Collective Protection 2005

Design of Catalytic Process for the Removal of CW Agents and TIC's

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Introduction

Catalytic Oxidation Technology is Well Suited for Military Air Purification Applications

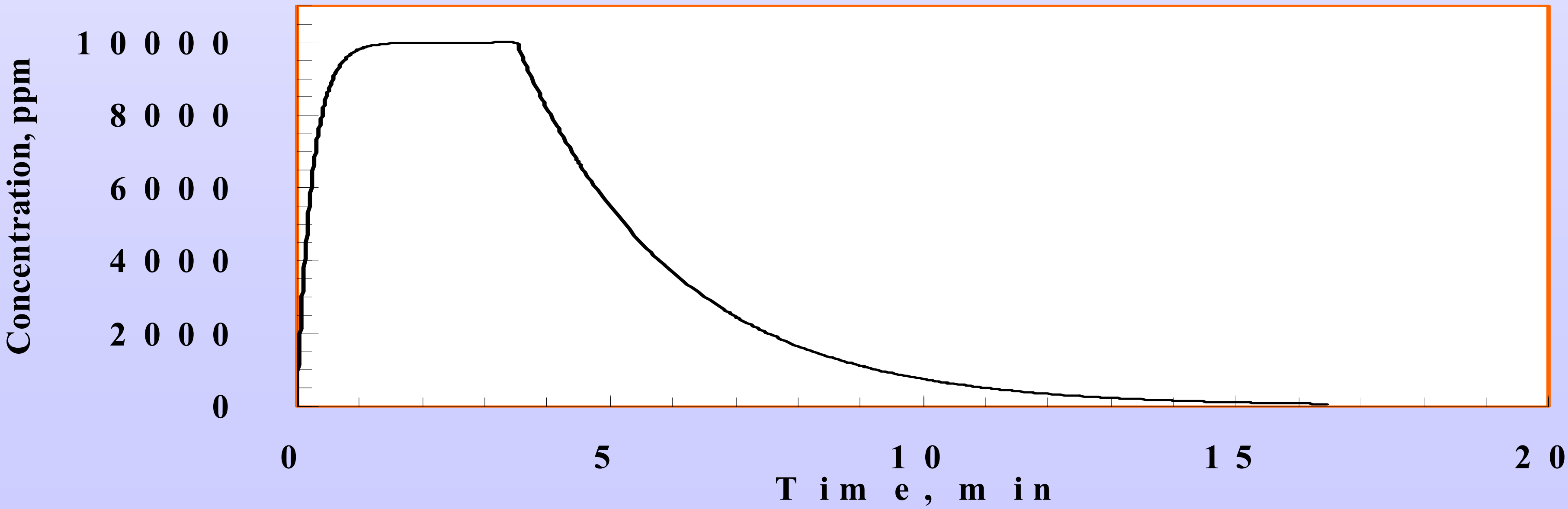
1. **Technology Non-selective: Agents and TIC's reduced to CO_2, H_2O and haloacids**
2. **Elevated Temperatures may Offer Biological Decontamination**
3. **Unlimited Capacity for Agents and TIC's: Catalytic sites not consumed during reaction**
4. **Technology lends itself well towards integration with many host applications**

Introduction

Catalytic Process versus Chemical Threat

1. **Chemical threat; how catalytic process will be exposed to chemical agent, differs greatly with how gas-mask and CP filters are tested.**

2. **During a chemical attack, a filtration device can be exposed to a rapidly increasing, high concentration of chemical agent that will decay over time.**



Introduction: Catalytic Response

1. Catalytic reaction rates can be highly non-linear in concentration. Catalyst must be operated at conditions sufficient to achieve high destruction efficiencies when challenged with high concentration of agent.

2. When exposed to high concentration of chemical agent, the temperature within the catalyst will increase significantly in a short period of time.
   - Conversion will increase, as catalyst performance increases exponentially with increasing temperature.
   - For nitrogen-containing compounds (e.g HCN, NH_3), product selectivity will shift from N_2 to NO_x with increasing temperature.

3. NO_x (NO and NO_2) is difficult to filter within the constraints of regeneration system. Therefore, catalytic process must be designed to minimize NO_x formation during the destruction of nitrogen-containing compounds.

Catalytic Destruction of Nitrogen-Containing Compounds

$$HCN + yO_2 \rightarrow CO_2 + NO_x + \tfrac{1}{2}H_2O$$

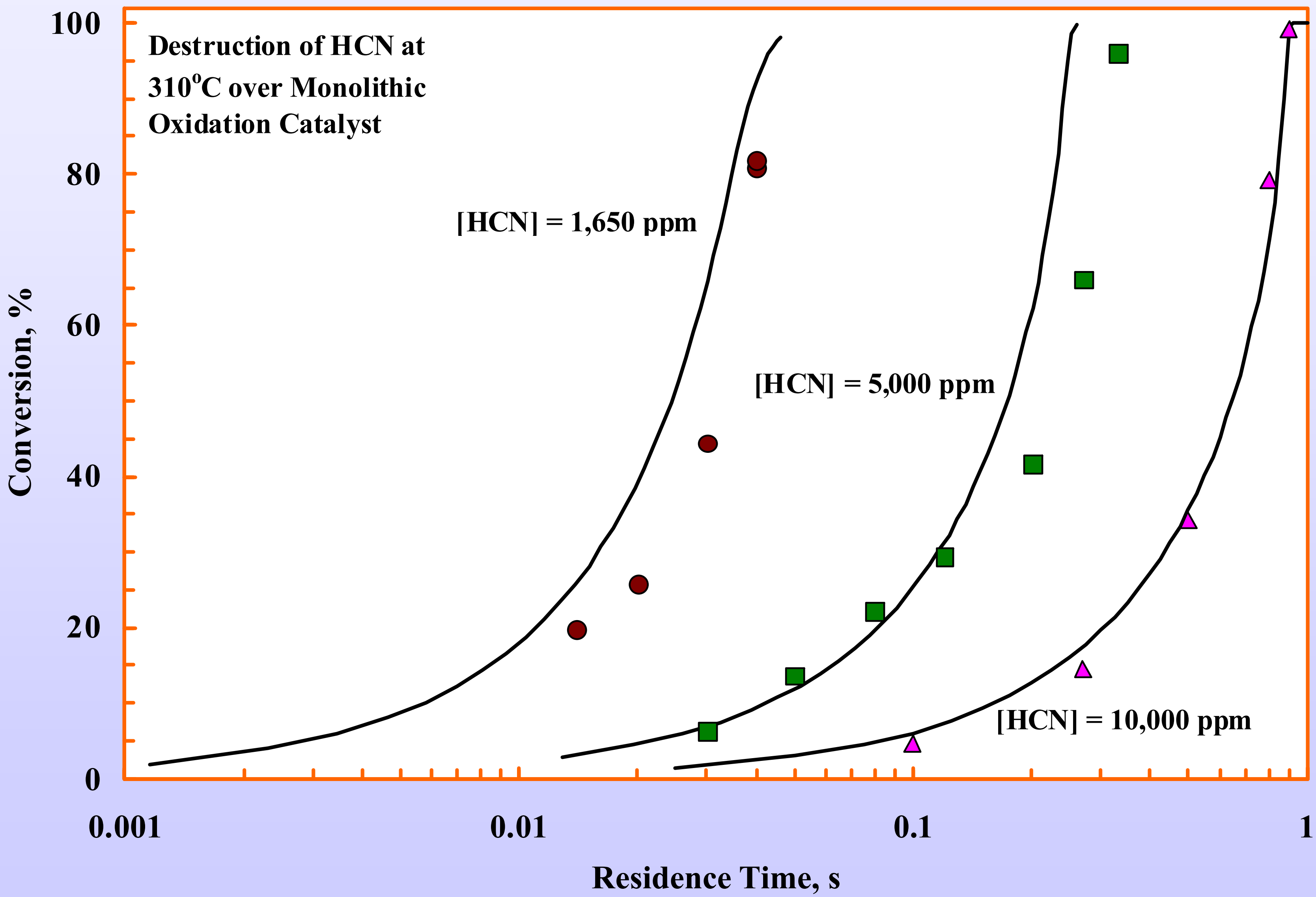
$$HCN + yO_2 \rightarrow CO_2 + \tfrac{1}{2}N_2 + \tfrac{1}{2}H_2O$$

