Non Noble Metal Based Diesel Oxidation & HC-SCR Catalyst

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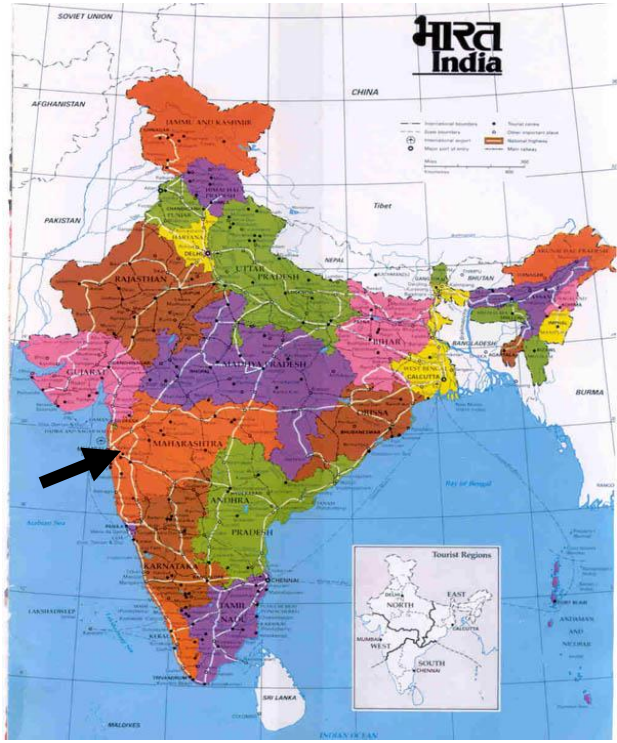
CSIR-NCL : A SNAP SHOT

A part of COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR)
Mission: To provide scientific industrial research & development that maximizes the economic, environmental & societal benefits for the people

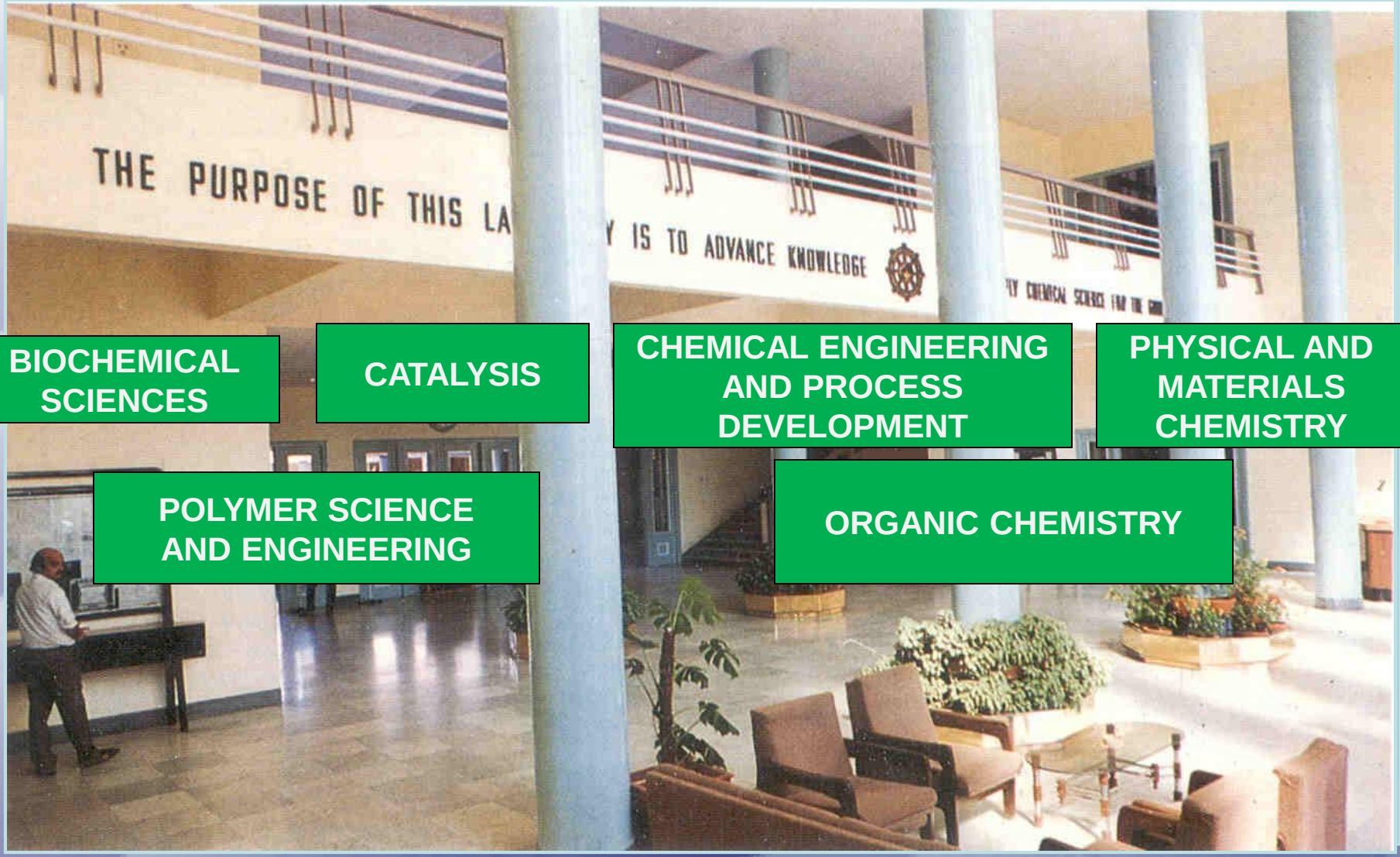
- **Established : 1950**
- **Location : Pune, India**
- **Total personnel**
  - **Permanent Staff : 750**
    - **Scientific : 226**
    - **Technical : 330**
    - **Administrative : 194**
  - **Research Fellows (CSIR, UGC) : ~600**
  - **Project Staff (M.Sc's) : ~ 400**
  - **Post doctoral fellows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



