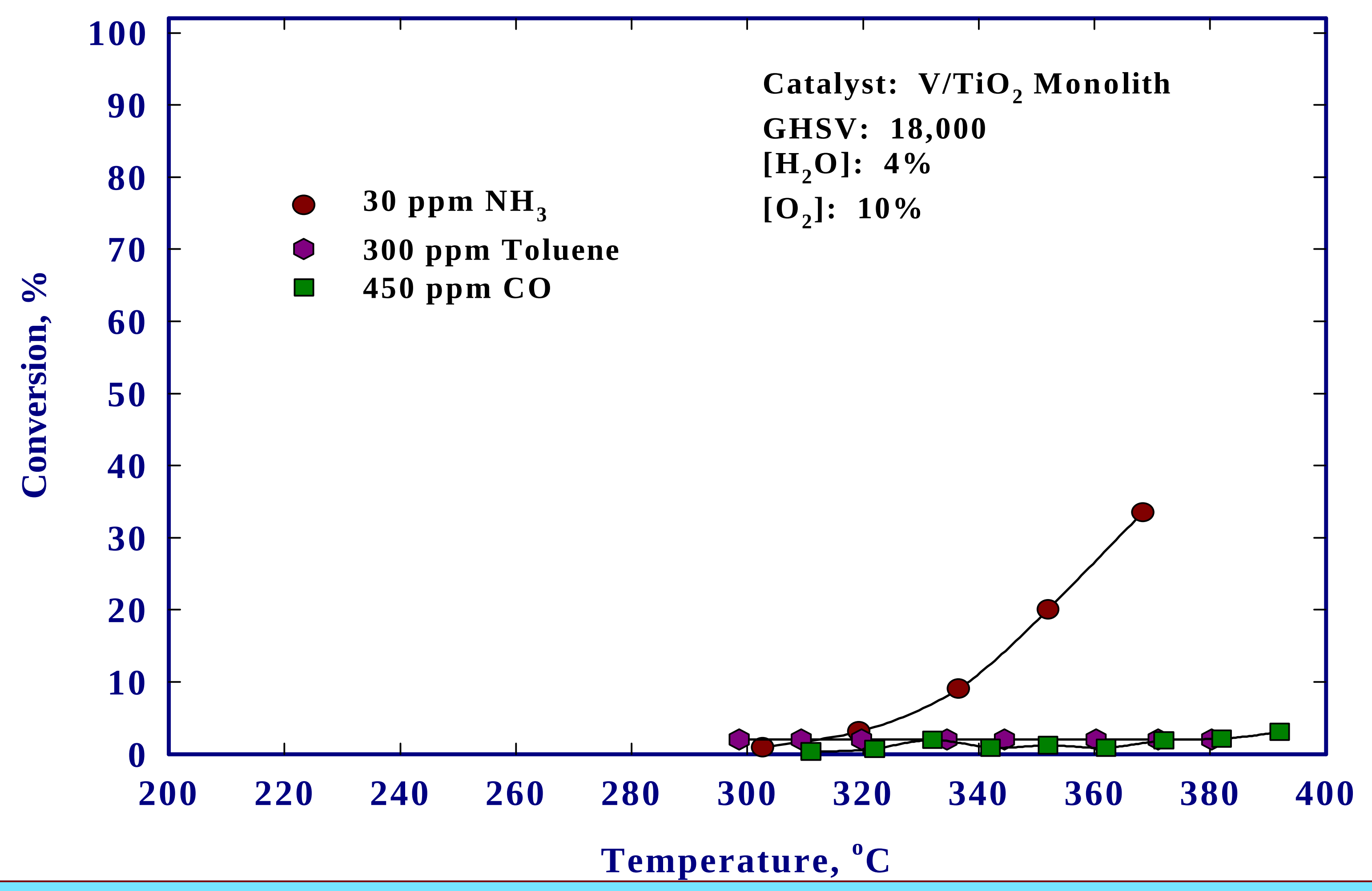
- **Light-off Curves:**
  - **Heat catalyst to desired temperature**
  - **Introduce feed**
  - **Maintain each temperature for 8-10 hrs, then decrease temperature**

- **Stability Tests**
  - **Maintain process conditions for extended period of time**
  - **Monitor effluent over 4-6 hour period, report time average**

