Ford Motor Company

Plasma-Catalysis During Temperature Transient Testing

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Research

Ford Motor Company

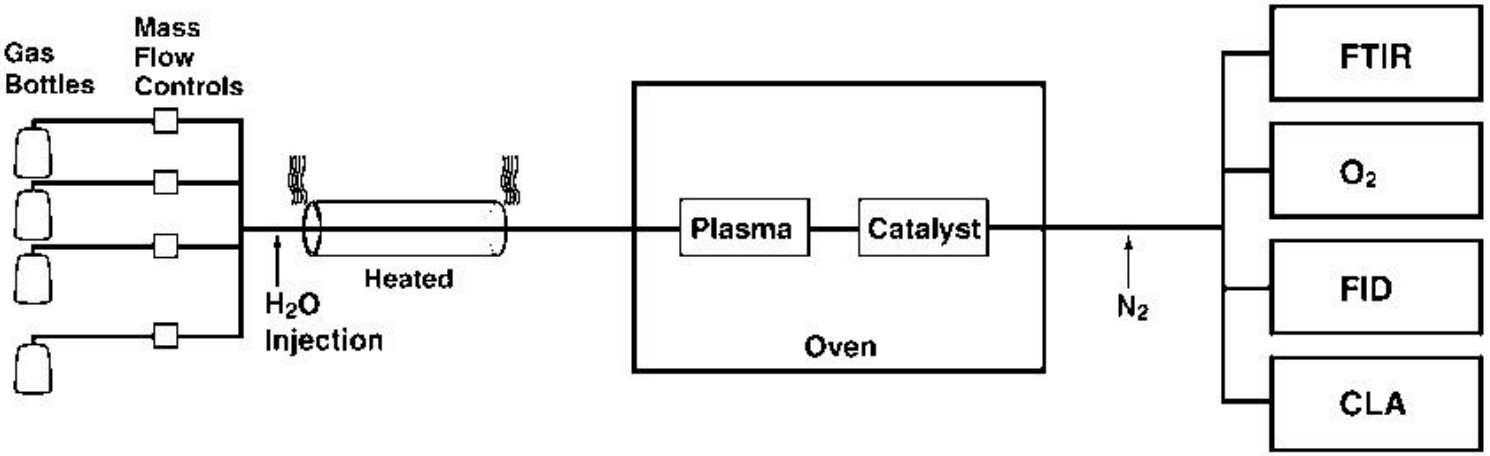
Background

- Plasma-catalysis
  - Various zeolite and alumina catalysts
  - Most have significant NOx storage
  - Previously reported results are steady state
- Temperature transients
  - In real vehicles, temperature varies
  - What happens to stored NOx?
  - Tested with temperature ramps

Test Description

- Plasma followed by Catalyst combination
  - BaY
  - Alumina
  - Pt
- Tested with catalyst temperature ramps
  - 100-420°C
  - 10°/min
  - Plasma held at 180°C
- What happens during temperature transients?