BIOCHEMICAL SCIENCES

CATALYSIS

CHEMICAL ENGINEERING AND PROCESS DEVELOPMENT

PHYSICAL AND MATERIALS CHEMISTRY

POLYMER SCIENCE AND ENGINEERING

ORGANIC CHEMISTRY

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

$$CO + O_2 \longrightarrow CO_2$$

$$HC + O_2 \longrightarrow CO_2 + H_2O$$

$$NOx + O_2 \longrightarrow NO_2$$

$$NO_2 + C\ (soot) \longrightarrow CO_2 + NO$$

- ❖ 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

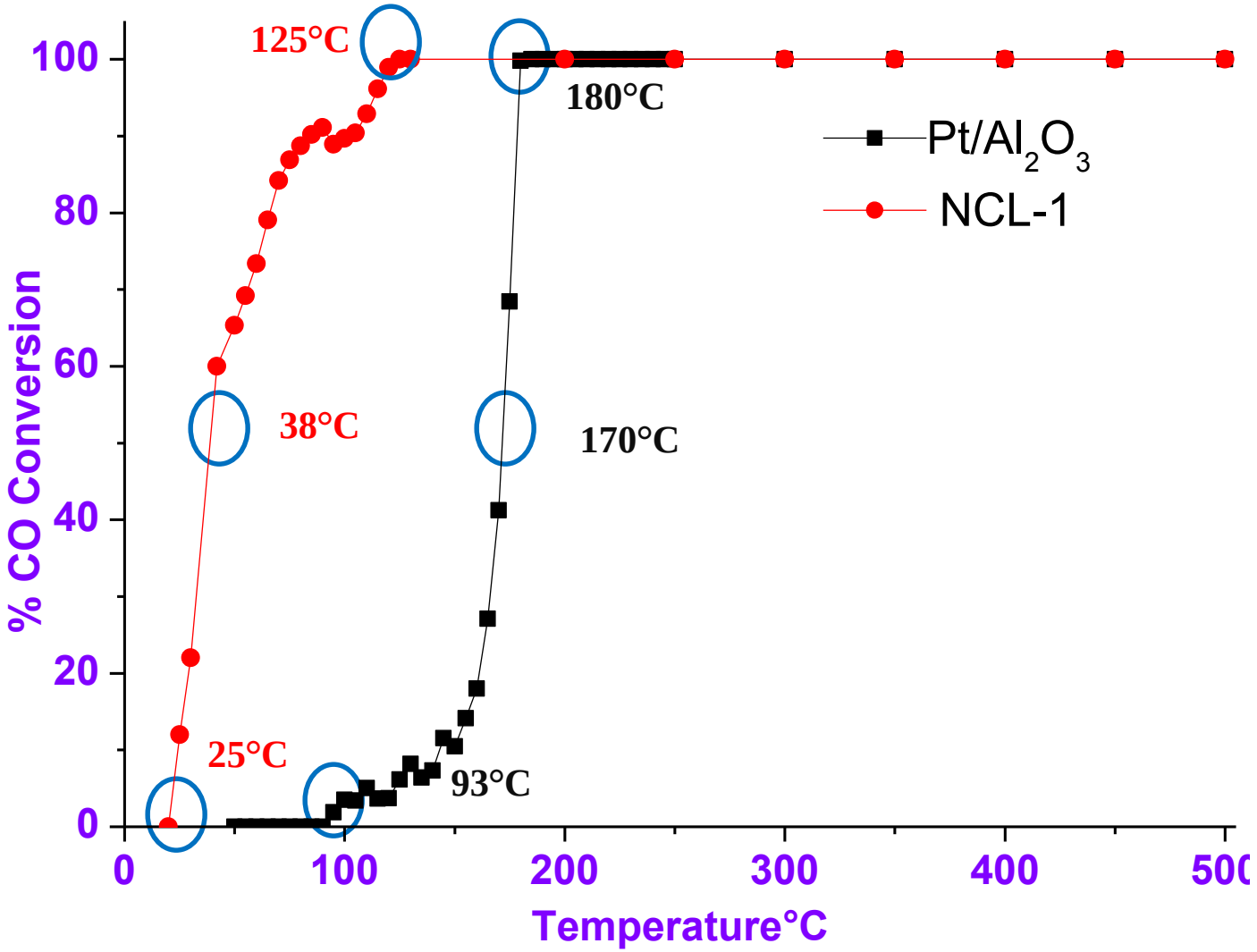
- ➢ Low light off temperature
- ➢ Sulphur and water resistibility
- ➢ Higher thermal stability