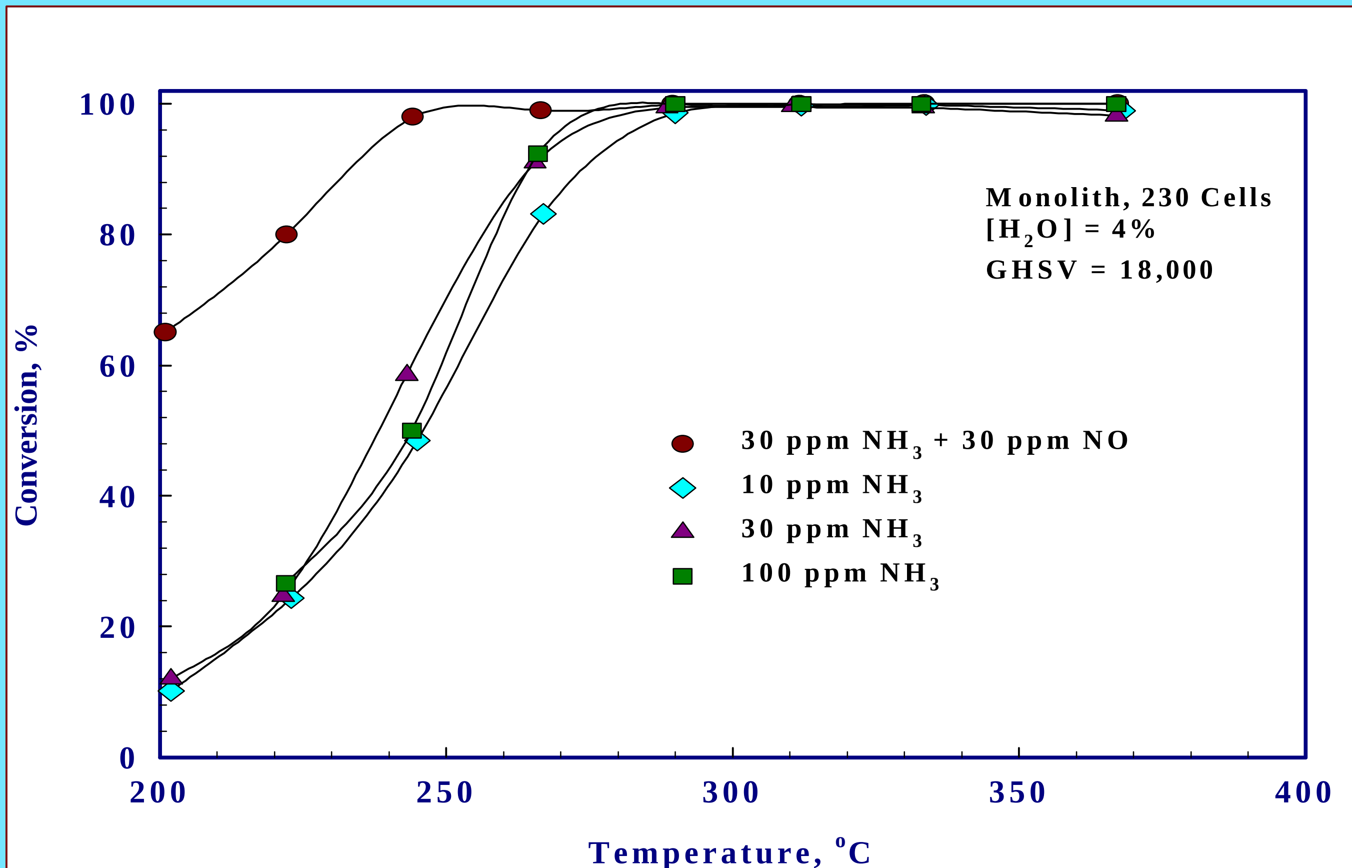
NO_x Reduction: V/TiO_2



V/TiO$_2$ Activity

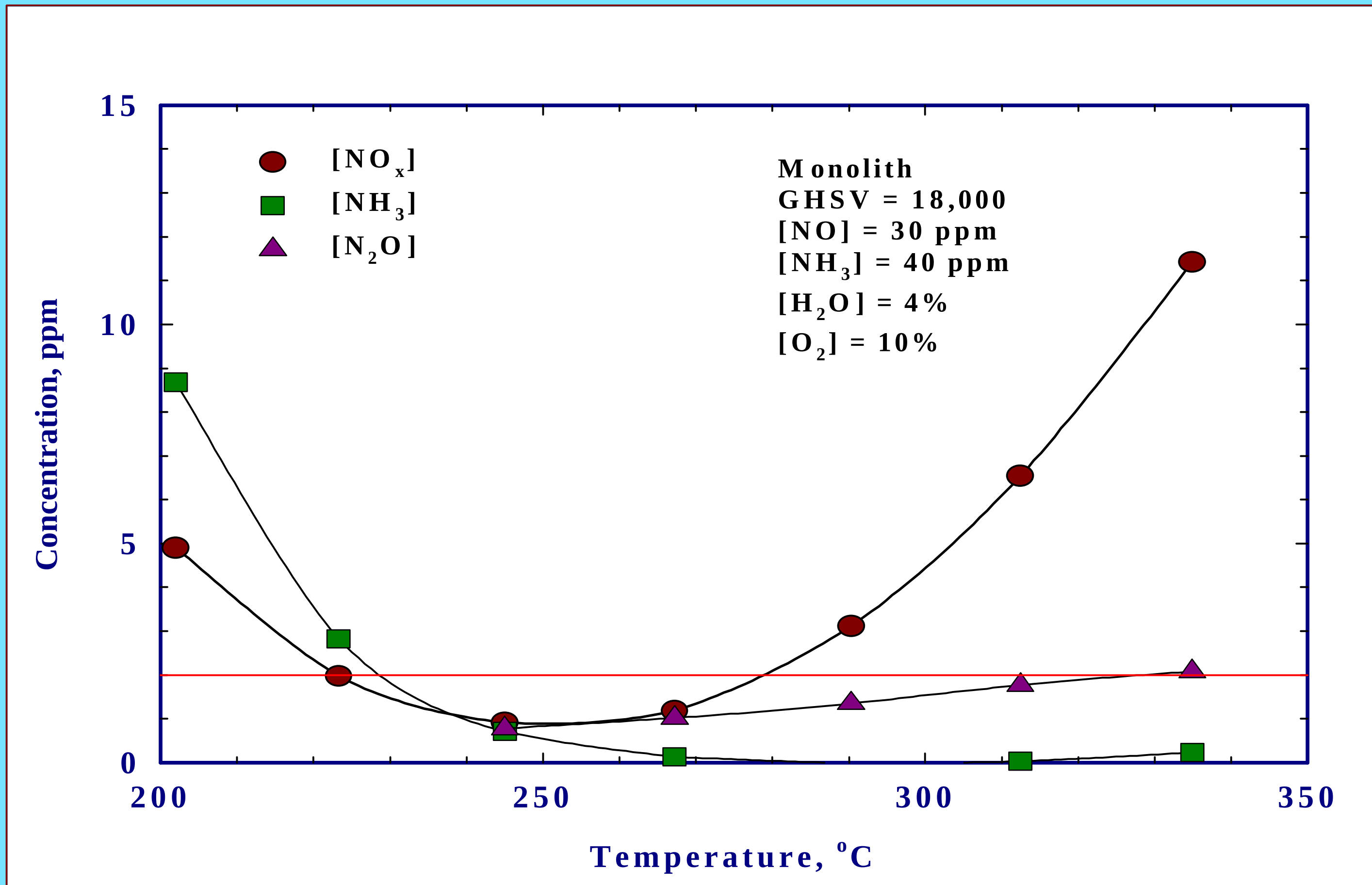


Effects of NO on NH_3 Destruction

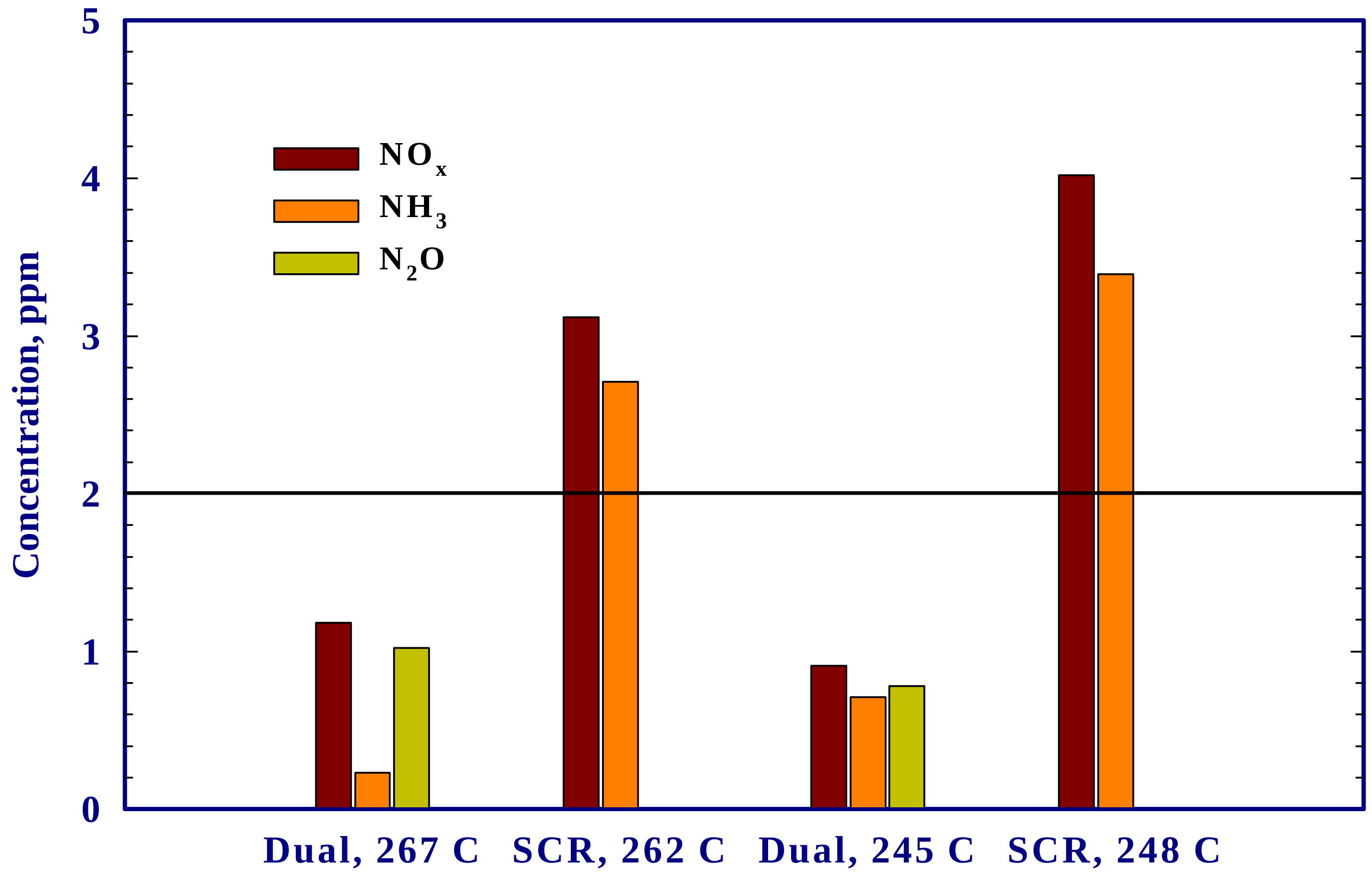


