

Design of Catalytic Materials for Plasma Assisted Catalysis System

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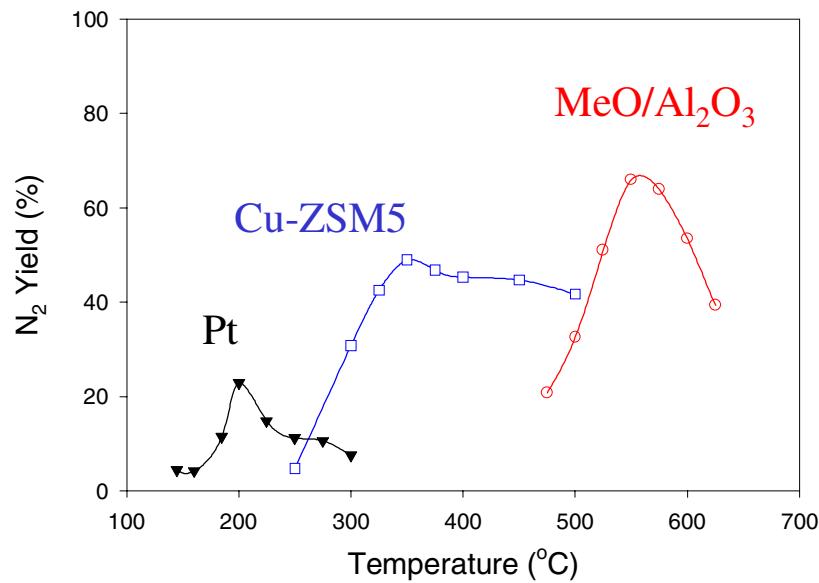


Lean-NOx Catalyst Groups

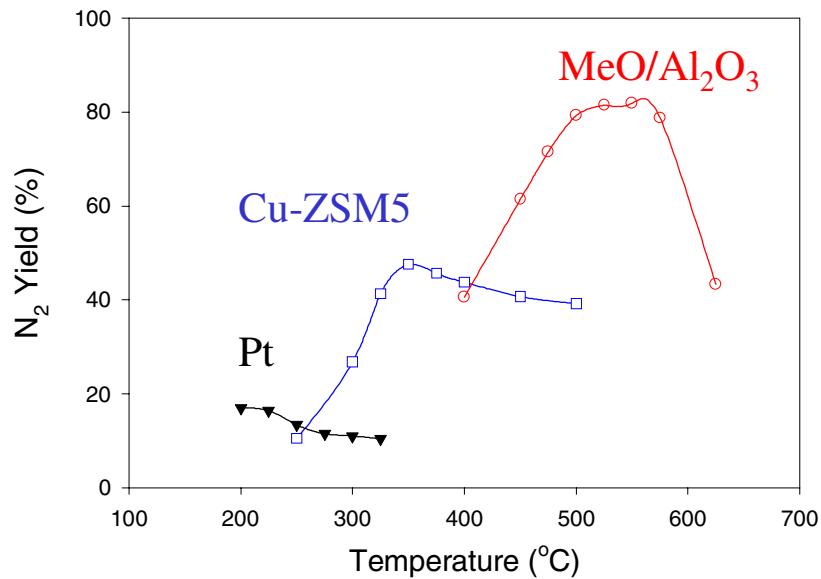
- Zeolites (Cu-ZSM-5)
active / hydrothermally unstable
- Noble metals (Pt/Al₂O₃)
very active and stable / poorly selective (N₂O)
- Transition metal oxides (M_xO_y/Al₂O₃)
very selective and stable / moderately active
flexible formulation

Comparison with reference samples for NOx reduction

NO Reduction

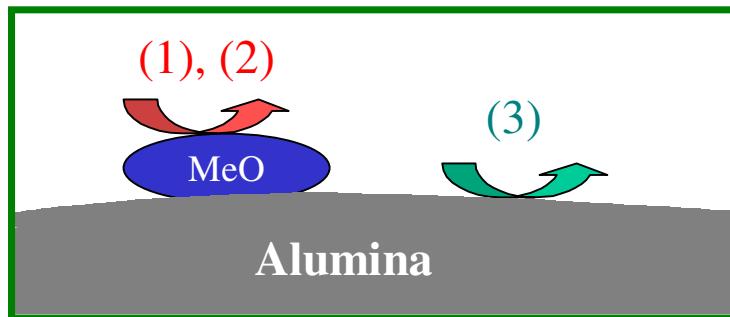


NO₂ Reduction



™ which catalyst benefits the most from plasma ?