$$HCN + yO_2 \rightarrow CO_2 + \tfrac{1}{2}N_2O + \tfrac{1}{2}H_2O$$

Requirements:

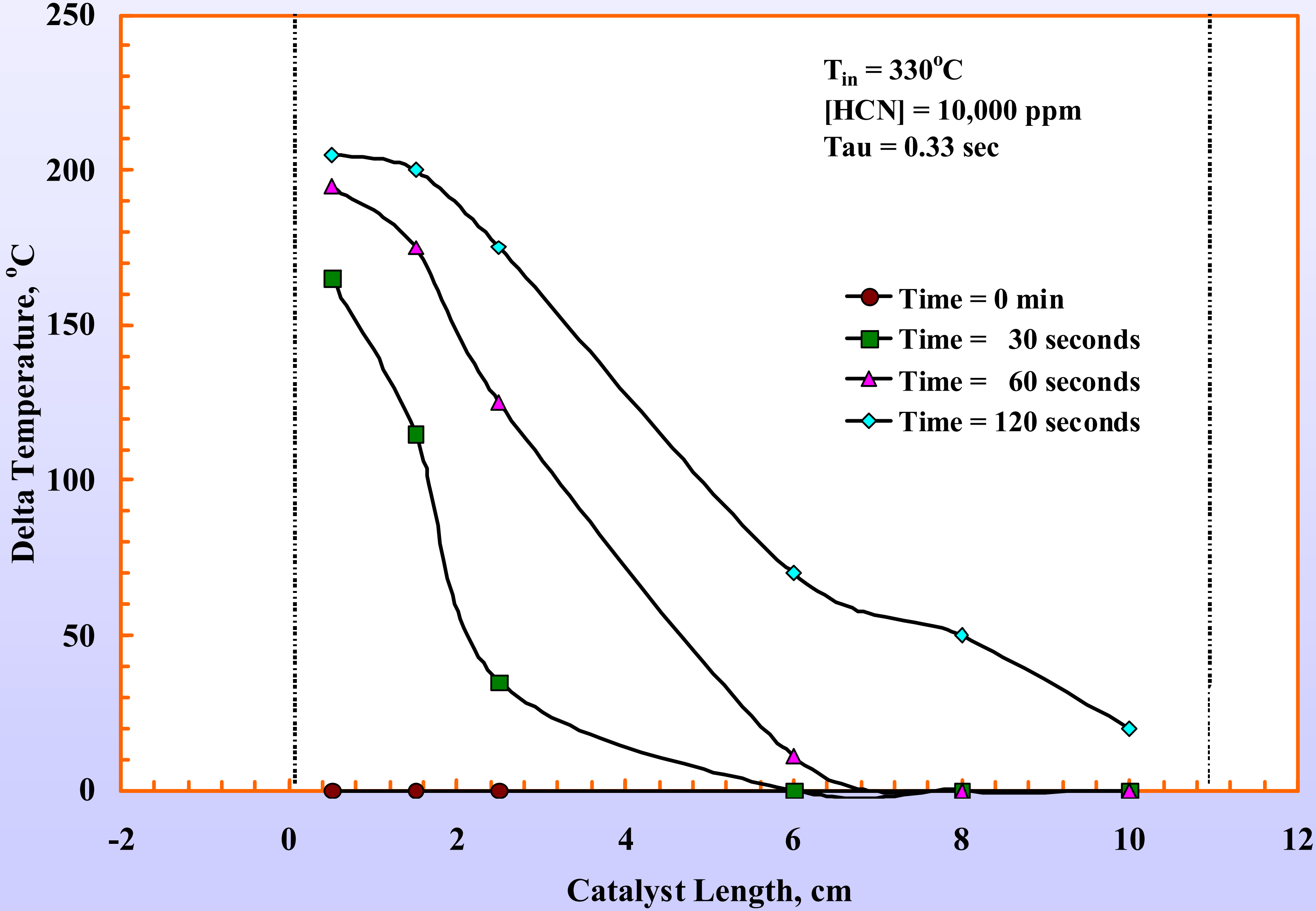
NO:	**Less than 30 mg/m^3**
NO_2:	**Less than 5 mg/m^3**
N_2O:	**Less than 60 mg/m^3**

Effects of Concentration of Reaction Rate



Rossin, 1995

Catalyst Thermal Response during Pulse of HCN



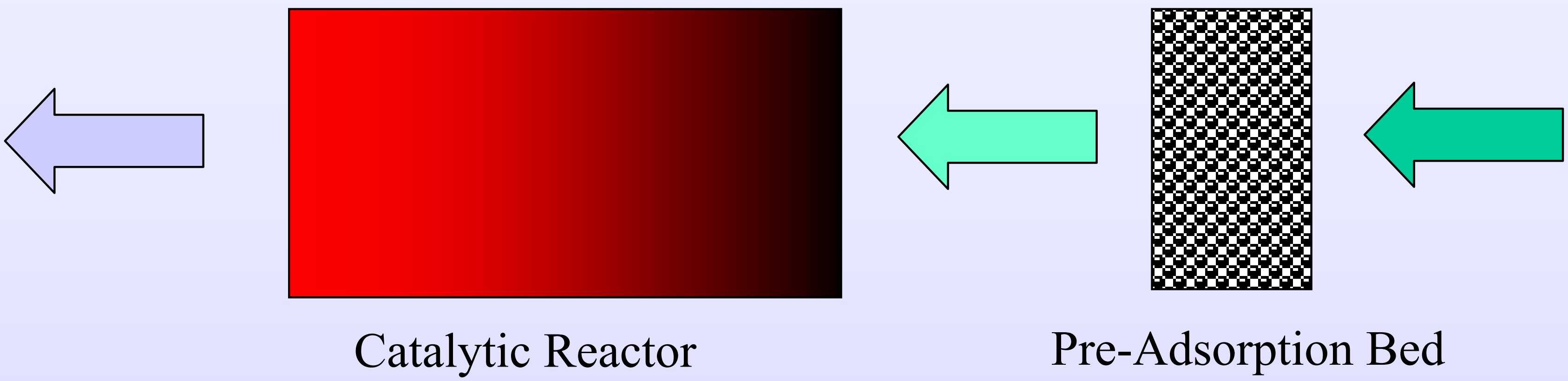
Rossin, 1995

Objective

Evaluate the use of an adsorption bed up-stream of the catalytic reactor to minimize NO_x formation