1. For T below about 330°C, NO_x selectivity less than 5%
2. First order dependency on $[NH_3]$
3. NH_3 reaction with NO preferred over reaction with oxygen

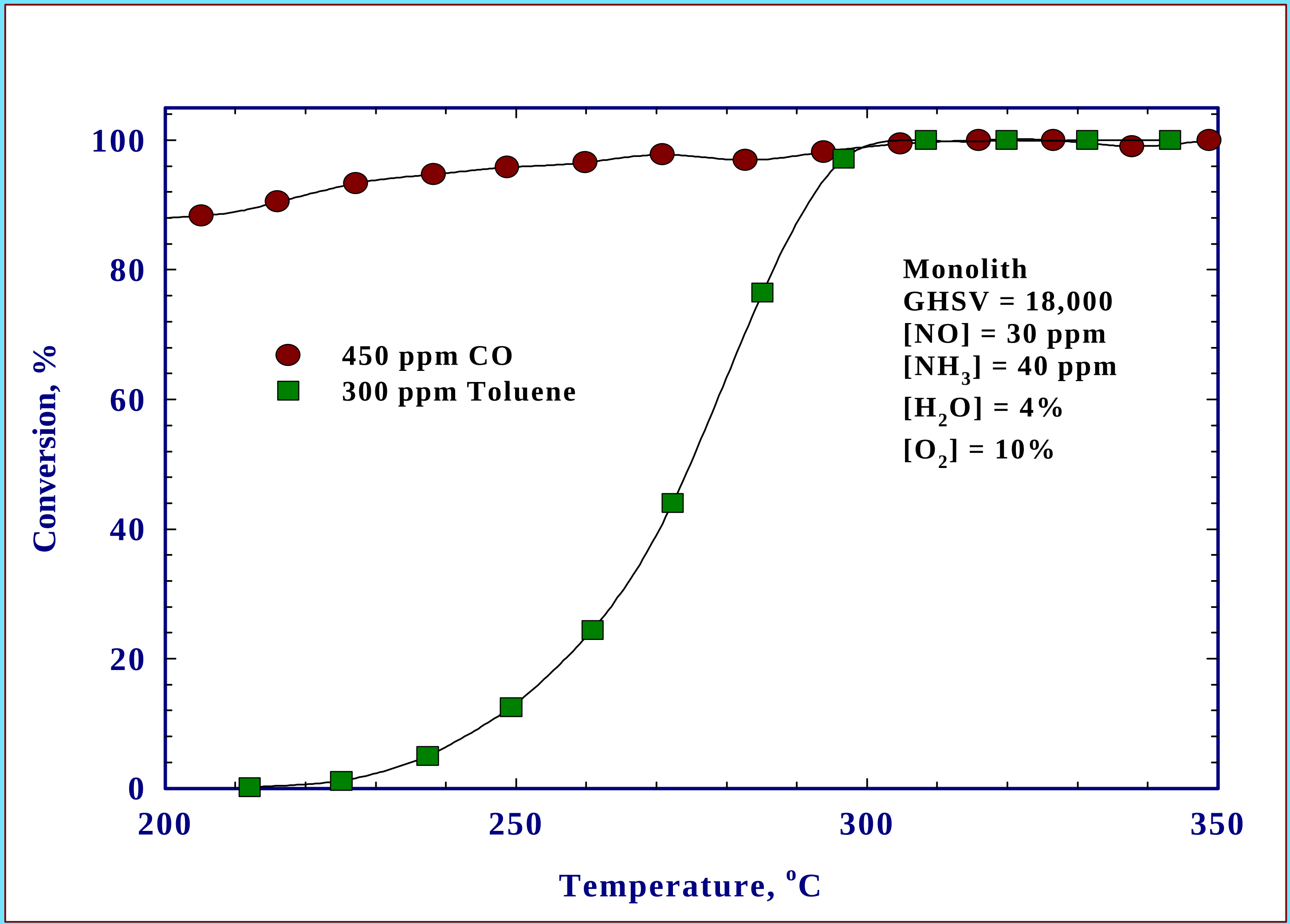
Effects of Temperature on NO_x Abatement