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

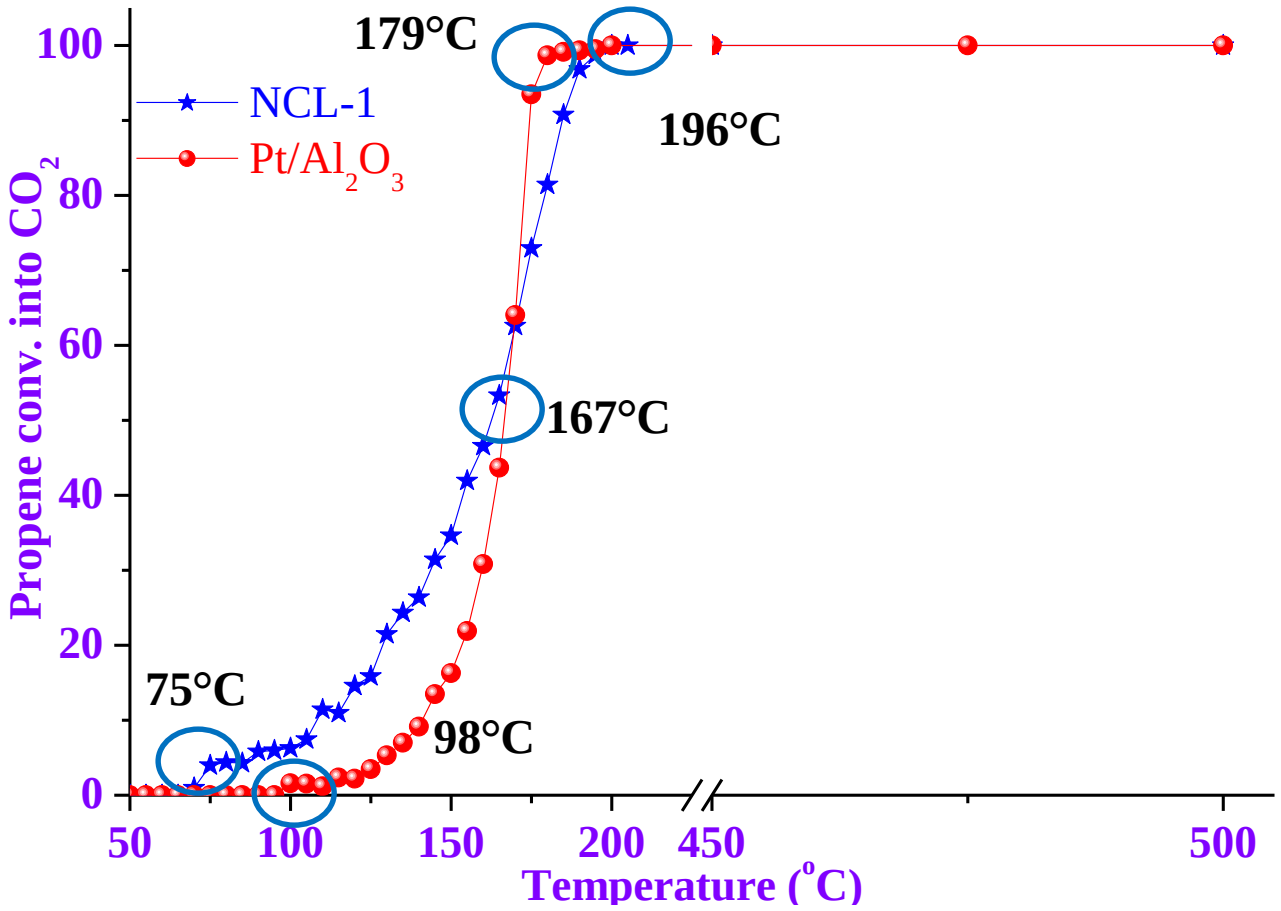
Patent filed

CO oxidation activity

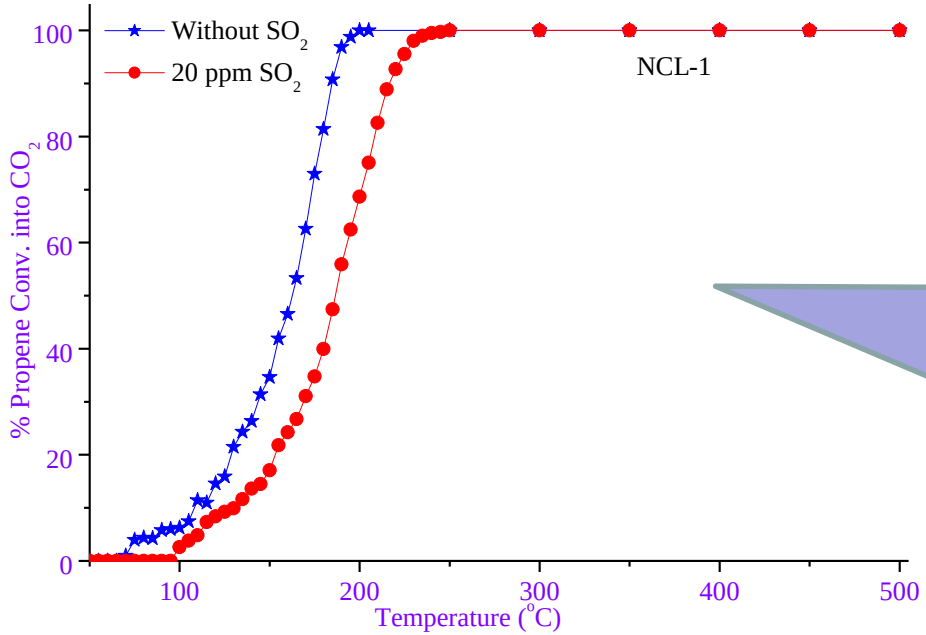


Reaction conditions - 1000 ppm CO, 5% O_2, He-balance, GHSV = 20,000 h^{-1}.

Propylene (C_3H_6) oxidation activity

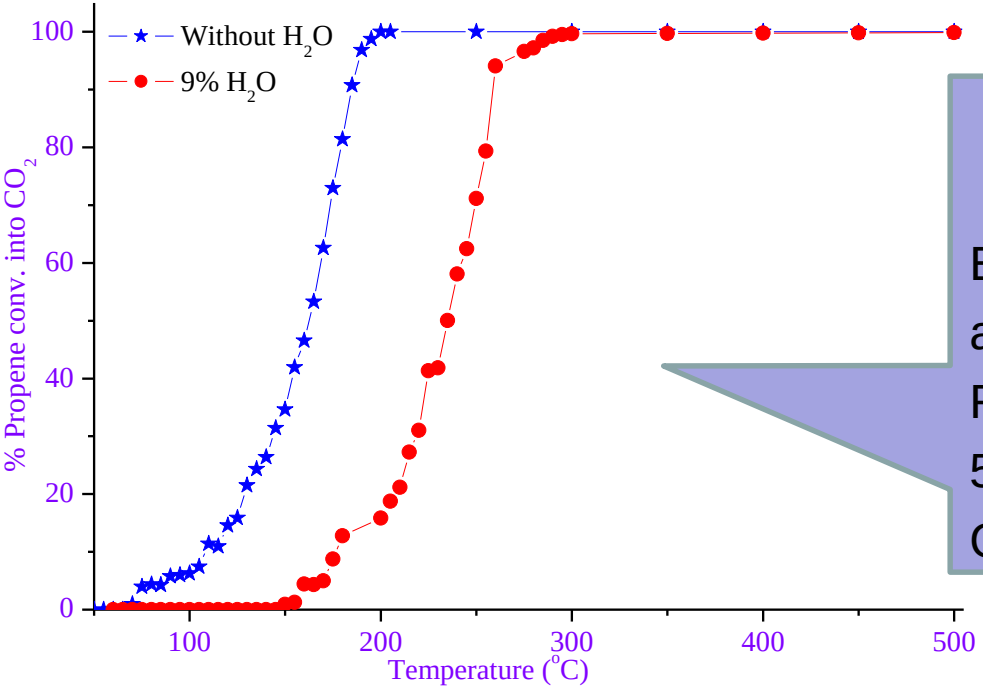


Reaction condition- 300 ppm C_3H_6, 5% O_2, He-balance, GHSV = 20,000 h^{-1}.



Sulfur Tolerance studies

Sulfur tolerance of NCL-1 catalyst. Reaction conditions - 300 ppm C_3H_6, 5% O_2,20 ppm SO_2, He balance, GHSV=20,000 h^{-1}.