Dual Functional Lean-NOx Catalysis Mechanism



- (1) NOx activation: $\text{NO} + \text{O}_2 \rightleftharpoons \text{NO}_2$
- (2) Hydrocarbon activation: $\text{C}_x\text{H}_y + \text{O}_2 \rightleftharpoons \text{C}_x\text{H}_y\text{O}_z$
- (3) NOx reduction with activated hydrocarbons



Desired Plasma Assisted Catalysis Mechanism “dual-functional system”

- plasma { (1) NOx activation: $\text{NO} + \text{O}_2 \rightarrow \text{NO}_2$
(2) Hydrocarbon activation: $\text{C}_x\text{H}_y + \text{O}_2 \rightarrow \text{C}_x\text{H}_y\text{O}_z$
- catalyst { (3) NOx reduction:
 $\text{NO}_x (\text{NO or } \text{NO}_2) + \text{C}_x\text{H}_y\text{O}_z + \text{O}_2 \rightarrow \text{N}_2 + \text{CO}_2 + \text{H}_2\text{O}$

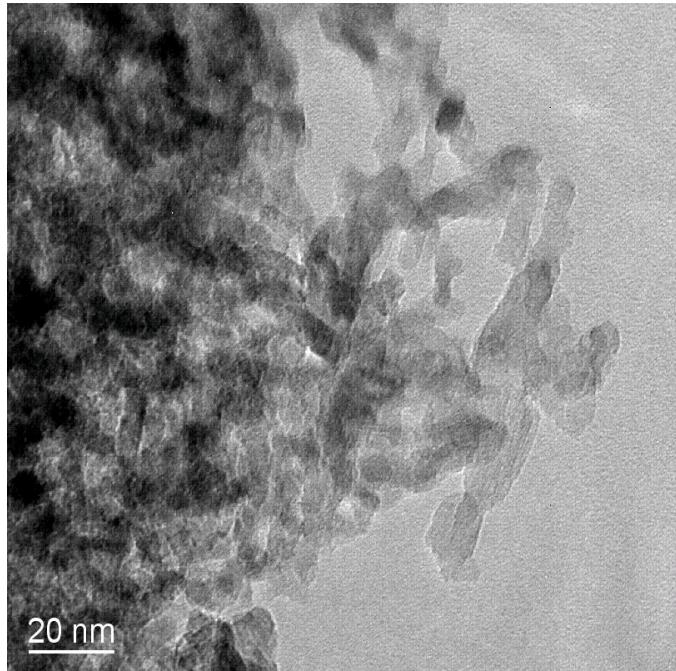
™key issue: if plasma promotes (1) & (2) fast & effectively,
catalysts can be designed to focus on (3)

Desired Plasma Reactor for PAC System

- ⦿ maximize NO τ NO₂ oxidation
- ⦿ minimize hydrocarbon combustion
- ⦿ produce target oxygenated hydrocarbons
- ⦿ prevent catalyst deactivation

™ Can plasma reactor be optimized ?

Desired Catalyst for PAC System



- ⦿ surface area
- ⦿ pore volume/size
- ⦿ impurity
- ⦿ acidity/basicity
- ⦿ promoter

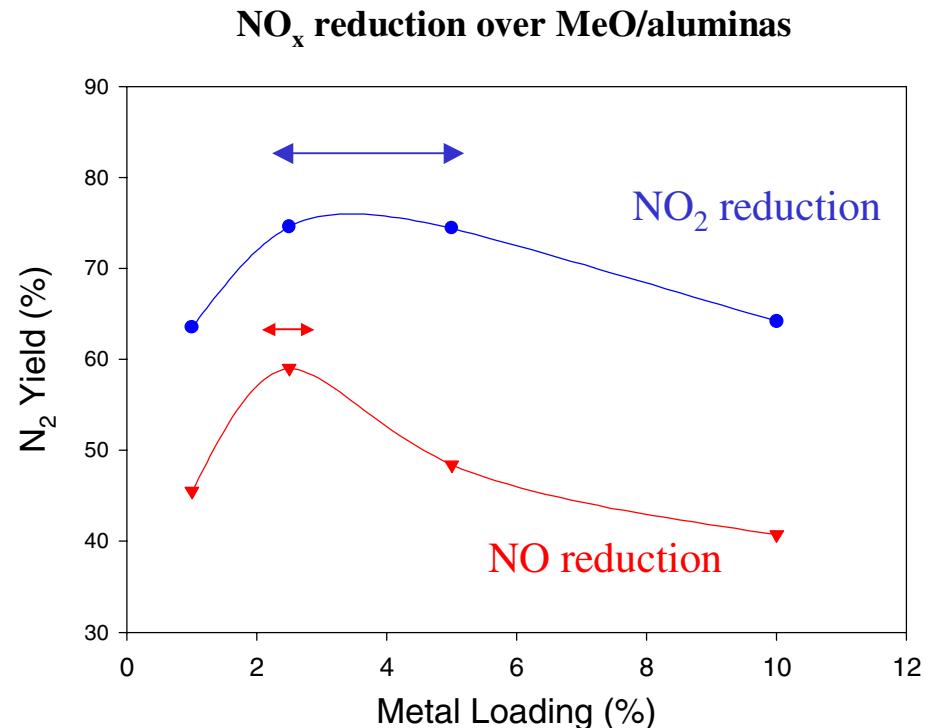
TM Catalyst can be optimized for PAC.