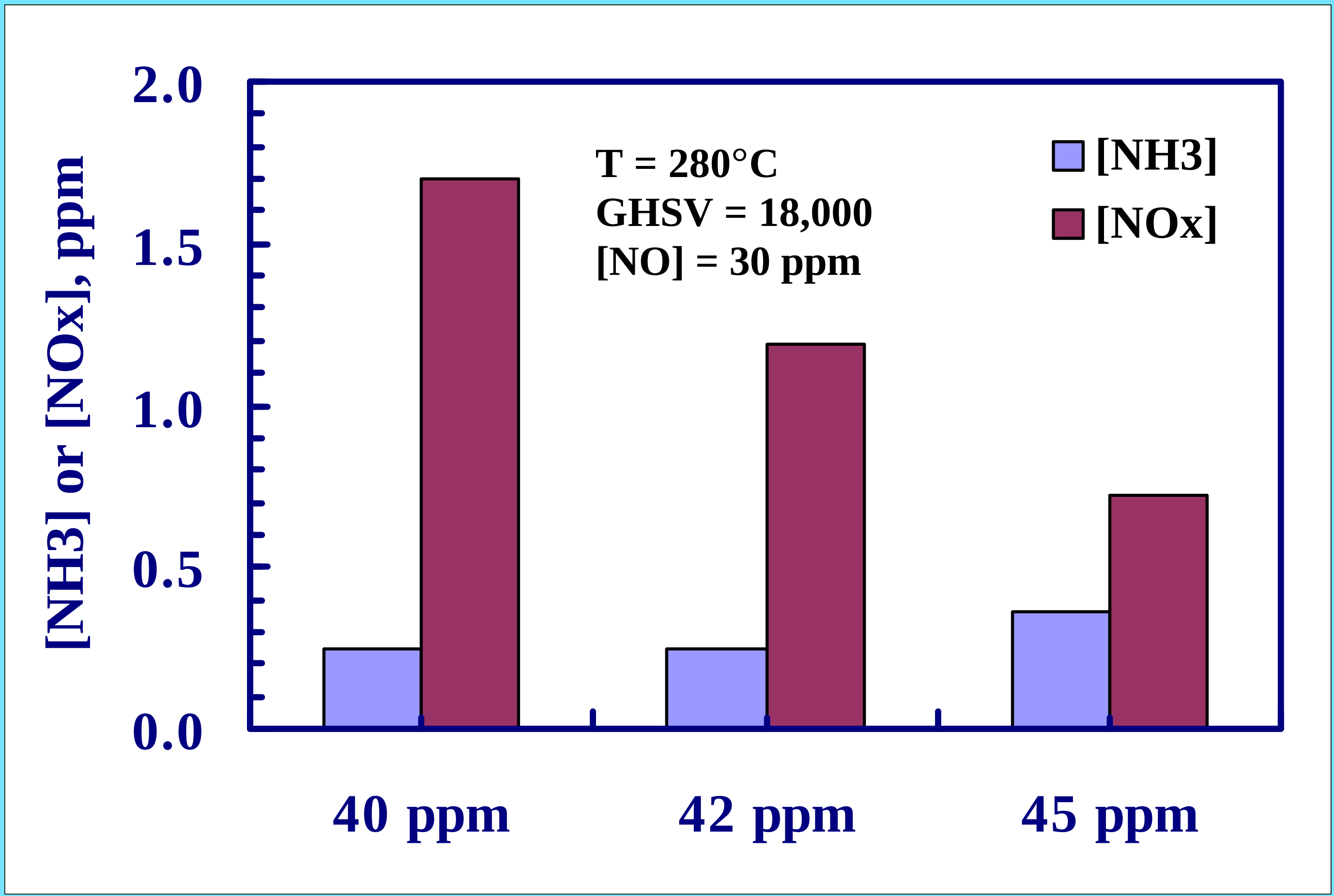
Comparison With SCR



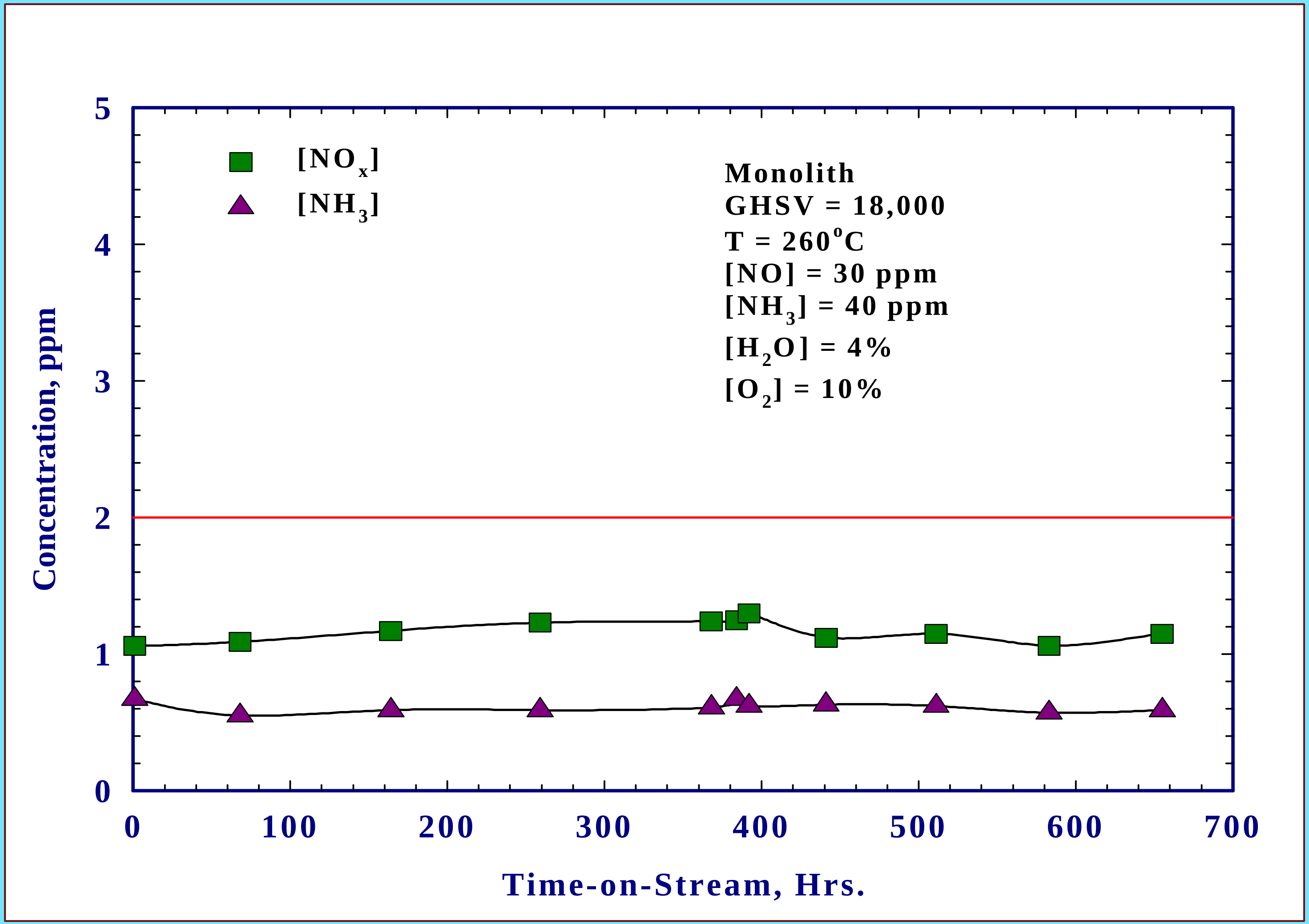