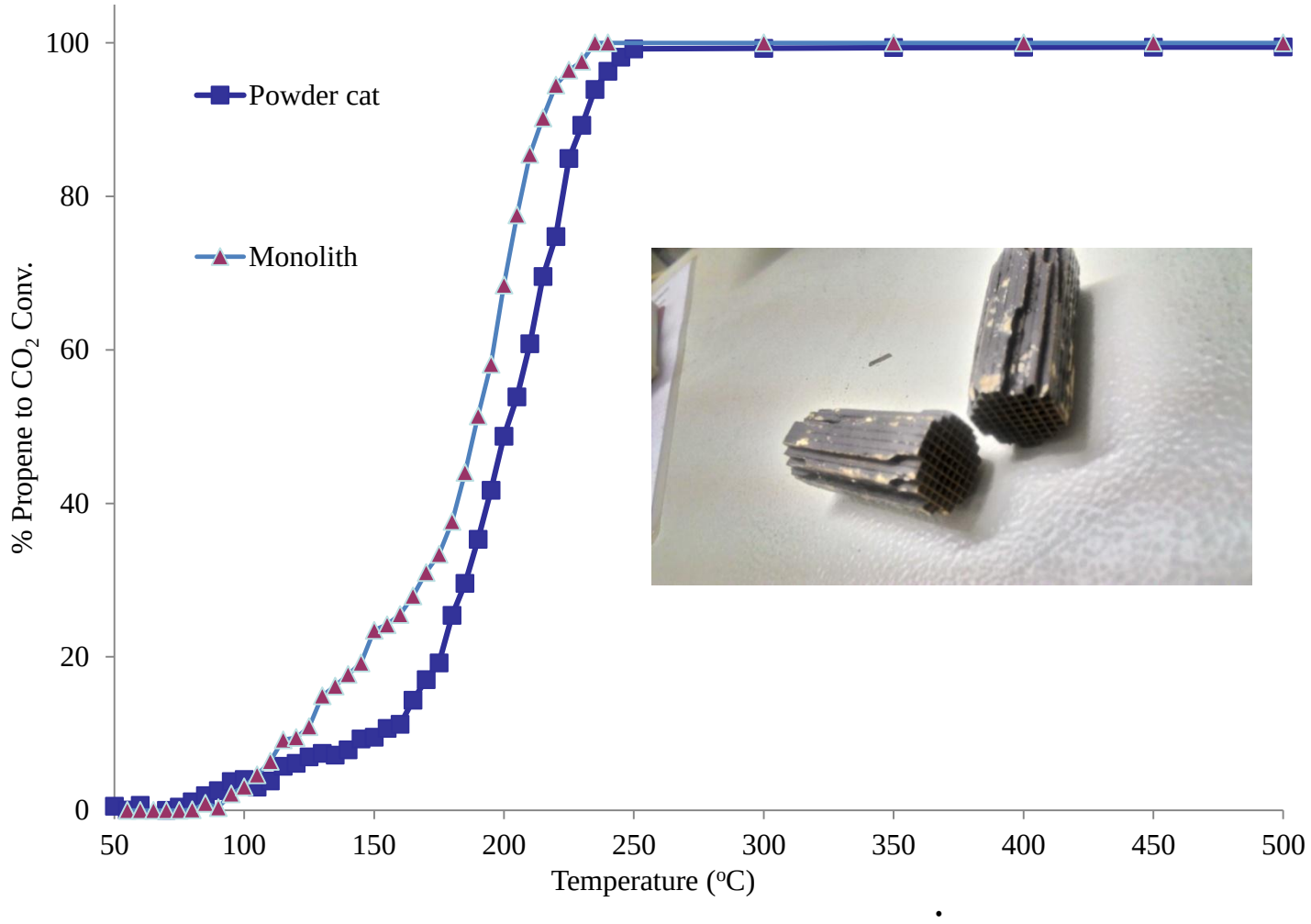


Water Tolerance studies

Effect of H_2O addition on oxidation activity of NCL-1.

Reaction conditions - 300 ppm C_3H_6, 5% O_2, 9% H_2O, He balance, GHSV=20,000 h^{-1}.

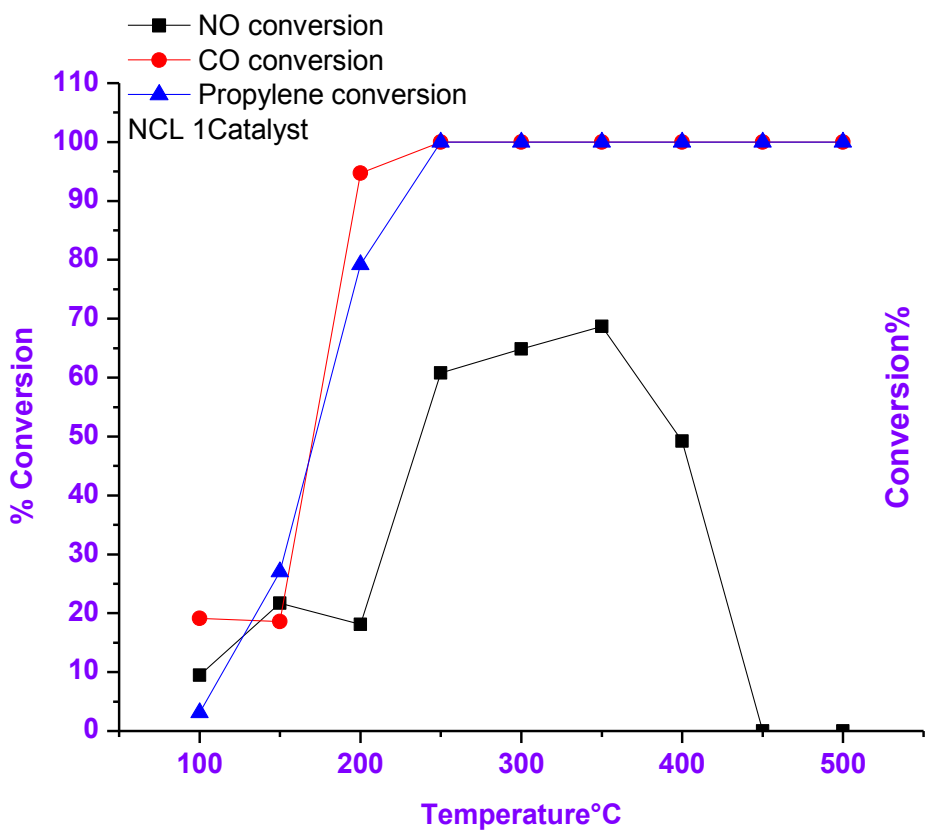
Oxidation performance of coated catalyst