Test Schematic



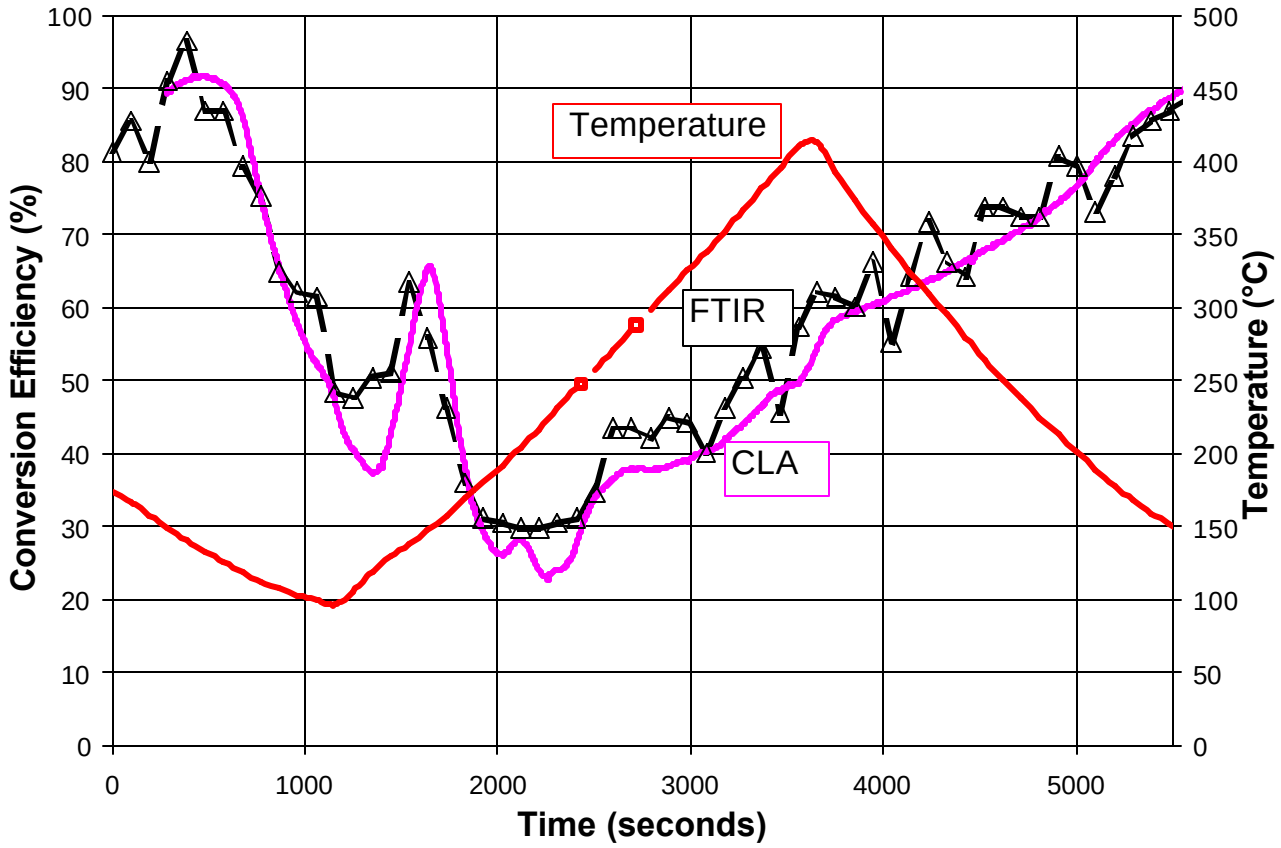
Simulated Exhaust Gas

GAS	*Units*	*Concentration*
NO	ppm	74
NO_2	ppm	2
C_3H_6	$ppmC_1$	1951
HC_1:NOx	ratio	26
H_2O	%	3
O_2	%	7
N_2		Balance
Plasma Energy	J/L	15