CO and Toluene Activity



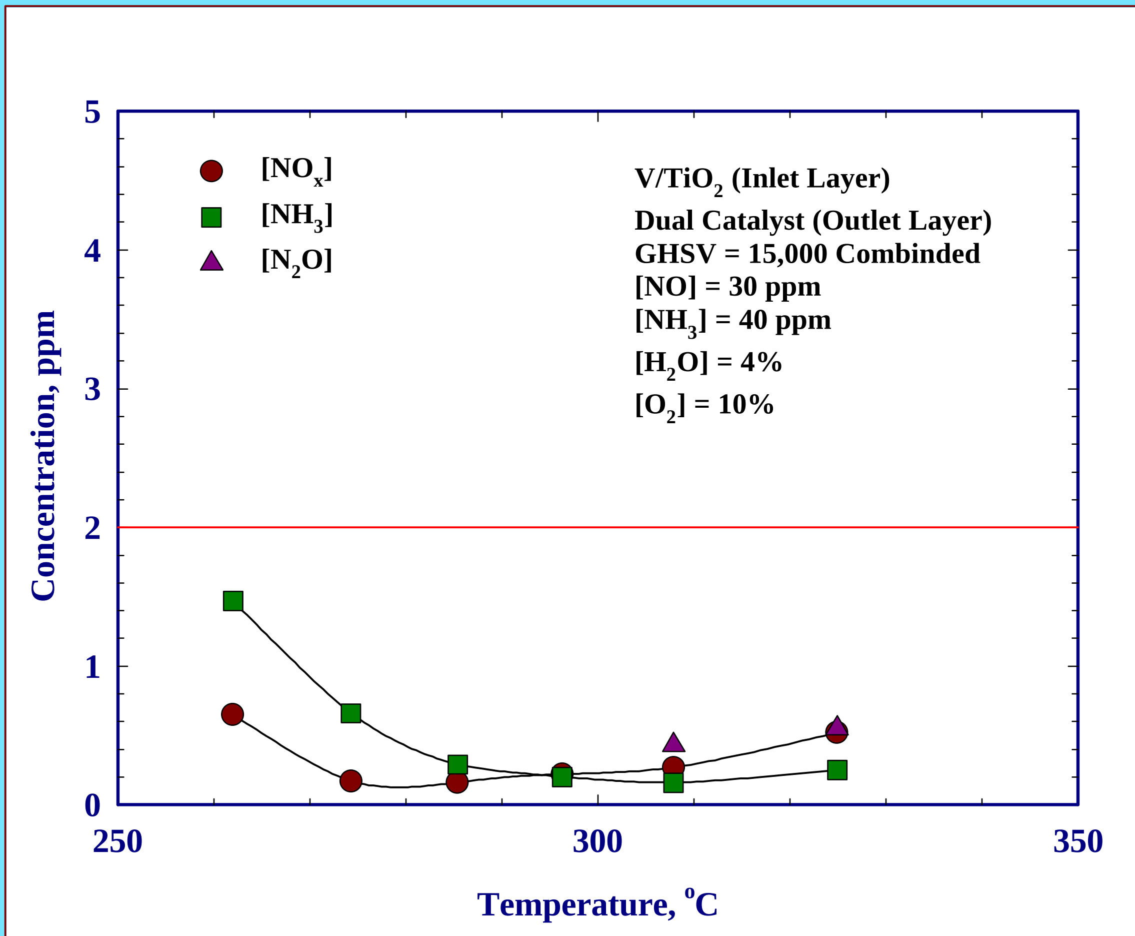
Effects of [NH_3]