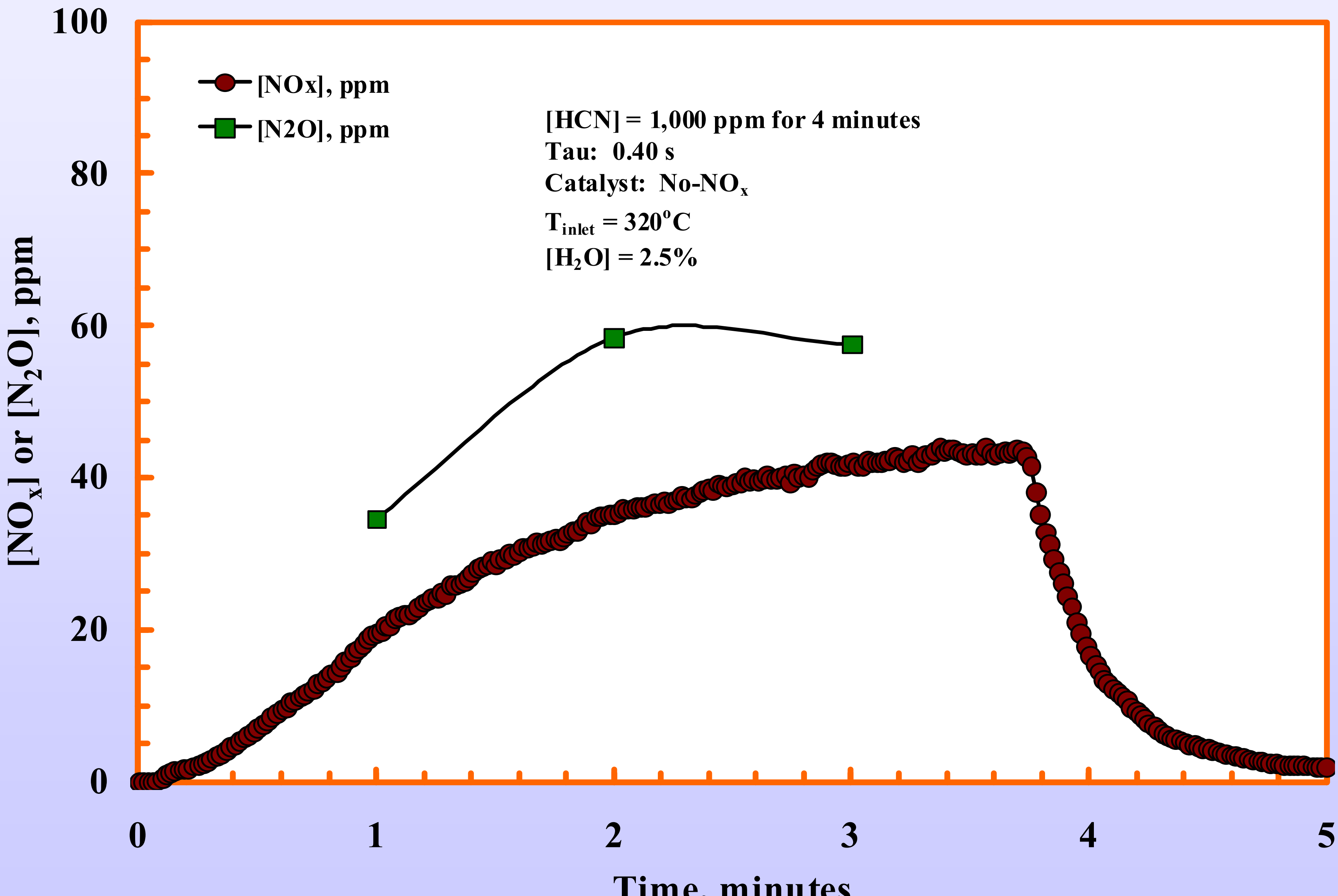
- o Adsorption bed expected to dampen high concentration spikes in chemical
- o Chemical will be delivered to the catalyst at lower concentrations over longer time.
  - Favorable reaction kinetics
  - Greater thermal management
- o NO_x formation will be reduced via lower catalyst temperature and lower chemical concentration.

Catalytic Oxidation Process



1. Expose catalytic process to pulse of chemical
2. Record catalyst temperature in real time
3. Monitor NO_x in real time using NO-NO_x analyzer
4. Monitor concentration of N_2O, CO_2 and chemical in effluent stream using grab bags and discrete on-line analysis.