Catalysts

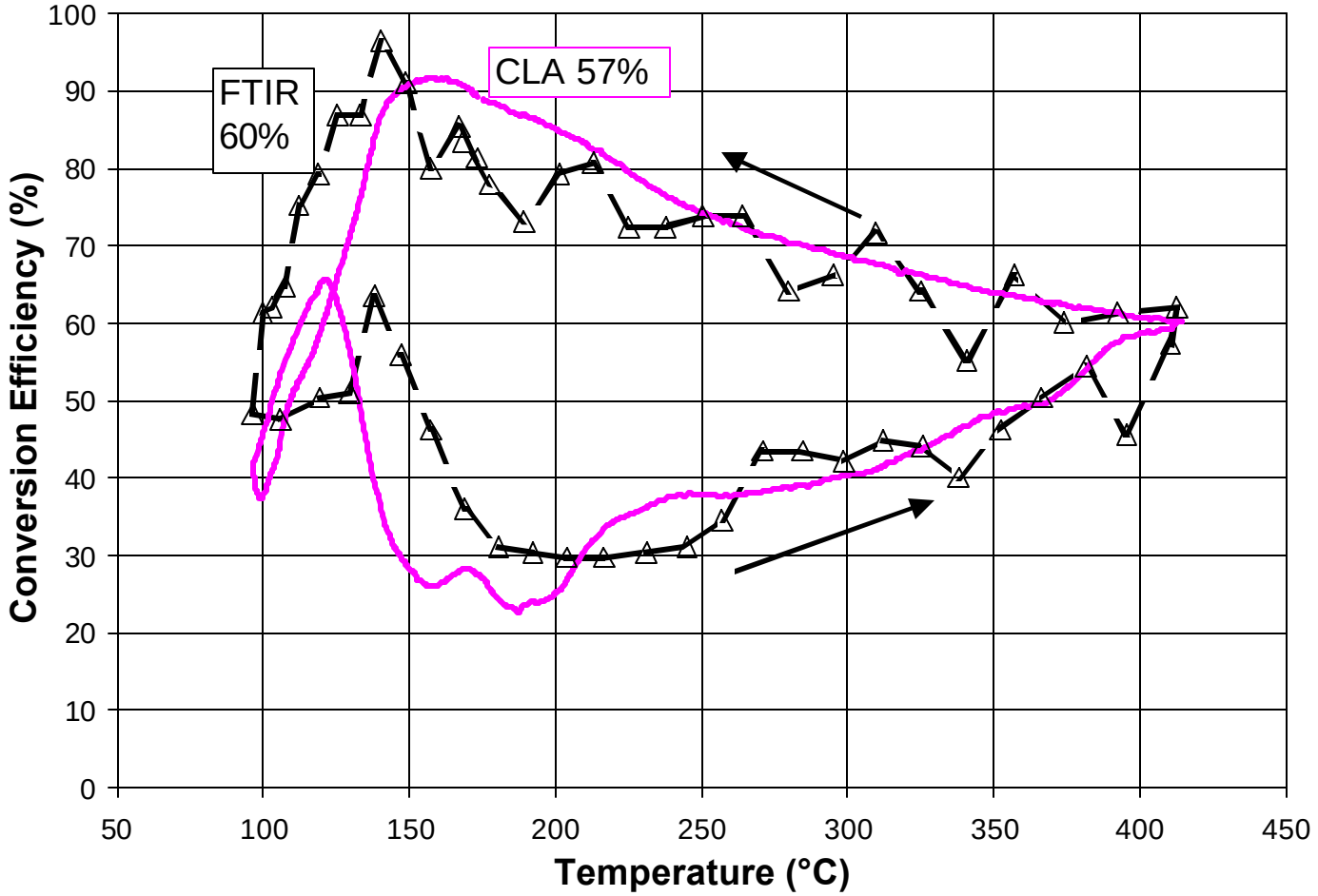
- BaY
  - Barium zeolite-Y provided by PNNL
  - Monolith 600 cpsi, 39 wt% loading
  - Space velocity 16,300 hr^{-1}
- Alumina
  - CondeaVista CATALOX Sba-200
  - Powder pressed into pellets
  - Space Velocity 19,960 hr^{-1}
- Pt
  - Johnson Matthey CRT catalyst
  - Monolith
  - Space Velocity 18,860 hr^{-1}
- Total SV 7,200 hr^{-1}