How to Design Catalytic Materials for PAC ?

- υ Activity: metal loading sensitivity
- υ Selectivity: hydrocarbon sensitivity
- υ Durability: sulfur sensitivity



The Effect of Metal Loading on Lean-NOx Performance of MeO/Alumina

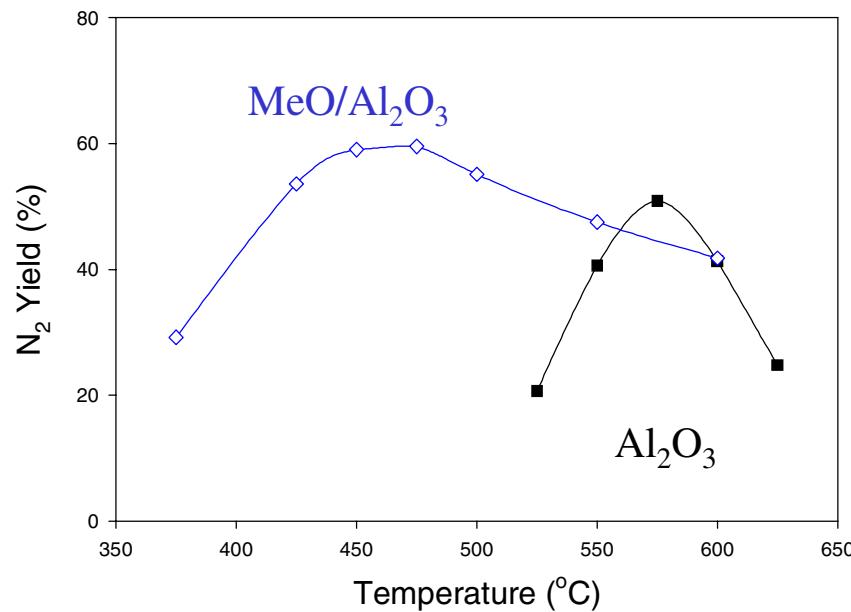


Potential Plasma Effect

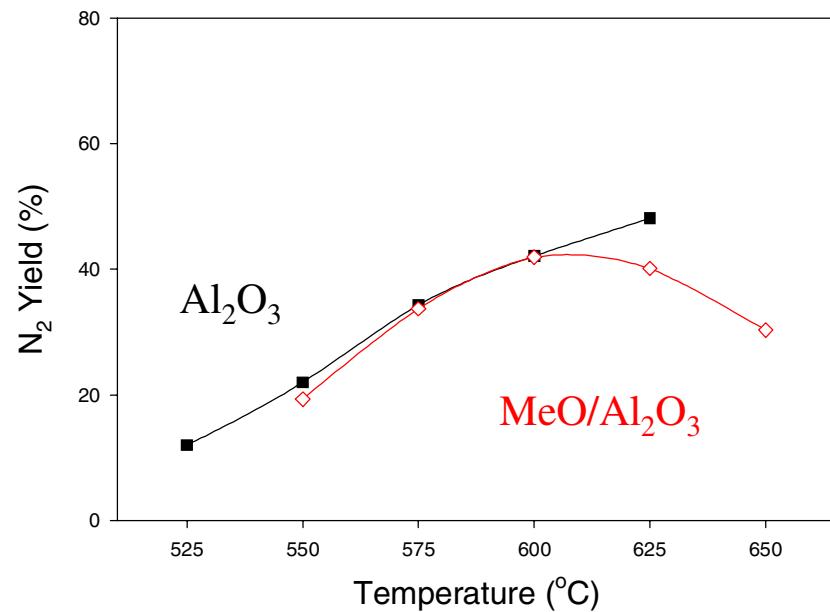
- less sensitive to metal loading
- ™ easy to reproduce catalyst
- ™ flexible formulation