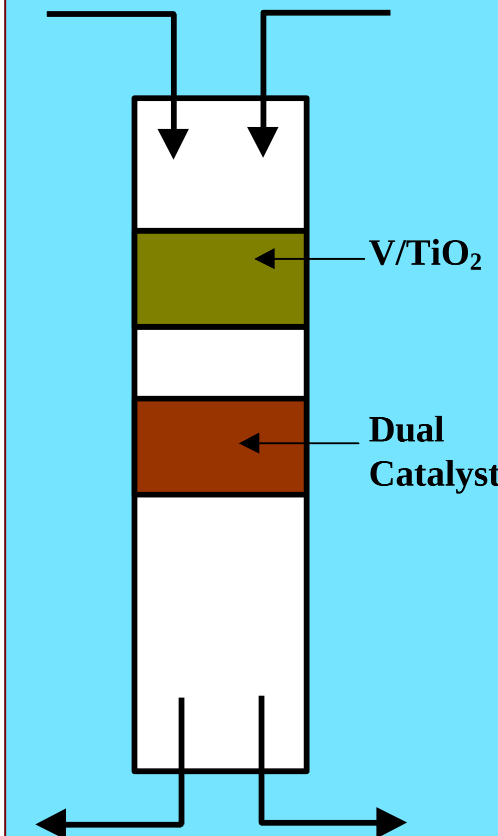


Catalyst Stability

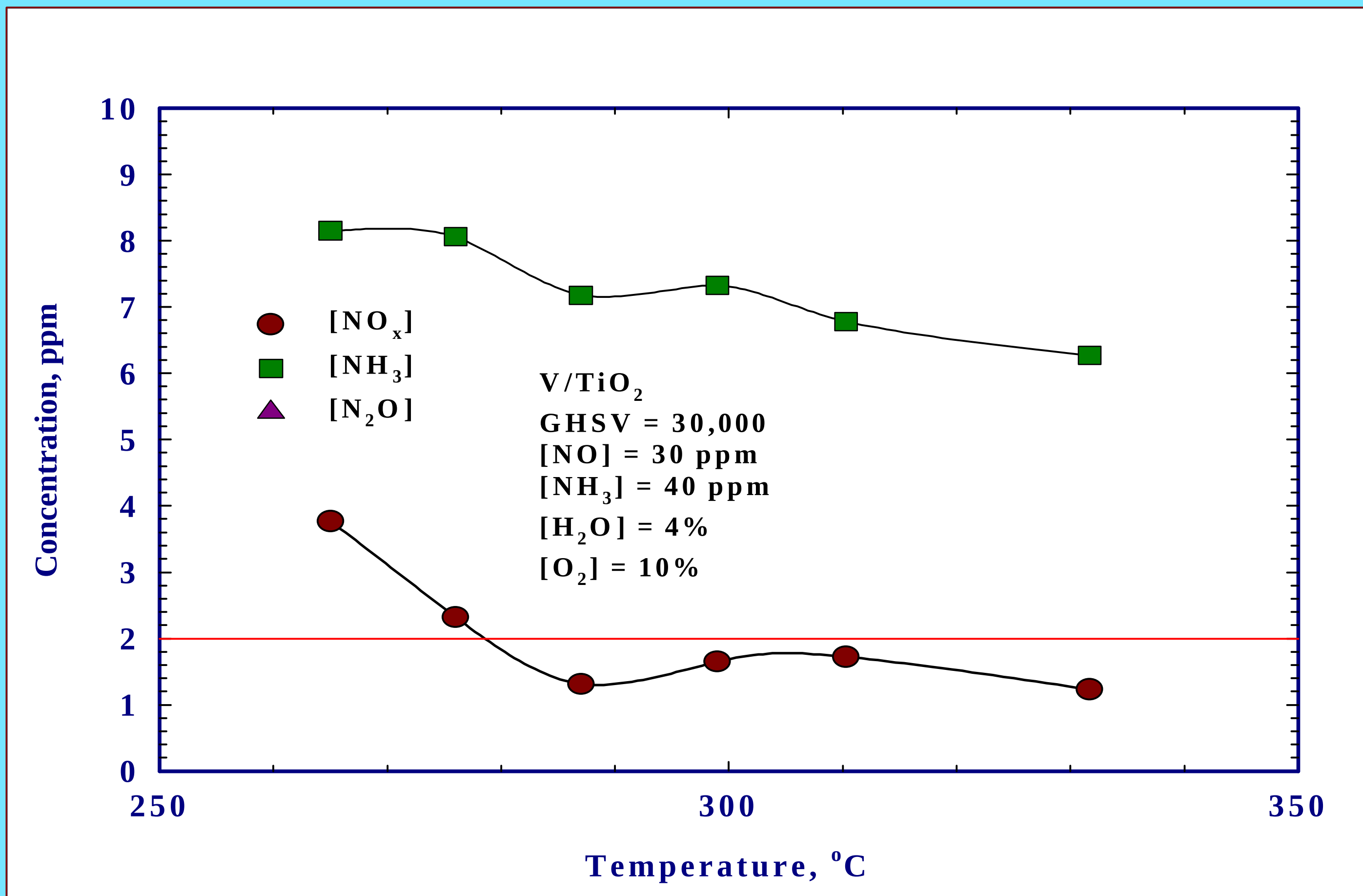


Layered Bed Concept



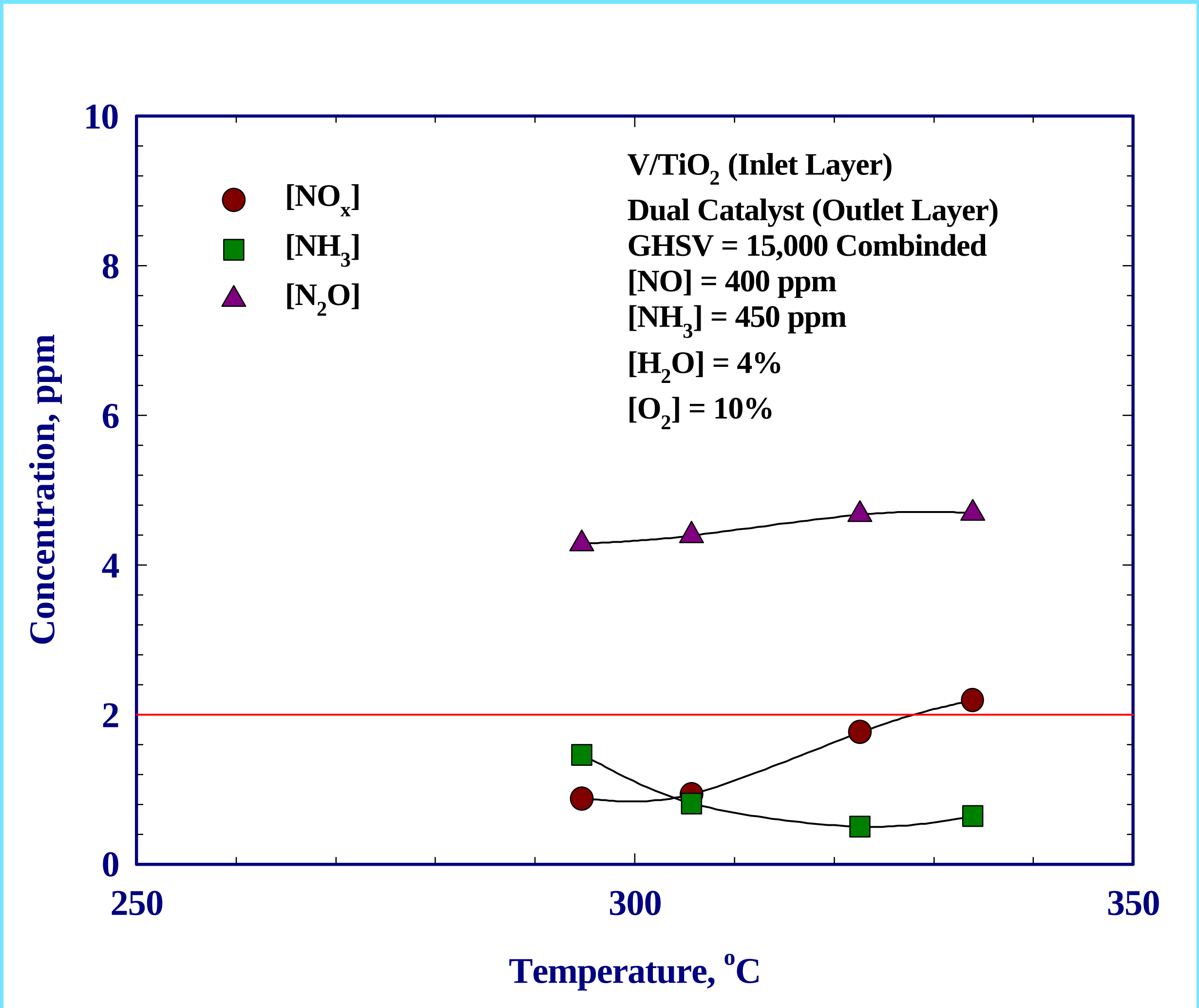


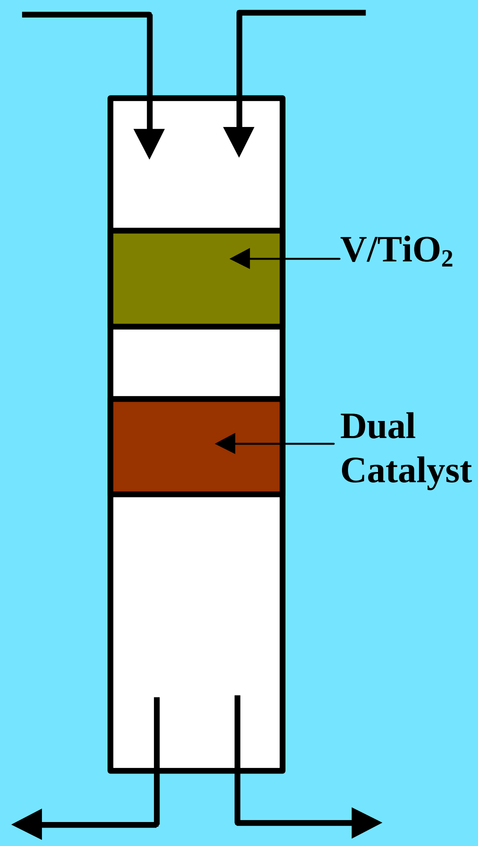
