Non Noble Metal Based Diesel Oxidation & HC-SCR Catalyst

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CSIR-NCL : A SNAP SHOT

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Mission: To provide scientific industrial research & development that maximizes the economic, environmental & societal benefits for the people

- Established : 1950
- Location : Pune, India
- Total personnel
  - Permanent Staff : 750
    - Scientific : 226
    - Technical : 330
    - Administrative : 194
  - Research Fellows (CSIR, UGC) : ~600
  - Project Staff (M.Sc’s) : ~ 400
  - Post doctoral fellows : ~25
  - Summer trainees : ~ 76

One of the largest publicly funded research institution in India
One of the oldest research institutions of independent India
THE PURPOSE OF THIS LABORATORY IS TO ADVANCE KNOWLEDGE AND TO APPLY CHEMICAL SCIENCE FOR THE GOOD OF THE PEOPLE

J W McBain
Main activities of the group in Environmental Catalysis

1. NOx- storage-reduction catalyst – Understanding the effect of environment around Ba on NOx storage capacity
2. Development of catalysts for removal of NOx from lean burn engine exhaust
3. Non noble metal based diesel oxidation catalysts (DOC)

Collaboration: Lille University, France, Humboldt University, Berlin, LIKAT Rostock, Germany
Project: BASF, USA
Interaction: ARAI, Cummins Emission Solutions, Tenneco
Diesel engine exhaust emissions – CO, HC, NOx, Soot

For deNOx – Urea – SCR for heavy duty vehicle

No deNOx for light duty vehicles

Oxidation catalyst for

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\begin{align*}
\text{CO} + \text{O}_2 & \rightarrow \text{CO}_2 \\
\text{HC} + \text{O}_2 & \rightarrow \text{CO}_2 + \text{H}_2\text{O} \\
\text{NOx} + \text{O}_2 & \rightarrow \text{NO}_2 \\
\text{NO}_2 + \text{C} \text{ (soot)} & \rightarrow \text{CO}_2 + \text{NO}
\end{align*}
\]
Commercial DOC: Pt on Alumina, Pt-Pd on Alumina.

- Some limitations of this catalyst
  - High cost of catalyst as noble metals are used
  - Sintering of noble metal on the support surface after long use and at high temperature
  - Low temperature activity, hence ineffective in cold start
  - Sulphur and water irresistibility

Hence need to develop non noble metal based oxidation catalyst with

- Low light off temperature
- Sulphur and water resistibility
- Higher thermal stability
Non Noble metal based DOC

- NCL has developed a non-noble metal based catalyst for oxidation
- Composition of the catalyst – Ceria based catalyst
- Many similar compositions reported in the open literature
- Our method of preparation is modified
- Catalyst prepared using Indigenous raw material
  - No Pt, Pd, Ag, Au

Patent filed
**Reaction conditions** - 1000 ppm CO, 5% O₂, He-balance, GHSV = 20,000 h⁻¹.
Propylene (C\textsubscript{3}H\textsubscript{6}) oxidation activity

Reaction condition- 300 ppm C\textsubscript{3}H\textsubscript{6}, 5% O\textsubscript{2}, He-balance, GHSV = 20,000 h\textsuperscript{-1}. 
Sulfur Tolerance studies

Sulfur tolerance of NCL-1 catalyst. Reaction conditions - 300 ppm C\textsubscript{3}H\textsubscript{6}, 5\% O\textsubscript{2}, 20 ppm SO\textsubscript{2}, He balance, GHSV=20,000 h\textsuperscript{-1}.

Water Tolerance studies

Effect of H\textsubscript{2}O addition on oxidation activity of NCL-1. Reaction conditions - 300 ppm C\textsubscript{3}H\textsubscript{6}, 5\% O\textsubscript{2}, 9\% H\textsubscript{2}O, He balance, GHSV=20,000 h\textsuperscript{-1}.
Oxidation performance of coated catalyst

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**Reaction condition** - 300 ppm $\text{C}_3\text{H}_6$, 5% $\text{O}_2$, He-balance, 
$\text{GHSV} = 1,000,000 \text{ h}^{-1}$
Oxidation performance in model diesel engine exhaust

NO oxidation to NO$_2$ – conversion in the thermodynamic equilibrium limit

**Reaction Conditions**: 300 ppm NO, 1000 ppm CO, 10% CO$_2$, 10% O$_2$, 1000 ppm C$_3$H$_6$, 9% H$_2$O, 100 ppm decane, He balance, GHSV 20000 h$^{-1}$
**CO oxidation activity**

**Reaction condition**: 1000 ppm CO, 5% O₂, He-balance, GHSV = 20,000 h⁻¹.

**Hydrothermal Treatment Condition**: 300 ppm NO, 1000 ppm CO, 10% CO₂, 10% O₂, 1000 ppm C₃H₆, 9% H₂O, 100 ppm decane, He balance, GHSV 20000 h⁻¹, at 800°C for 8 h.
CO oxidation activity

Reaction condition: 1000 ppm CO, 5% O₂, He balance, GHSV = 20,000 h⁻¹.

Hydrothermal Treatment Condition: 300 ppm NO, 1000 ppm CO, 10% CO₂ 10% O₂, 1000 ppm C₃H₆, 9% H₂O, 100 ppm decane, He balance, GHSV 20000 h⁻¹, at 800°C for 8 h
Reaction feed: 1000 ppm CO, 5% O₂, He balance, GHSV 20,000 h⁻¹. After Hydrothermal treatment

Hydrothermal Treatment Condition: 300 ppm NO, 1000 ppm CO, 10% CO₂ 10% O₂, 1000 ppm C₃H₆, 9% H₂O, 100 ppm decane, He balance, GHSV 20000 h⁻¹, at 800°C for 8 h
DeNO\textsubscript{x} activity comparison of AgAuAl with AgAl and AuAl

![Graph showing DeNO\textsubscript{x} activity comparison of AgAuAl with AgAl and AuAl with T\textsubscript{50} values for each material.

After aging activity of AgAuAl increased.

Reaction feed: 300 ppm NO, 300 ppm CO, 300 ppm C\textsubscript{3}H\textsubscript{6}, 2000 ppm H\textsubscript{2}, 100 ppm C\textsubscript{10}H\textsubscript{22}, 10% CO\textsubscript{2}, 10% O\textsubscript{2}, 5% H\textsubscript{2}O, He balance, GHSV=50,000 mL.g\textsuperscript{-1}.h\textsuperscript{-1}.

Ph.D. Viva
Correlation of deNO$_x$ activity with measurement of CO, H$_2$ and C$_3$H$_6$

Reaction feed:
- 300 ppm NO, 300 ppm CO, 300 ppm C$_3$H$_6$, 2000 ppm H$_2$, 100 ppm C$_{10}$H$_{22}$, 10% CO$_2$, 10% O$_2$, 5% H$_2$O, He balance, GHSV=50,000 mL.g$^{-1}$.h$^{-1}$.

High DeNO$_x$ activity at high temperature

Ph.D. Viva

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Experimental facilities for Environmental Catalysis
Thank You

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Interaction & Feedback from:
Tenneco, Cummins, ARAI, BASF, Ecocat