No Pre-Adsorber, Low Concentration



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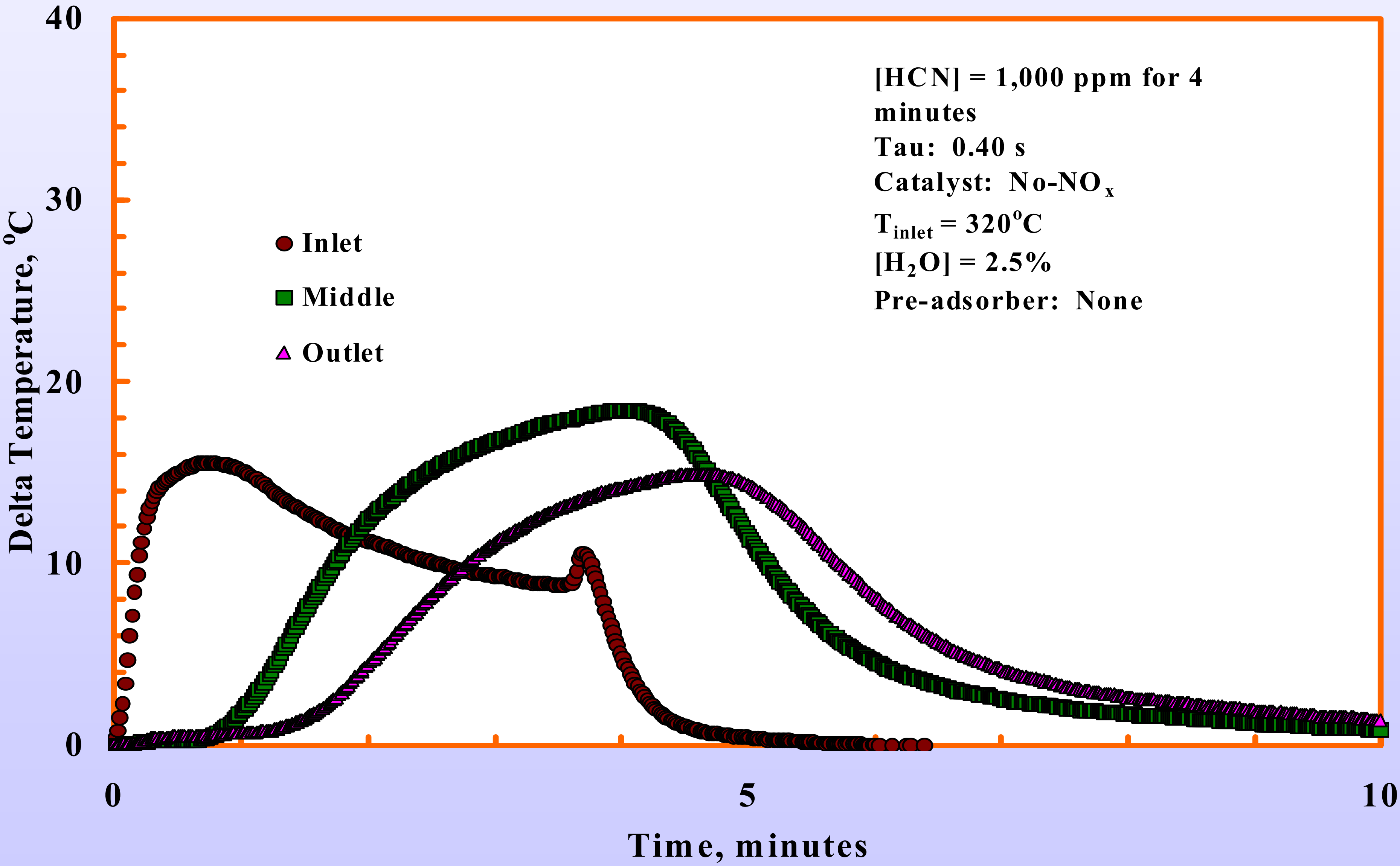
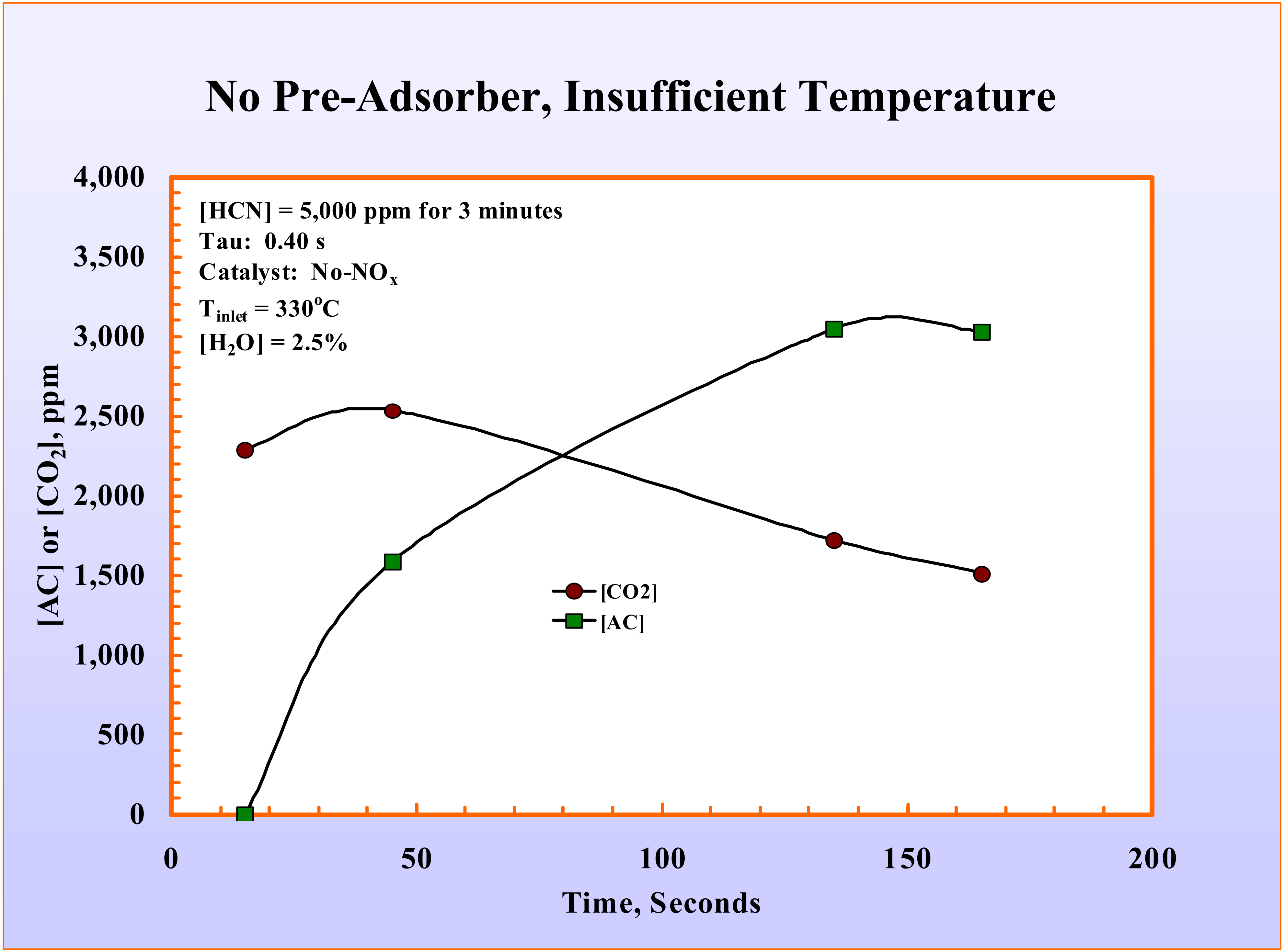
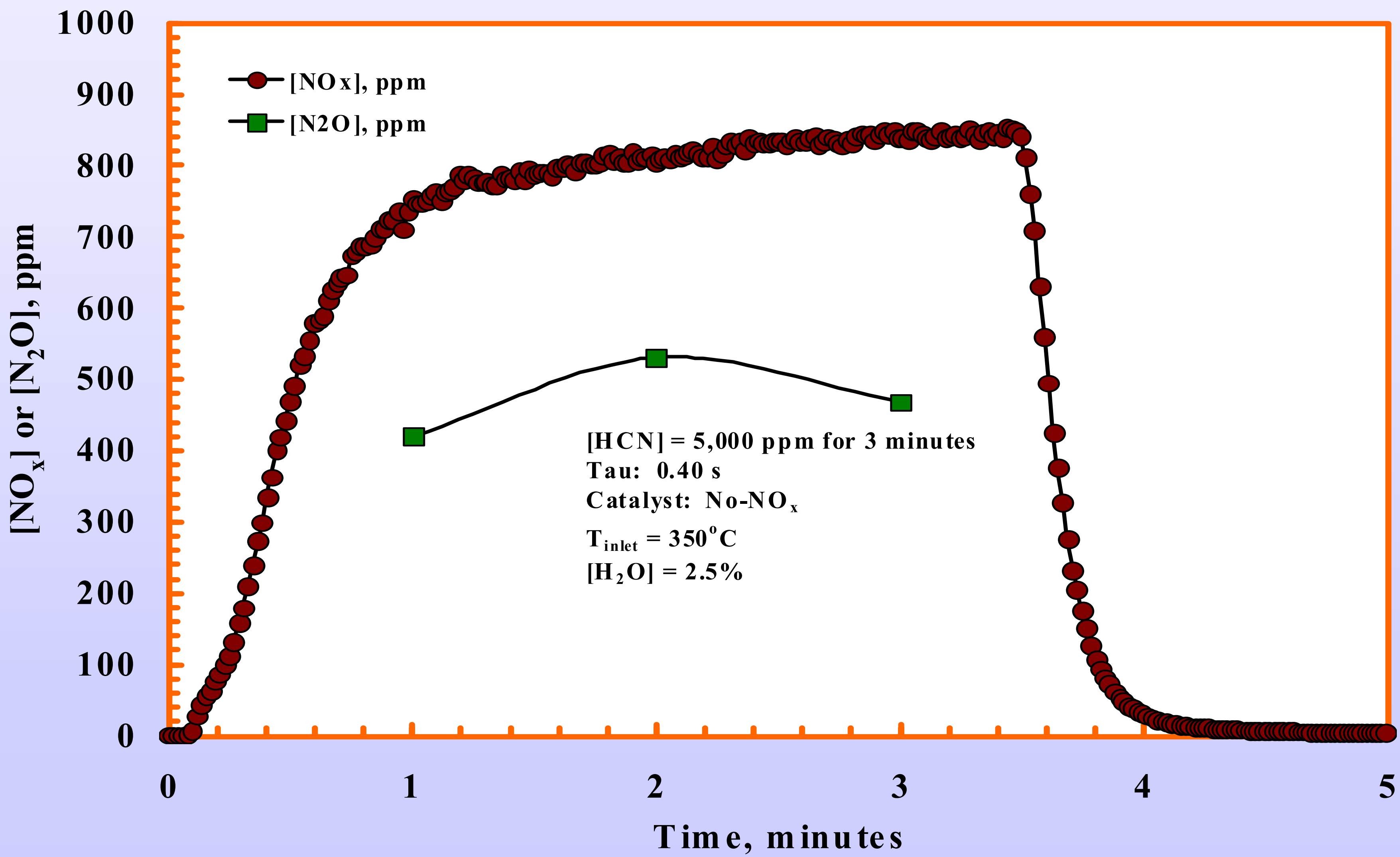