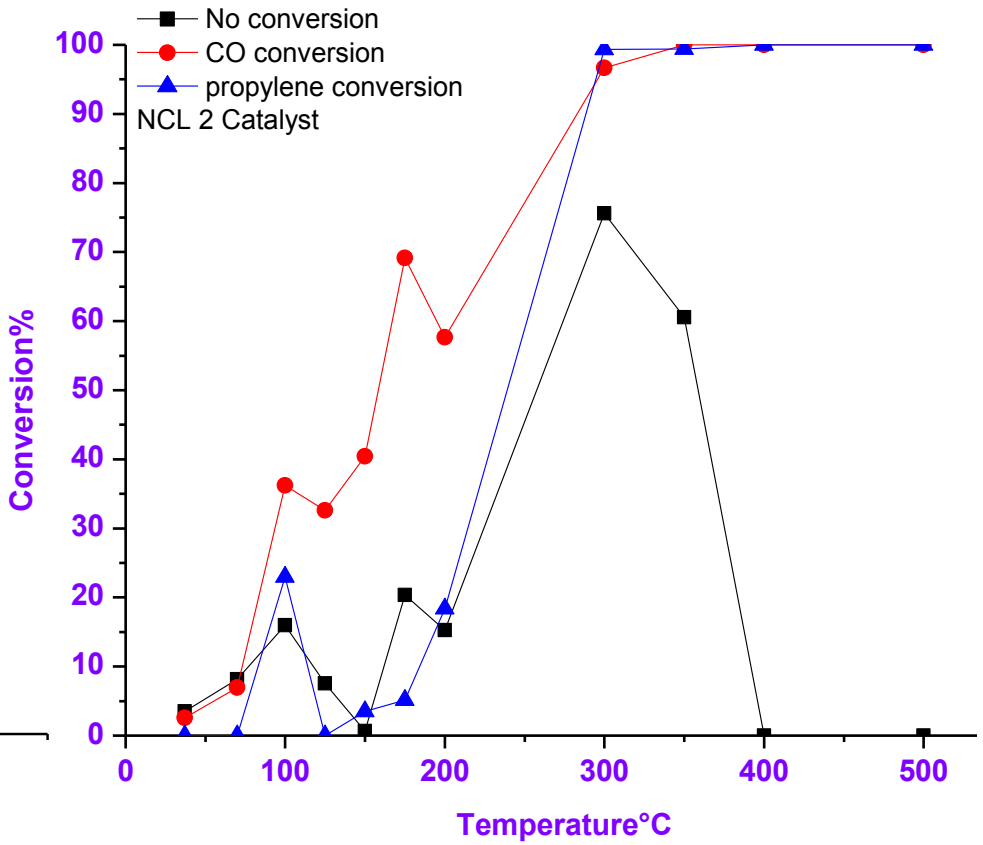


Reaction condition- 300 ppm C_3H_6, 5% O_2, He-balance,

GHSV = 1,00,000 h^{-1}

Oxidation performance in model diesel engine exhaust

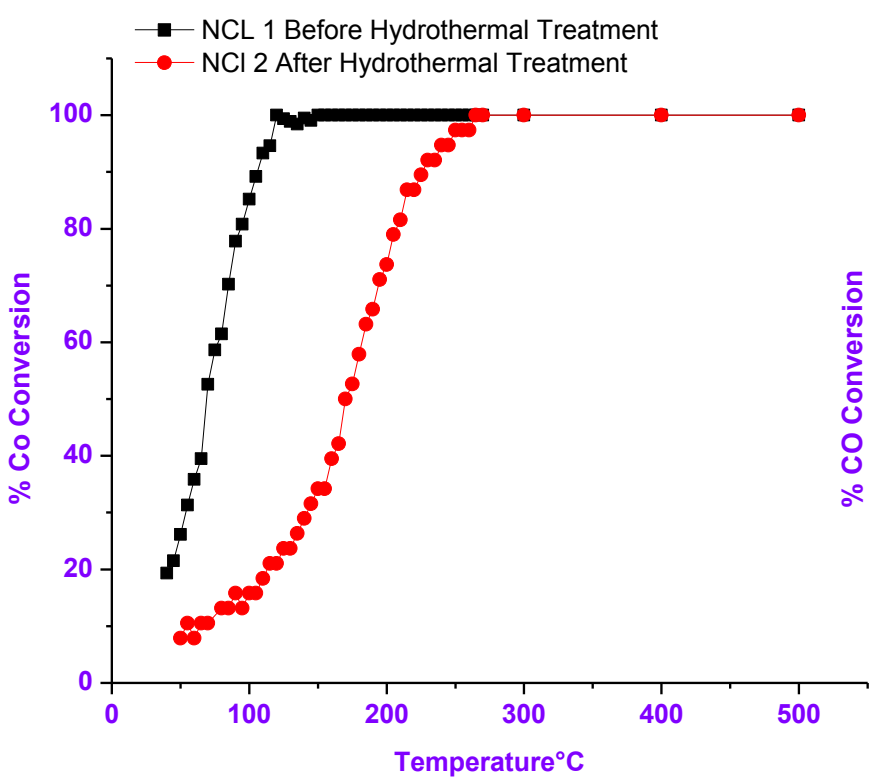


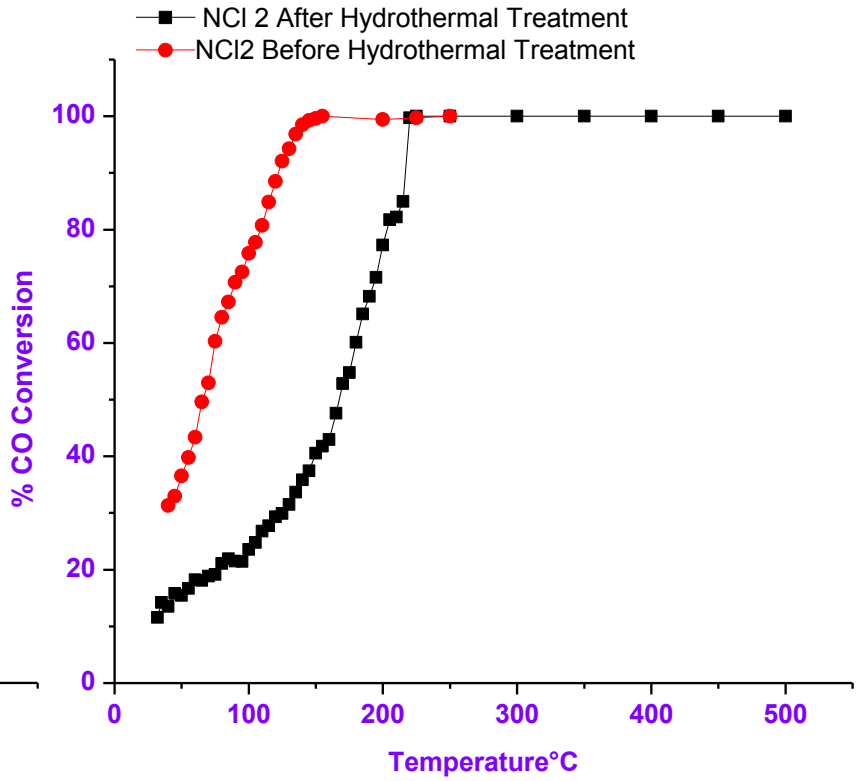


NO oxidation to NO_2 – conversion in the thermodynamic equilibrium limit

Reaction Conditions: 300 ppm NO, 1000 ppm CO, 10% CO_2 10% O_2, 1000 ppm C_3H_6, 9% H_2O, 100 ppm decane, He balance, GHSV 20000 h^{-1}