NOx Conversion Versus Time

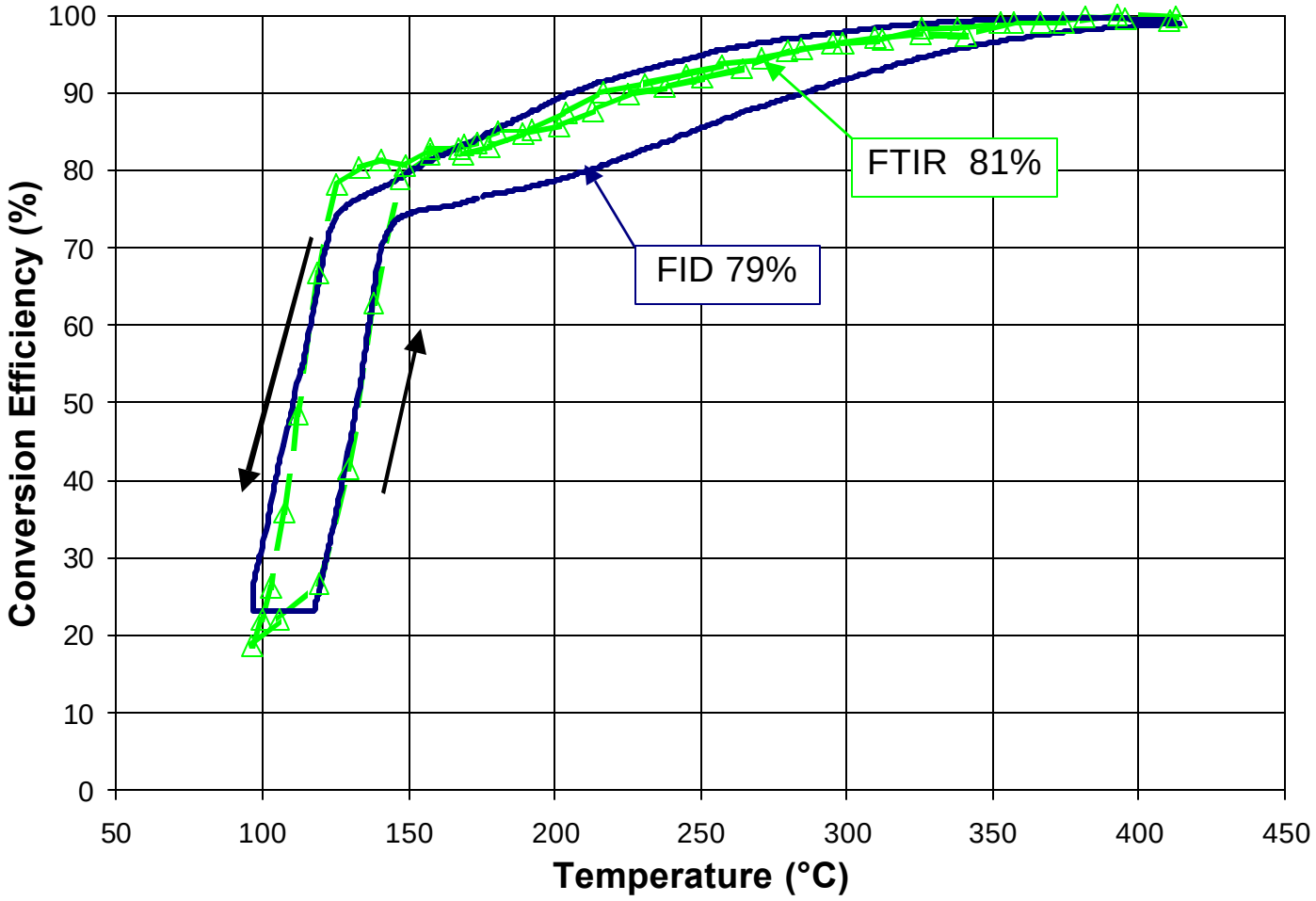


Data shown is last of four temperature cycles
First cycle not repeatable due to history effects
FTIR NOx = NO + NO_2 + HONO + HNO_3 + CH_3ONO_2