The Effect of Hydrocarbon on Lean-NOx Performance of MeO/Al₂O₃

NO Reduction with C₃H₆ Reductant



NO Reduction with C₃H₈ Reductant

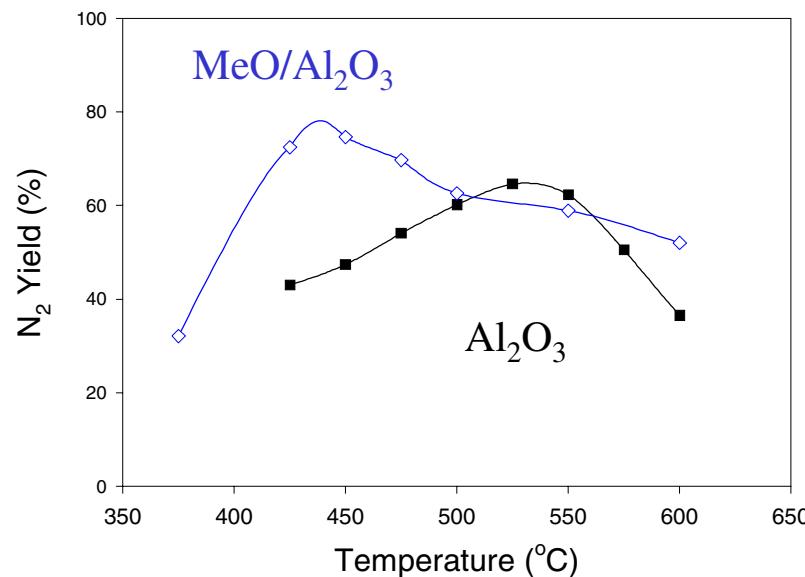


™ cannot catalyze propane with NO

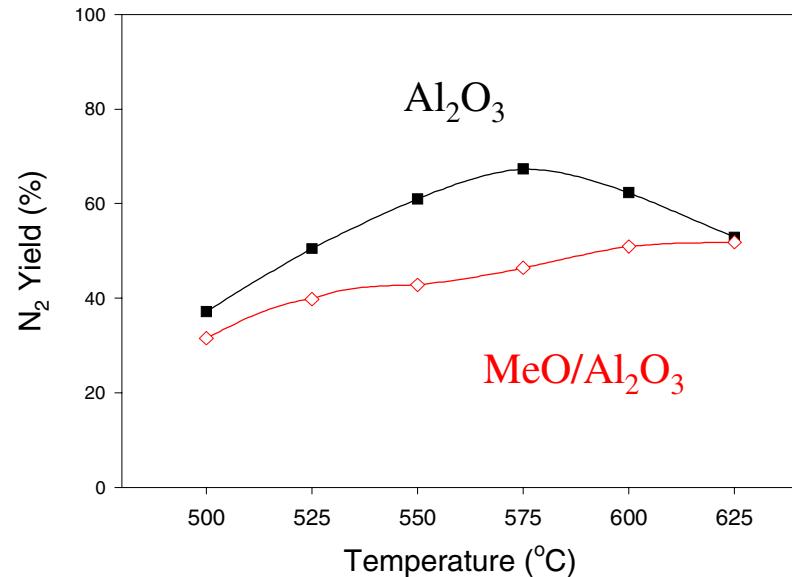
™ sensitive to hydrocarbon

The Effect of Hydrocarbon on Lean-NOx Performance of MeO/Al₂O₃

NO₂ Reduction with C₃H₆ Reductant



NO₂ Reduction with C₃H₈ Reductant

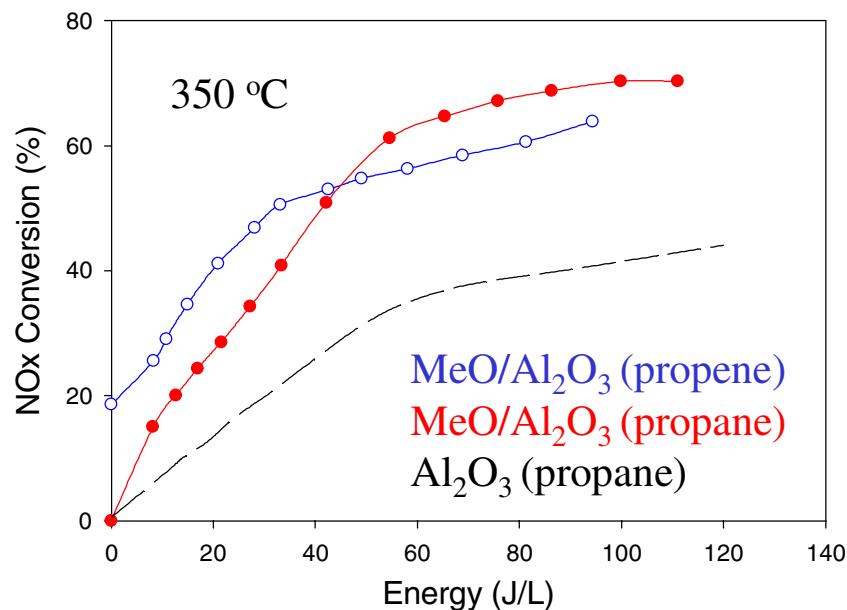


™cannot catalyze propane with NO₂

™sensitive to hydrocarbon

The Effect of Plasma on Hydrocarbon Dependence of MeO/Al₂O₃

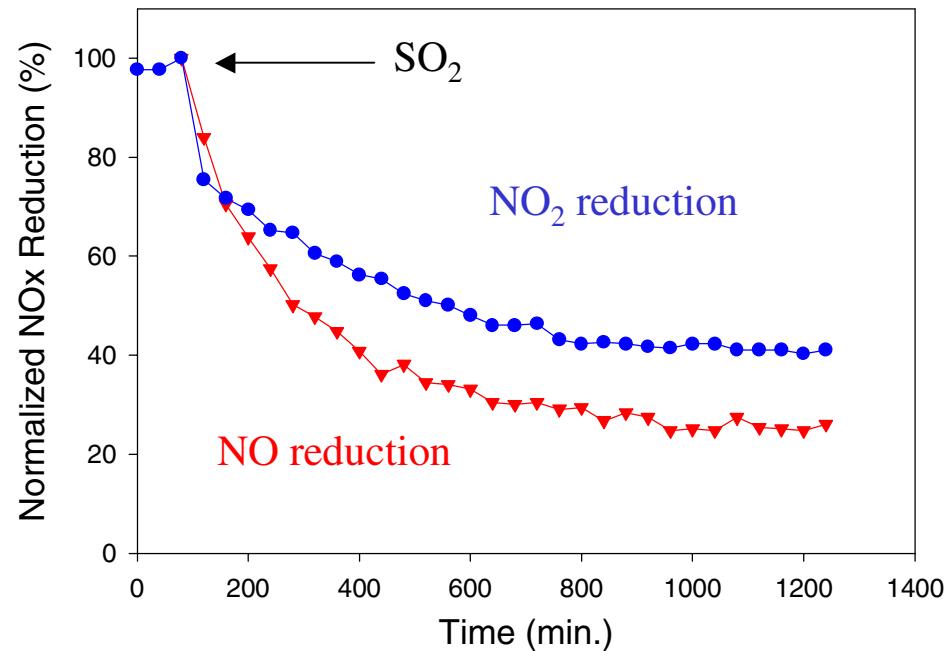
NOx Reduction with plasma + MeO/Al₂O₃



Potential Plasma Effect

- less sensitive to hydrocarbon
- ™ enhance catalytic performance
- ™ concept for new formulation

The Effect of SO_2 on NOx Species for Catalyst Lean-NOx Performance



Potential Plasma Effect

- ⦿ less sensitive to SO_2
 - NO_2 adsorption
 - oxygenated hydrocarbon
- ⦿ increase catalyst life time

Summary

- Plasma & MeO/Al₂O₃ catalyst is a promising combination.
 - ⦿ dual functional system $\begin{cases} \text{plasma: NOx & HC activation} \\ \text{catalyst: NOx reduction} \end{cases}$
 - ⦿ metal loading, hydrocarbon, SO₂
- Understanding the plasma chemistry will help to formulate a better catalyst.
 - ⦿ NOx/SOx species
 - ⦿ hydrocarbon species
 - ⦿ other unknown ?