CO oxidation activity

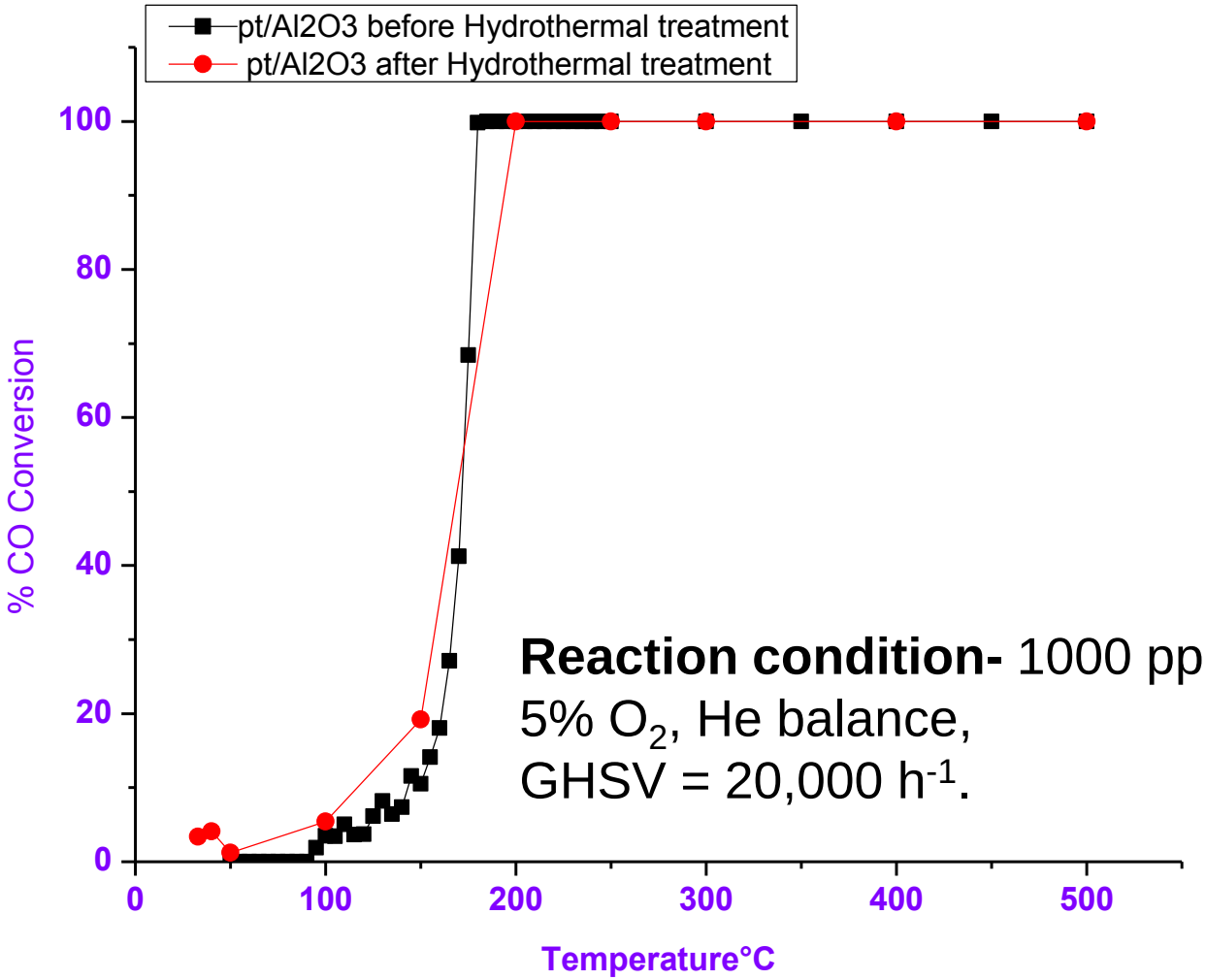




Reaction condition- 1000 ppm CO, 5% O_2, He-balance, GHSV = 20,000 h^{-1}.

Hydrothermal Treatment Condition: 300 ppm NO, 1000 ppm CO, 10% CO_2 10% O_2, 1000 ppm C_3H_6, 9% H_2O, 100 ppm decane, He balance, GHSV 20000 h^{-1} , at 800°C for 8 h