NOx Conversion Vs. Temperature

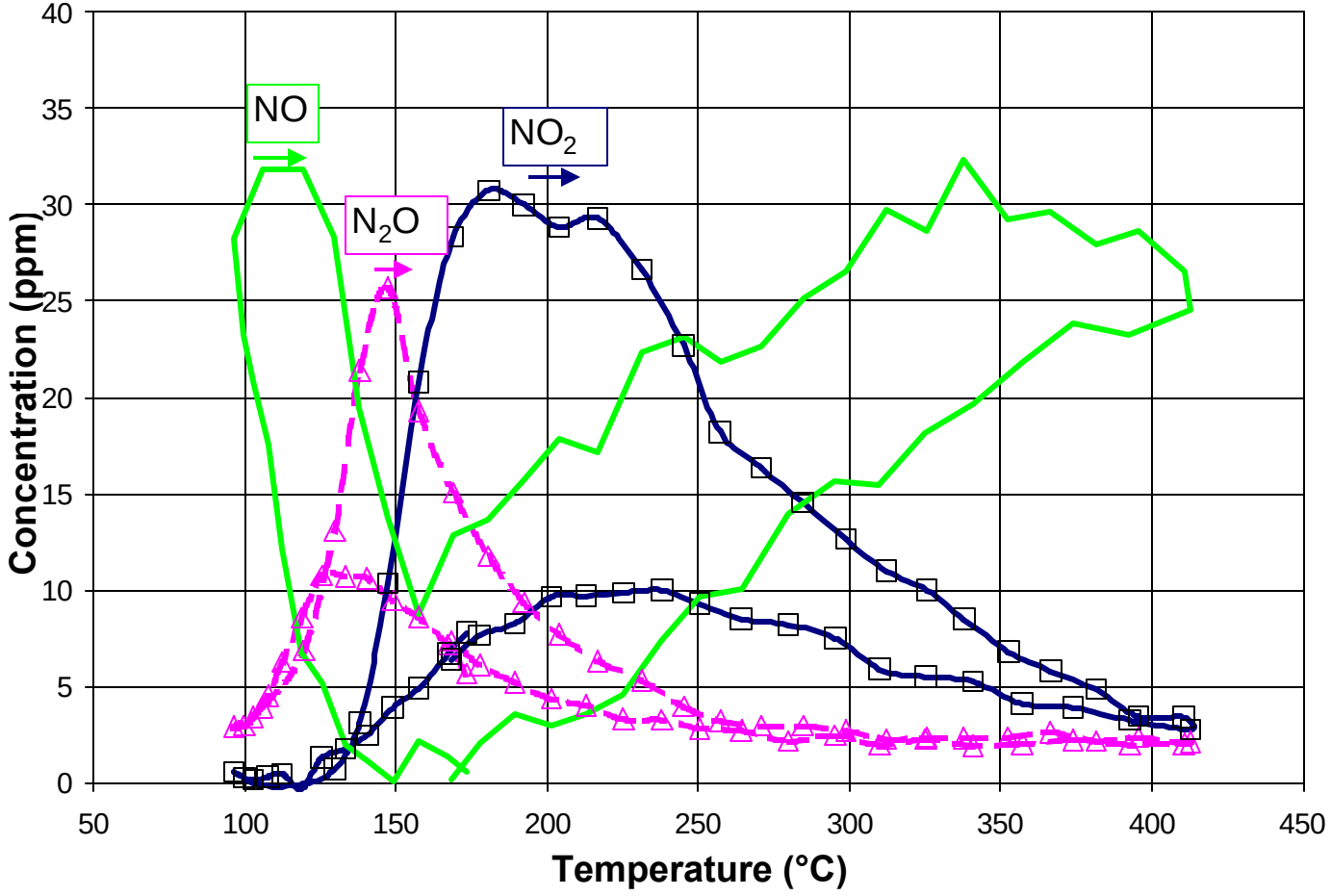


HC Conversion

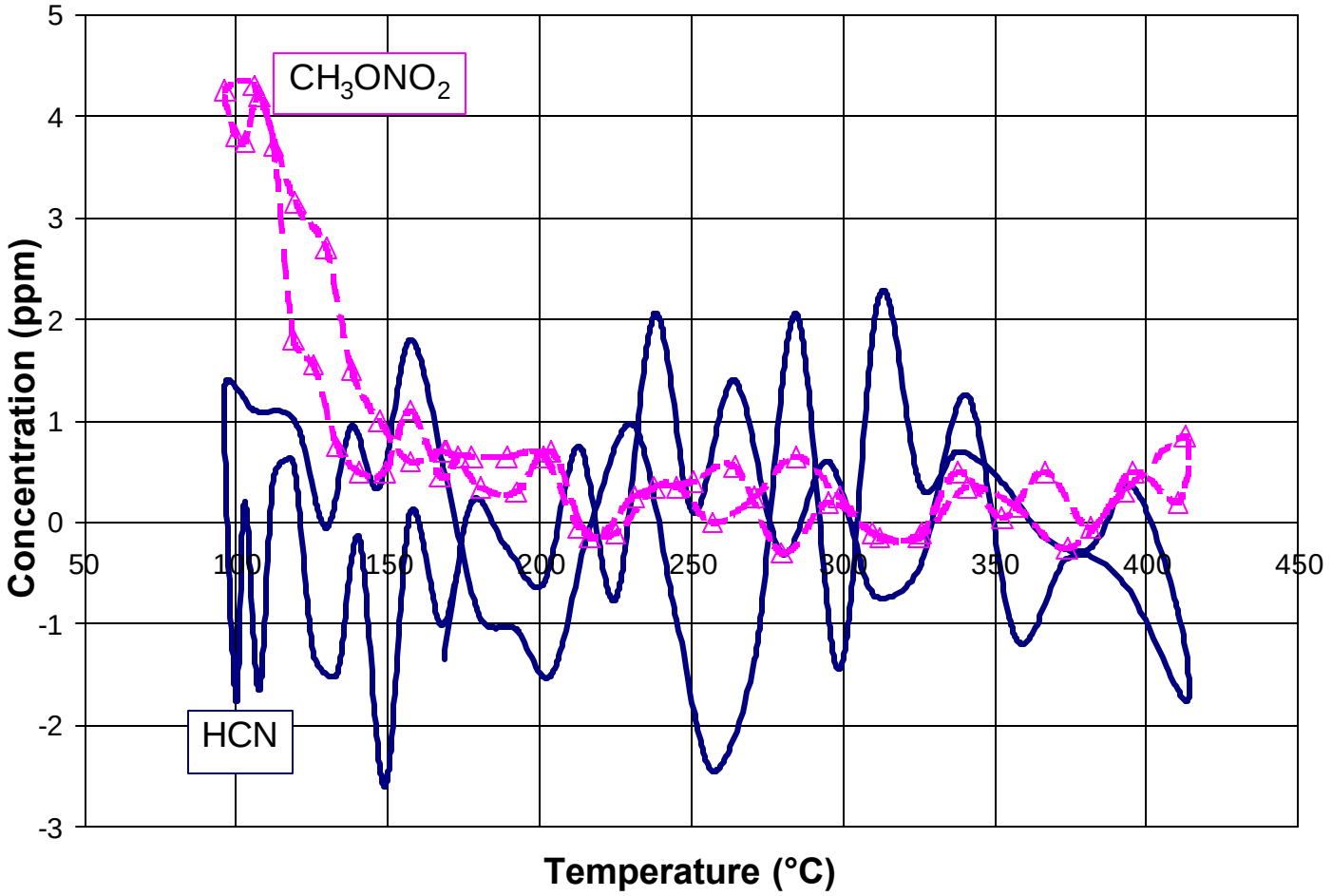


FTIR HC = $CH_4 + 2C_2H_2 + 2C_2H_6 + 3C_3H_6 + 3C_3H_8 + CH_3OH + 2C_2H_6OH + CH_3ONO + CH_3ONO_2$

NO, NO_2, N_2O

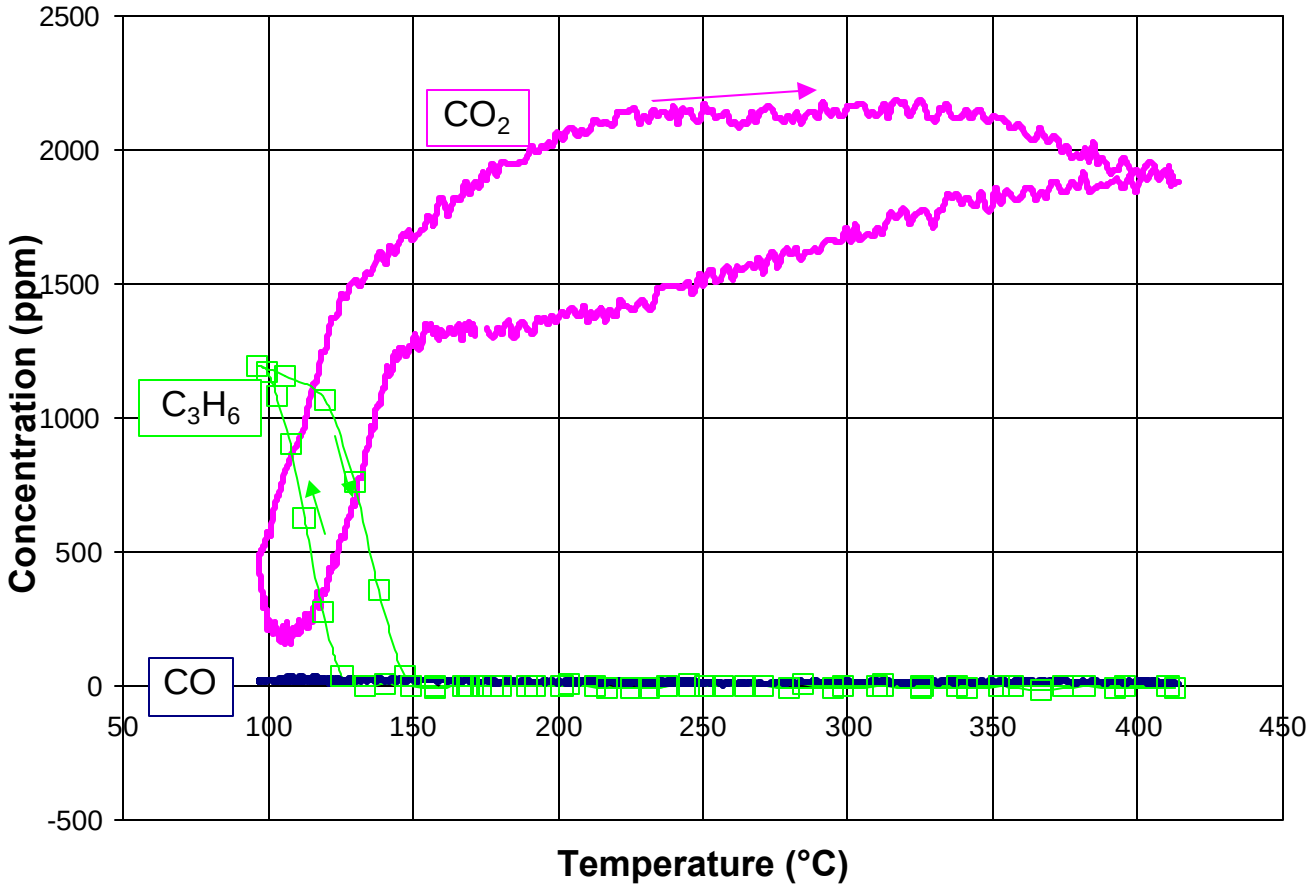

NO
NO2
N2O
Concentration (ppm)
Temperature (°C)
0
5
10
15
20
25
30
35
40
50
100
150
200
250
300
350
400
450

CH_3ONO_2 & HCN



HCN and methyl nitrate are removed before the tailpipe

CO, CO_2, Propene



Conclusions

- Temperature history is important!
- Average NOx conversion 100-400°C is 57-60%
- Average HC conversion is 79-81%
- Significant HC and NOx adsorption
  - Large hysteresis loops
- Remaining NOx is NO, NO_2 or N_2O
  - Depends on temperature
- The Pt catalyst removes HCN and organics above 125°C

Acknowledgements

- This work was performed as part of a CRADA with DOE and PNNL.
- The work was performed at the Ford Research Laboratory