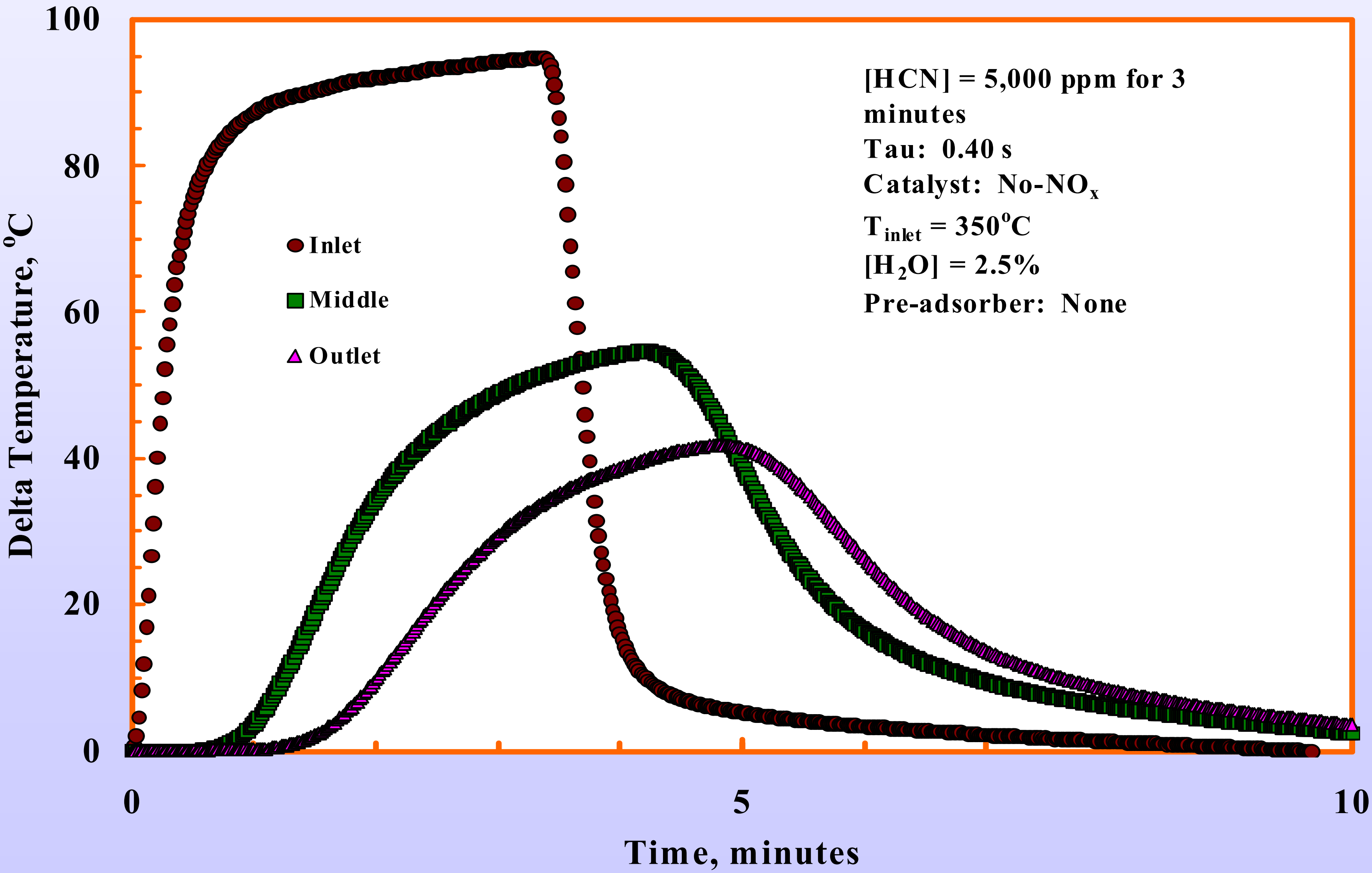


No Pre-Adsorber, Insufficient Temperature
[HCN] = 5,000 ppm for 3 minutes
Tau: 0.40 s
Catalyst: No-NO_x
T_{inlet} = 330°C
$[H_2O]$ = 2.5%
[CO2]
[AC]
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
50
100
150
200
[AC] or $[CO_2]$, ppm
Time, Seconds