CO oxidation activity



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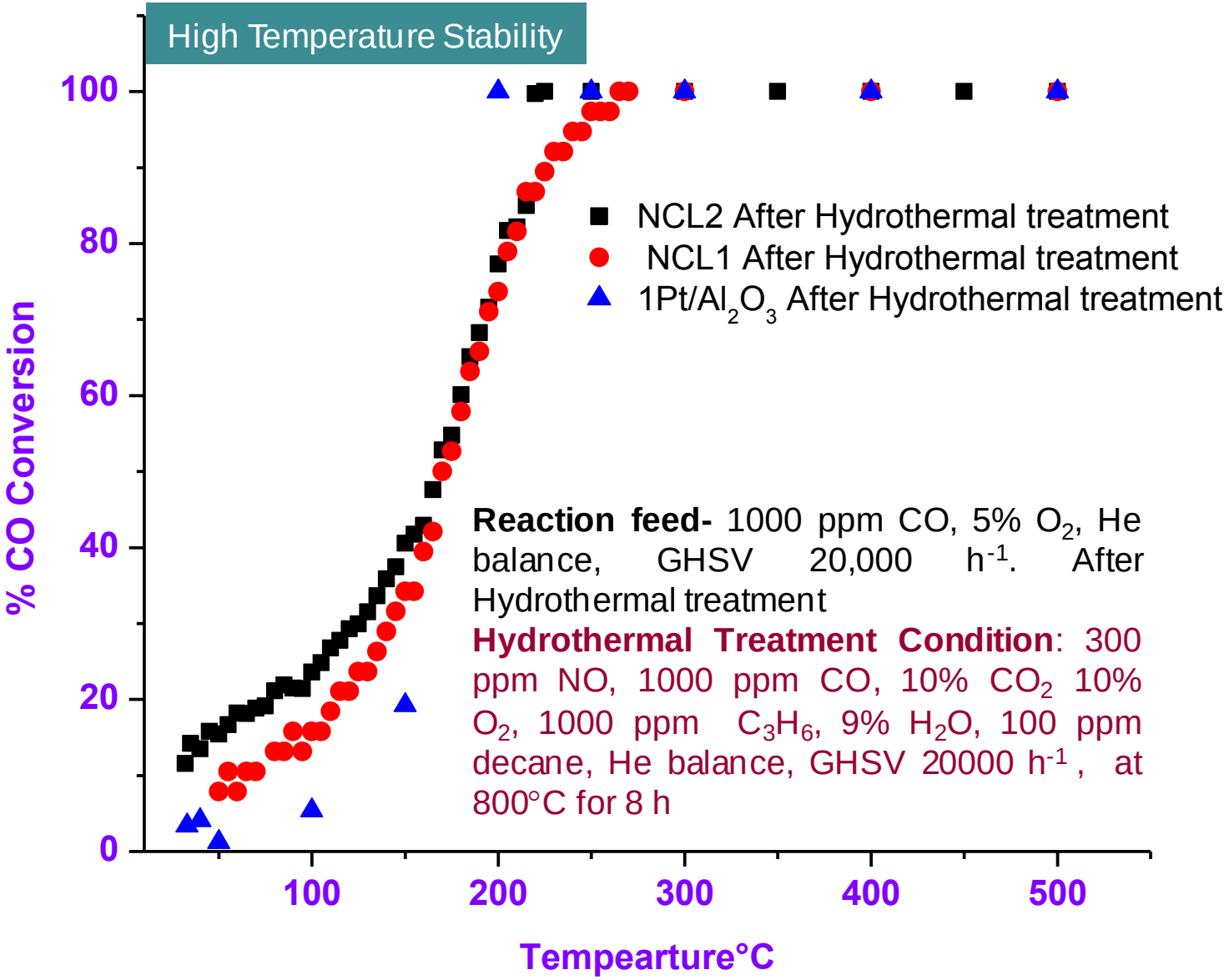
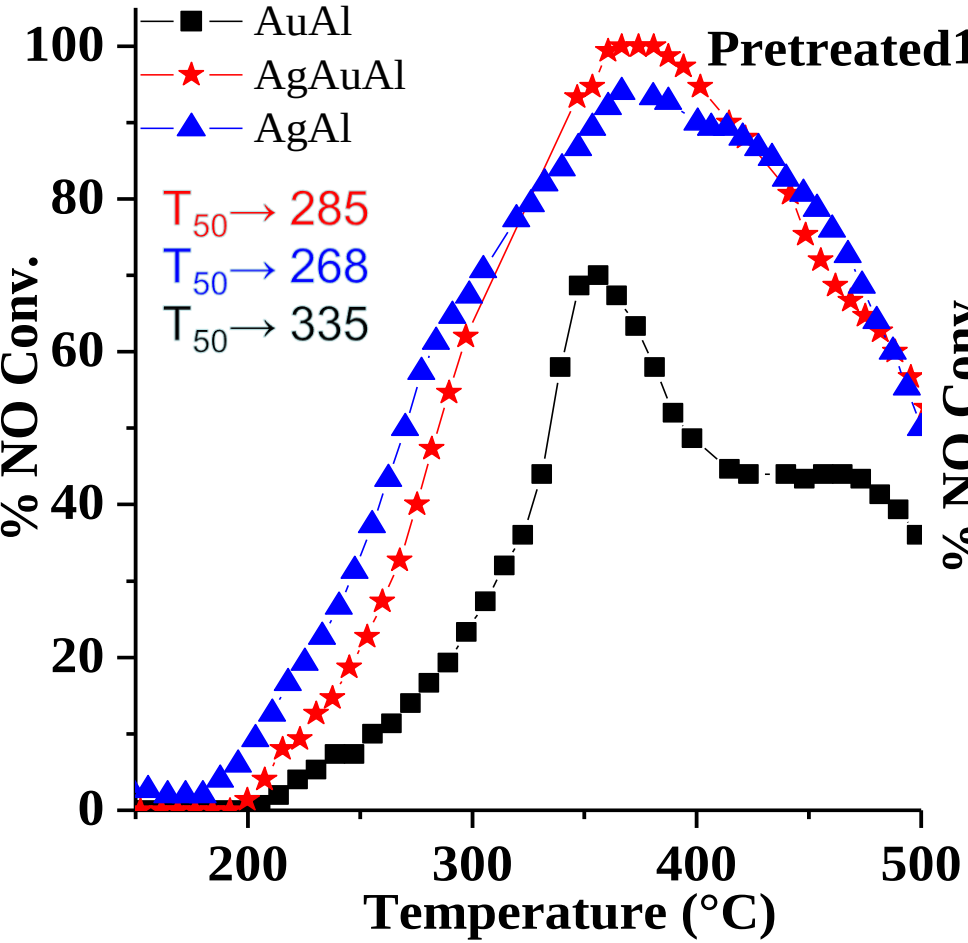
High Temperature Stability