Between Layers



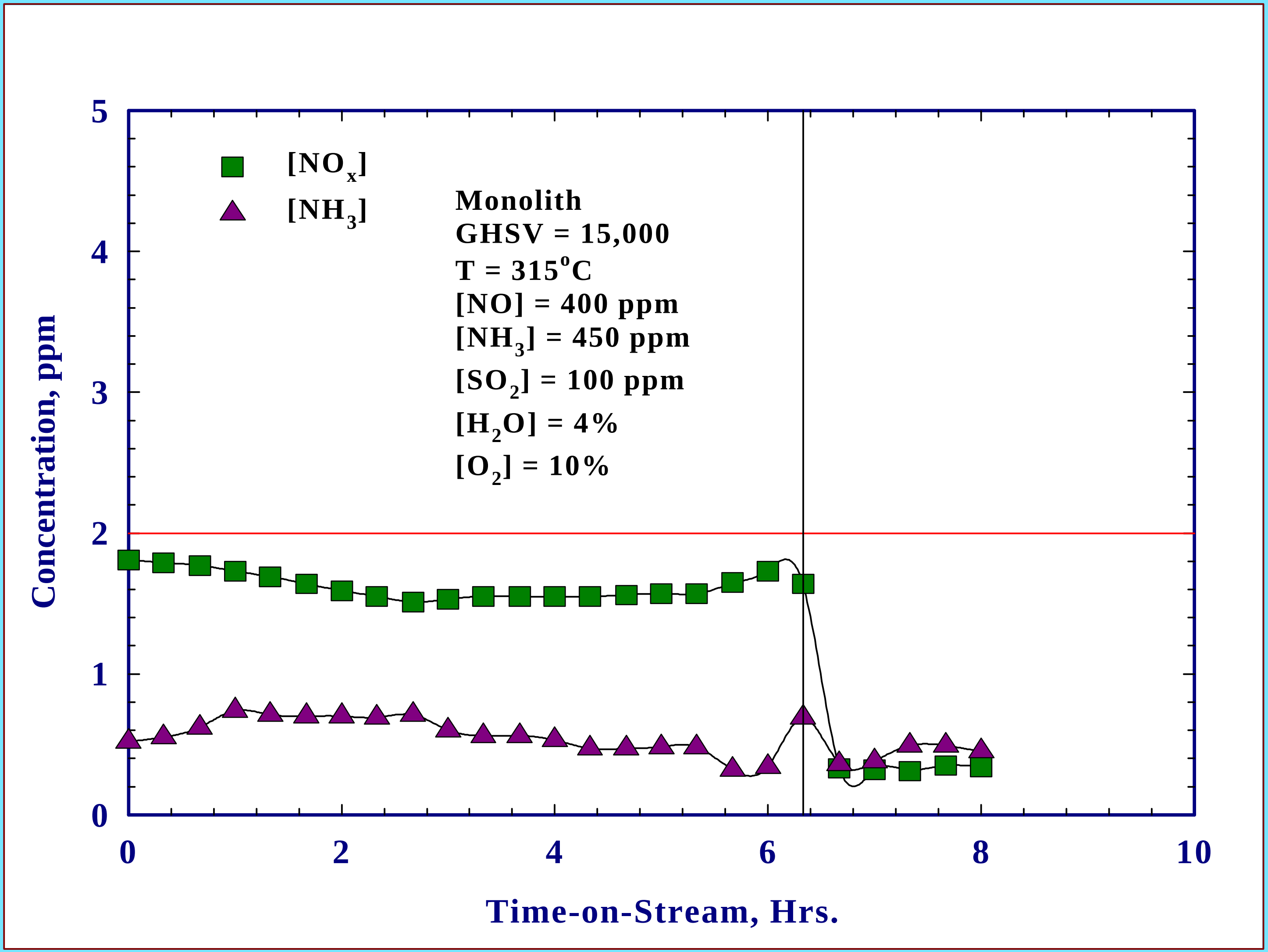
Low NO_x due to high NH_3/NO_x ratio over Dual Catalyst
Low NH_3 slip due to Dual Catalyst operating at temperatures sufficient to decompose NH_3.