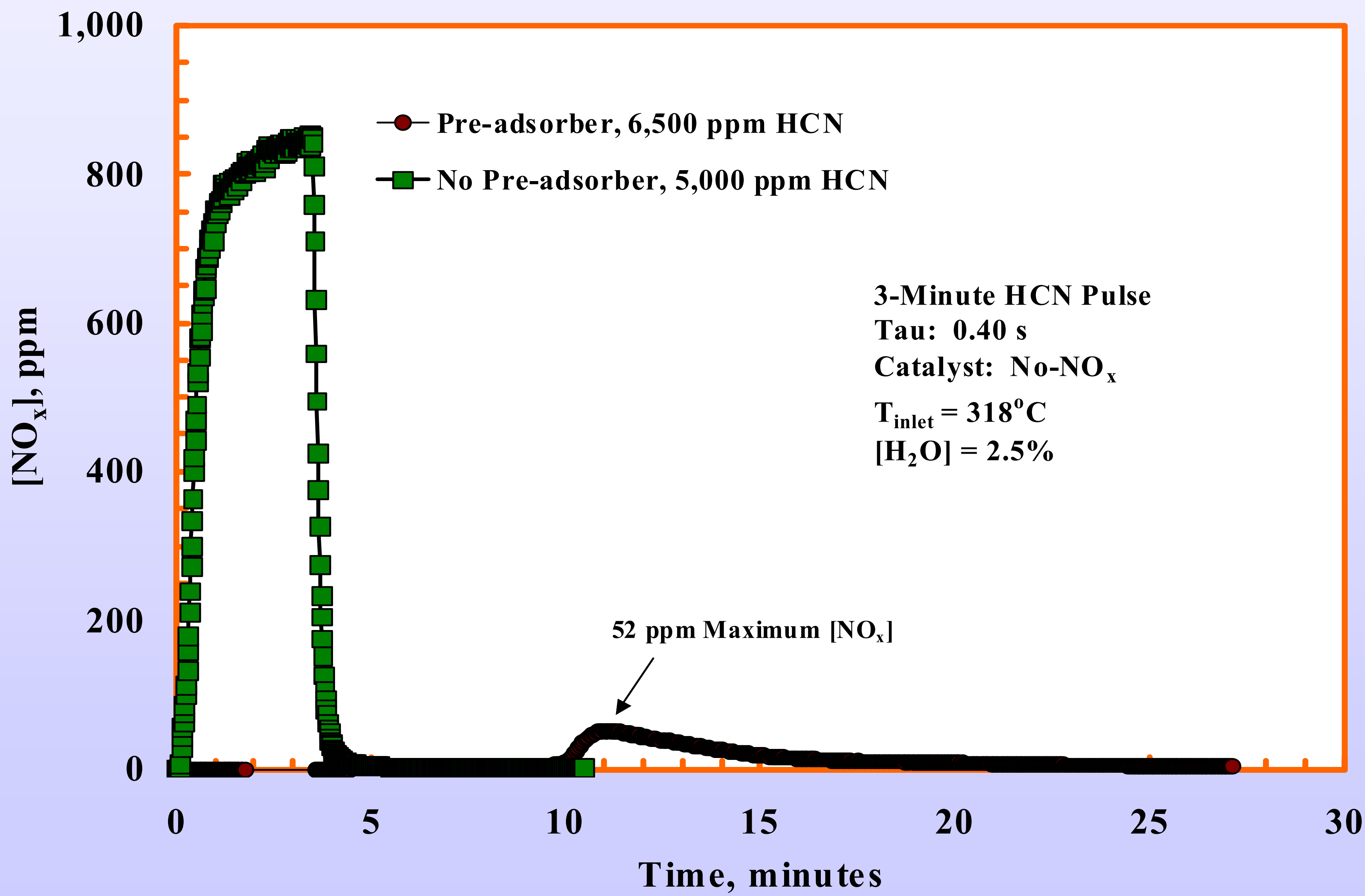
No Pre-adsorber, Increased Temperature



No Pre-adsorber, Increased Temperature



Use of Pre-adsorber for Destruction of HCN



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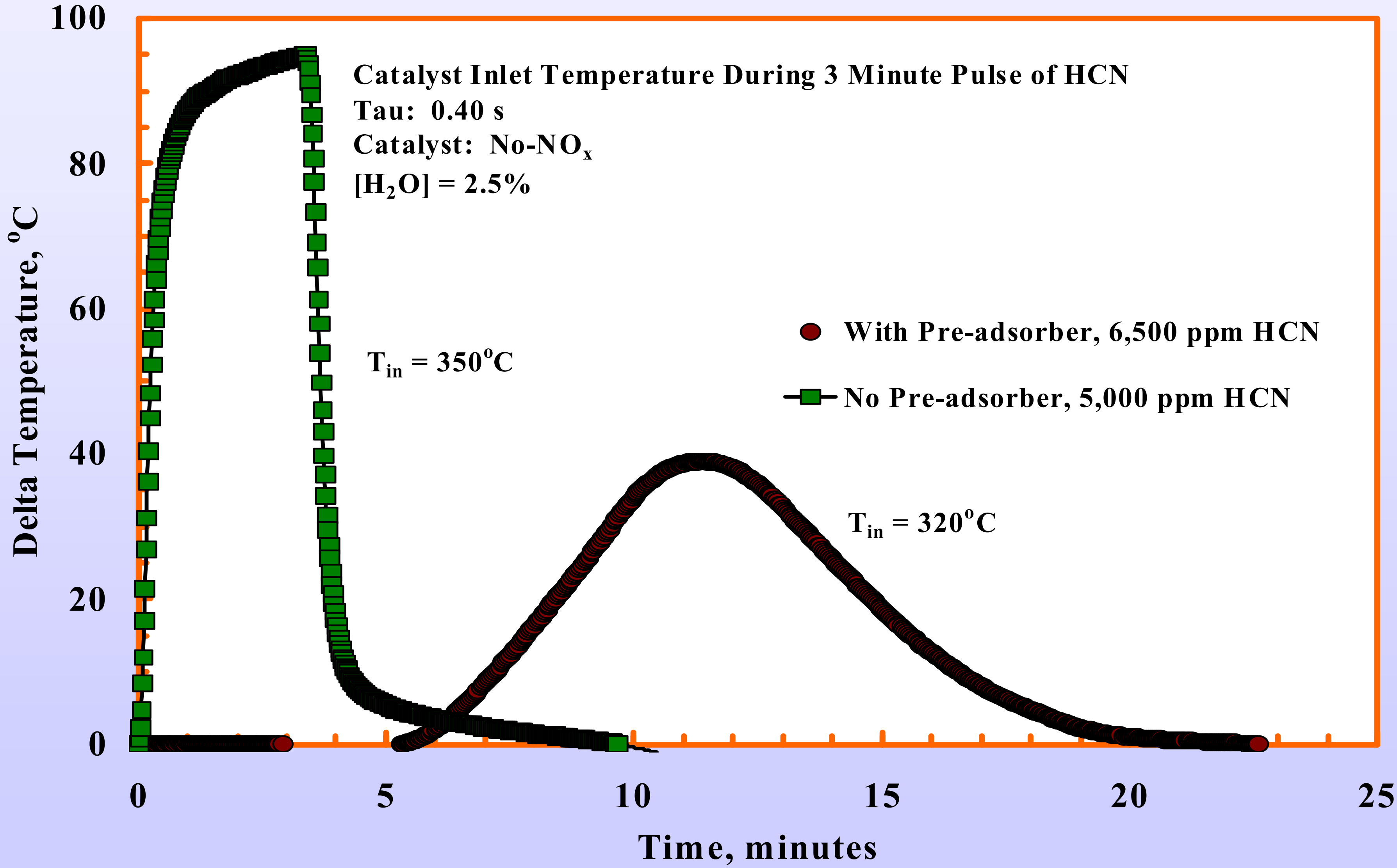