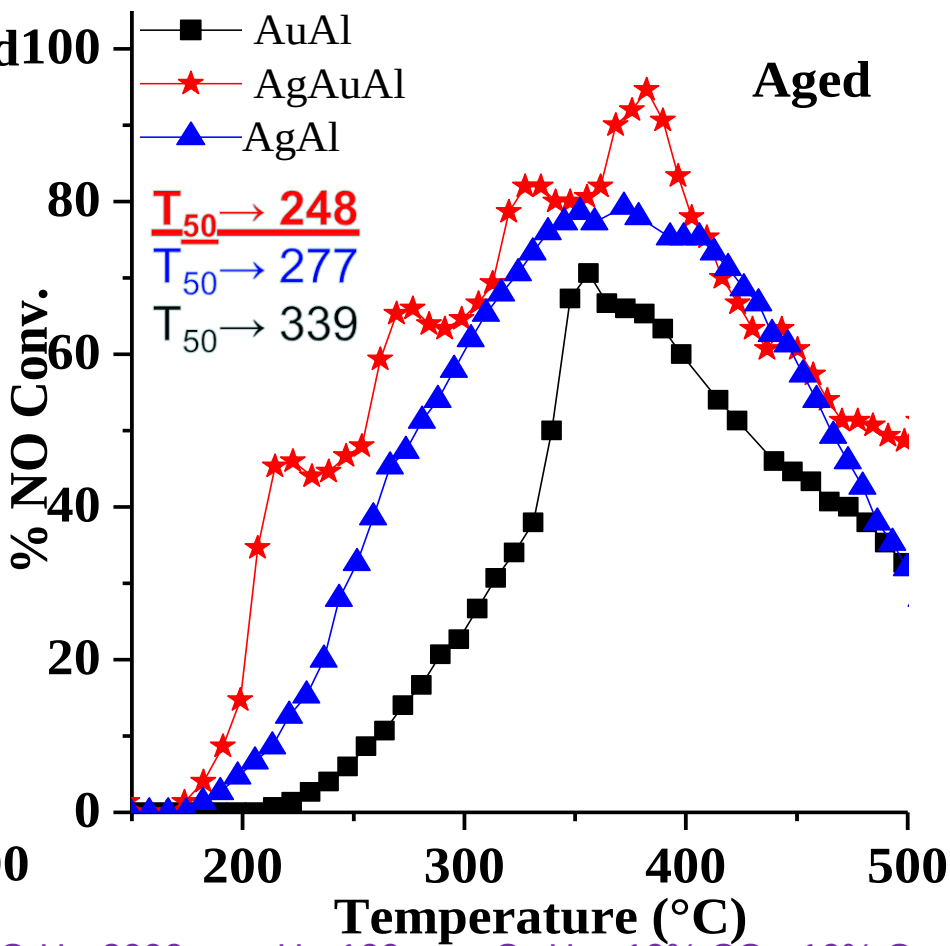


Reaction feed- 1000 ppm CO, 5% O_2, He balance, GHSV 20,000 h^{-1}. After Hydrothermal treatment

Hydrothermal Treatment Condition: 300 ppm NO, 1000 ppm CO, 10% CO_2 10% O_2, 1000 ppm C_3H_6, 9% H_2O, 100 ppm decane, He balance, GHSV 20000 h^{-1}, at 800°C for 8 h

$DeNO_x$ activity comparison of AgAuAl with AgAl and AuAl

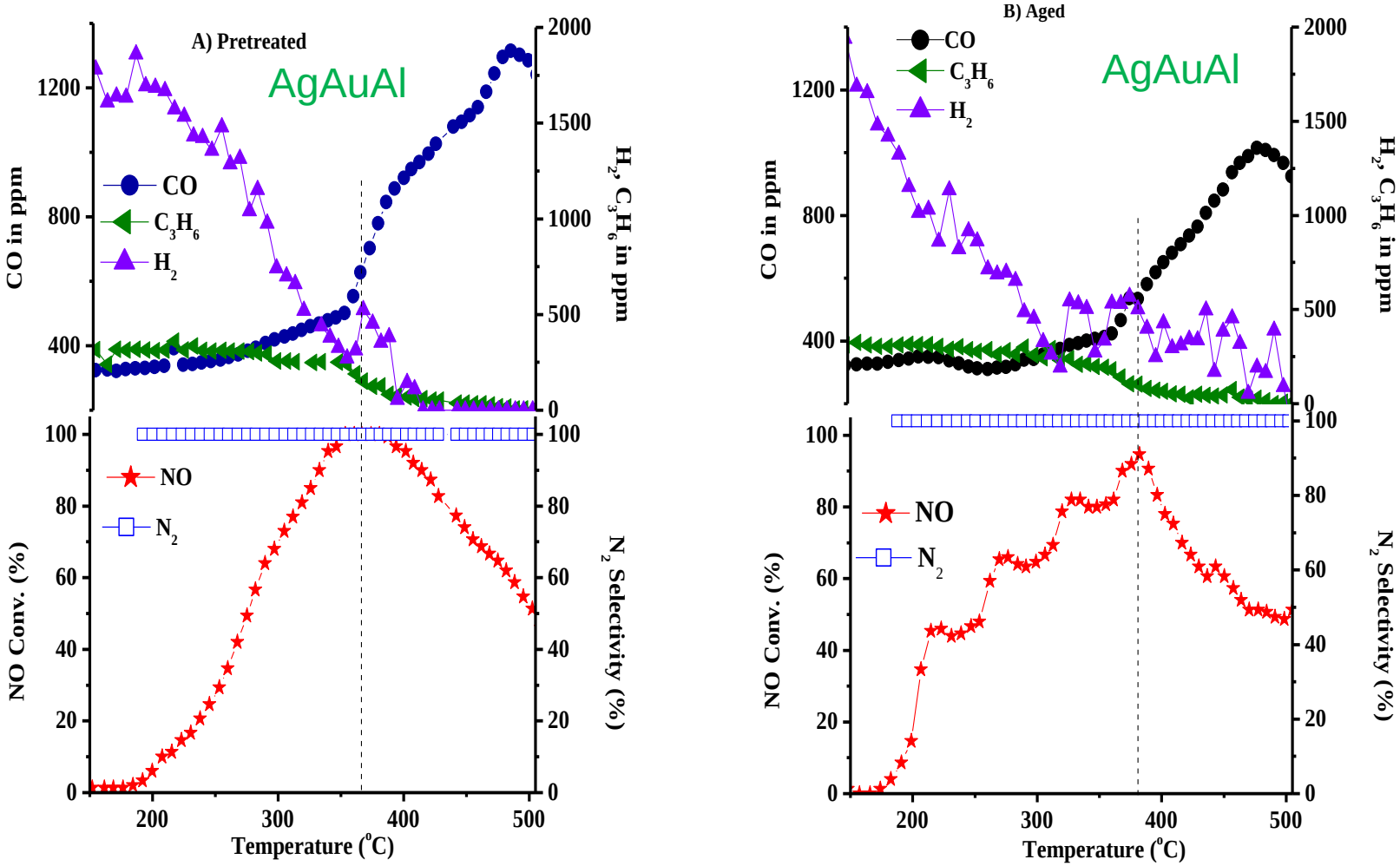




Reaction feed:- 300 ppm NO, 300 ppm CO, 300 ppm C_3H_6, 2000 ppm H_2, 100 ppm $C_{10}H_{22}$, 10% CO_2, 10% O_2, 5% H_2O, He balance, GHSV=50,000 $mL.g^{-1}.h^{-1}$.

After aging activity of AgAuAl increased

Correlation of deNO$_x$ activity with measurement of CO, H_2 and C_3H_6



Reaction feed:- 300 ppm NO, 300 ppm CO, 300 ppm C_3H_6, 2000 ppm H_2, 100 ppm $C_{10}H_{22}$, 10% CO_2, 10% O_2, 5% H_2O, He balance, GHSV=50,000 $mL.g^{-1}.h^{-1}$.

High DeNOx activity at high temperature

Experimental facilities for Environmental Catalysis

Thank You

Funding : DST, CSIR

Interaction & Feed back from:
Tenneco, Cummins, ARAI, BASF, Ecocat