Extension to Coal Application

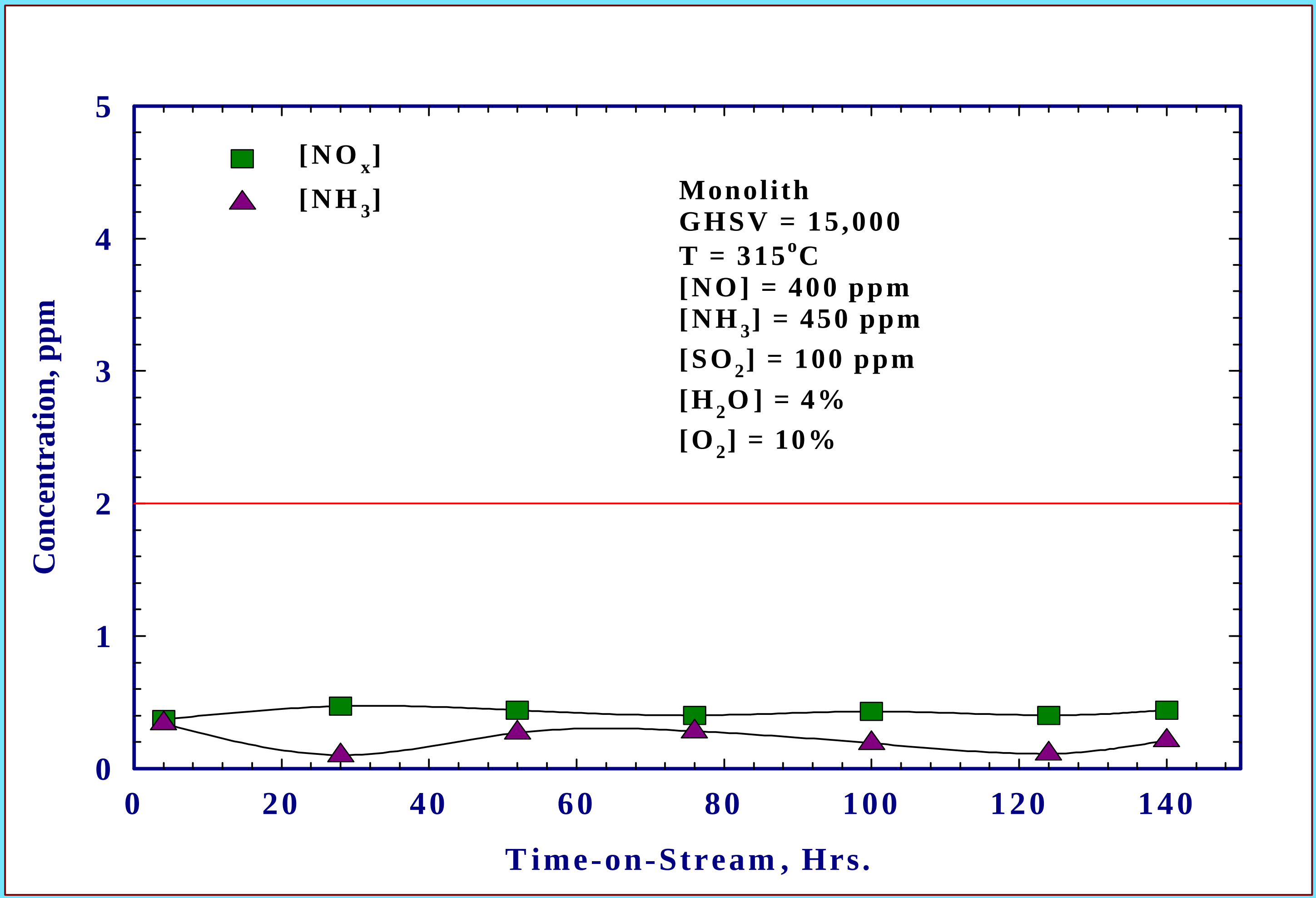




Introduction of SO_2 to Process Stream



Stability in Presence of SO_2



Note: Oxidation of SO_2 to SO_3 not measured but expected to be significant

Summary

The Dual Function Catalyst Able to:

1. **Achieve less than 2 ppm NO_x, 1 ppm NH_3 at GHSV of 18,000 at T between $240^{\circ}C$ and $280^{\circ}C$**
2. **Achieve greater than 95% CO oxidation for $T > 230^{\circ}C$**
3. **Achieve greater than 95% toluene oxidation for $T > 290^{\circ}C$**

Use of Catalyst in Layered Bed:

1. **Expands operating temperature range**
2. **Minimizes N_2O**
3. **Allows for use of less NH_3**

Dual Function Catalyst Demonstrated Stability for Greater than 600 Hours under Simulated Conditions

Dual Function Catalyst able to Achieve High NO_x Reduction in Presence of SO_2.

Acknowledgement

We Wish to Thank the National Science Foundation for Financial Support of This Effort