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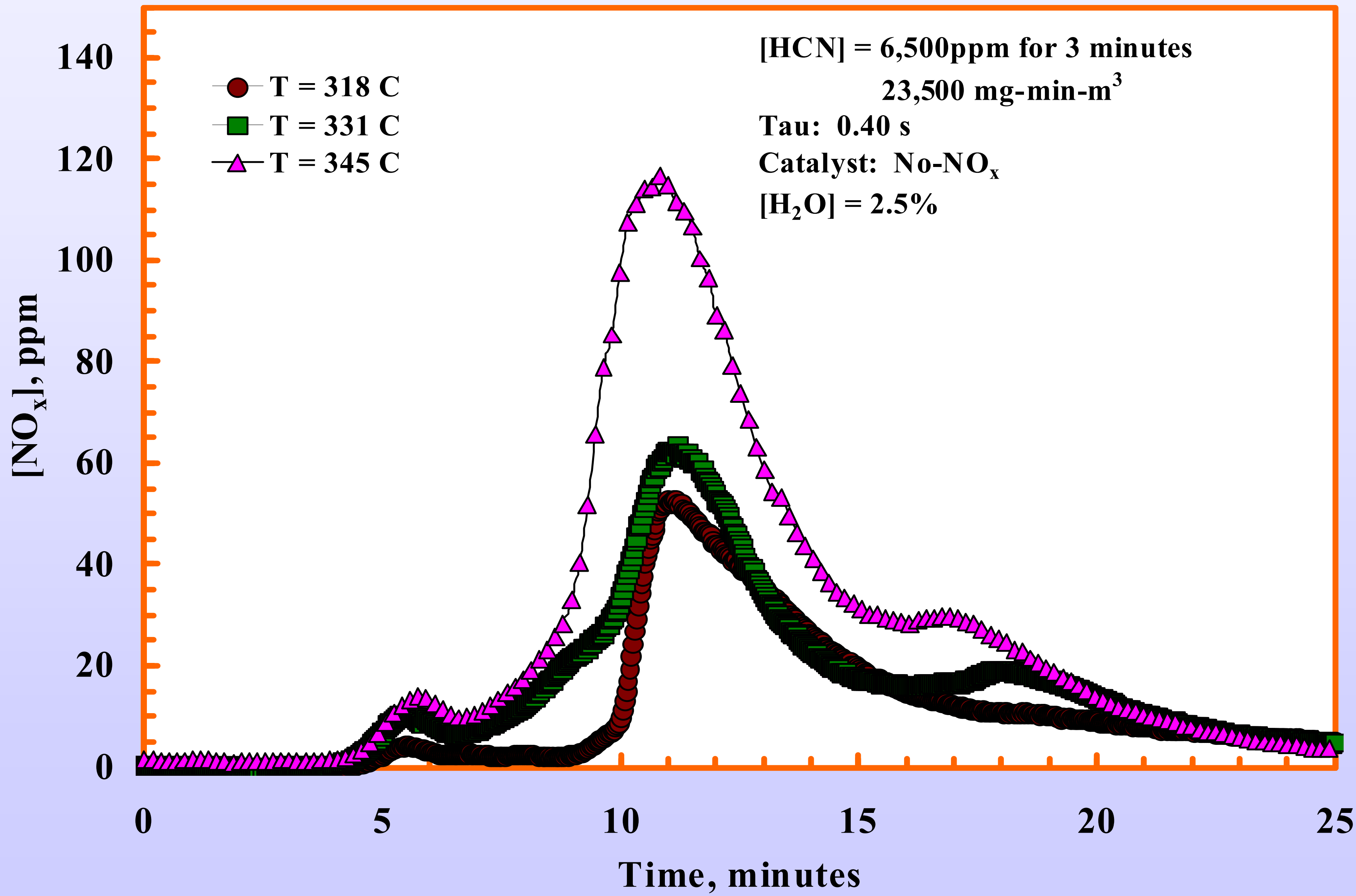
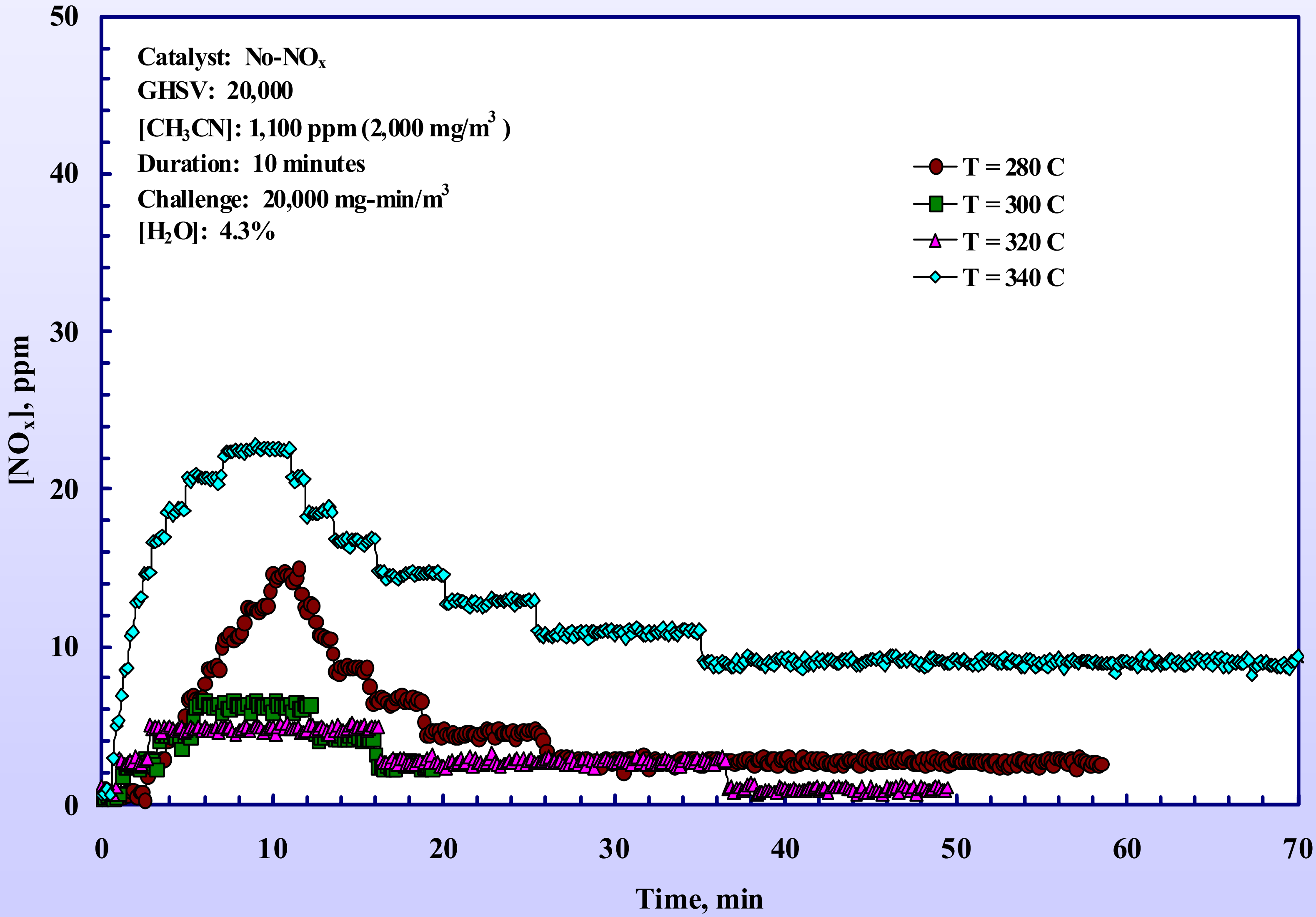
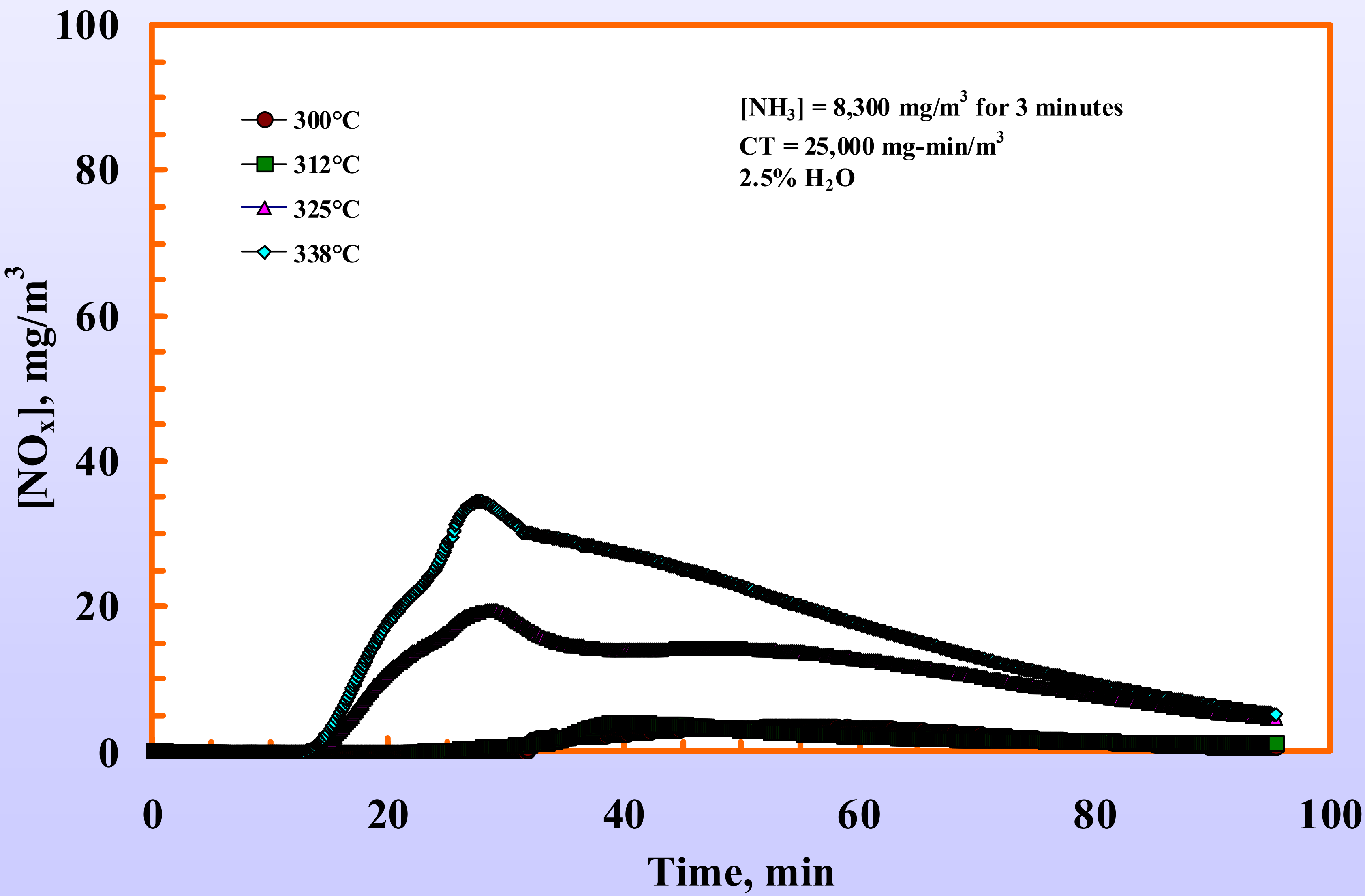


Results: Destruction of Acetonitrile using pre-adsorption



Results: Destruction of NH_3 using pre-adsorption



Conclusions

1. NO_x generation during destruction of nitrogen-containing compounds can be greatly minimized using a pre-adsorber.

2. Use of a pre-adsorption bed to minimize concentration excursions greatly improves catalyst performances
   - o Greatly reduced NO_x formation
   - o Improved thermal management

3. In the case of HCN, not able to meet low NO_x requirements. Identification of improved adsorption materials should allow for meeting this objective.