Innovative Circular Technologies for Harmful Nitrogen Compounds/ To Solve Planetary Boundary Issues

Theme 1. Recycling nitrogen compounds in gas phase to ammonia resource

Presenter : Prof. Masaru Ogura (The University of Tokyo), Prof. Masakazu Iwamoto (Waseda University),
Dr. Mitsuhiro Tanaka (Ube Industries, Ltd.)
PM： Dr. KAWAMOTO Tohru , National Institute of Advanced Industrial Science and Technology (AIST)
Implementing organizations : National Institute of Advanced Industrial Science and Technology (AIST),
The University of Tokyo, Waseda University,
Tokyo University of Agriculture and Technology, Kobe University,
Osaka University, Yamaguchi University, Kyowa,Hakko Bio Co., Ltd.,
ASTOM Corporation, Toyobo Co., Ltd., FUSO Corporation, Ube Industries, Ltd,

Elimination of nitrogen oxides for environmental issues

Decomposition$\rightarrow N_2 + O_2$ the most ideal but difficult

Reduction

+HC$\rightarrow N_2 + CO_2 + H_2O$

+CO$\rightarrow N_2 + CO_2$

the current process
low selectivity by O_2 coexisted

+$NH_3 \rightarrow N_2 + H_2O$

the current process
necessary to add from external

Ammonia synthesis for food and energy issues

$N_2 + H_2 \rightarrow NH_3$

the Haber-Bosch process
high temperature & pressure

NOx as a chemical resource!!

LNG thermal power generation facility

Game changer

※detoxification

<denitrification>

(exhaust) NO + NH_3 → N_2

※resource recycling
"process innovation"

<NOx reforming>

Hydrogen source
(CH_4, etc)

(resource) NO → NH_3

Merit① Eliminate needs for reductant

Merit② No need to invest more energy

Avoiding HB process

Merit③ Reduction of NH_3 imported

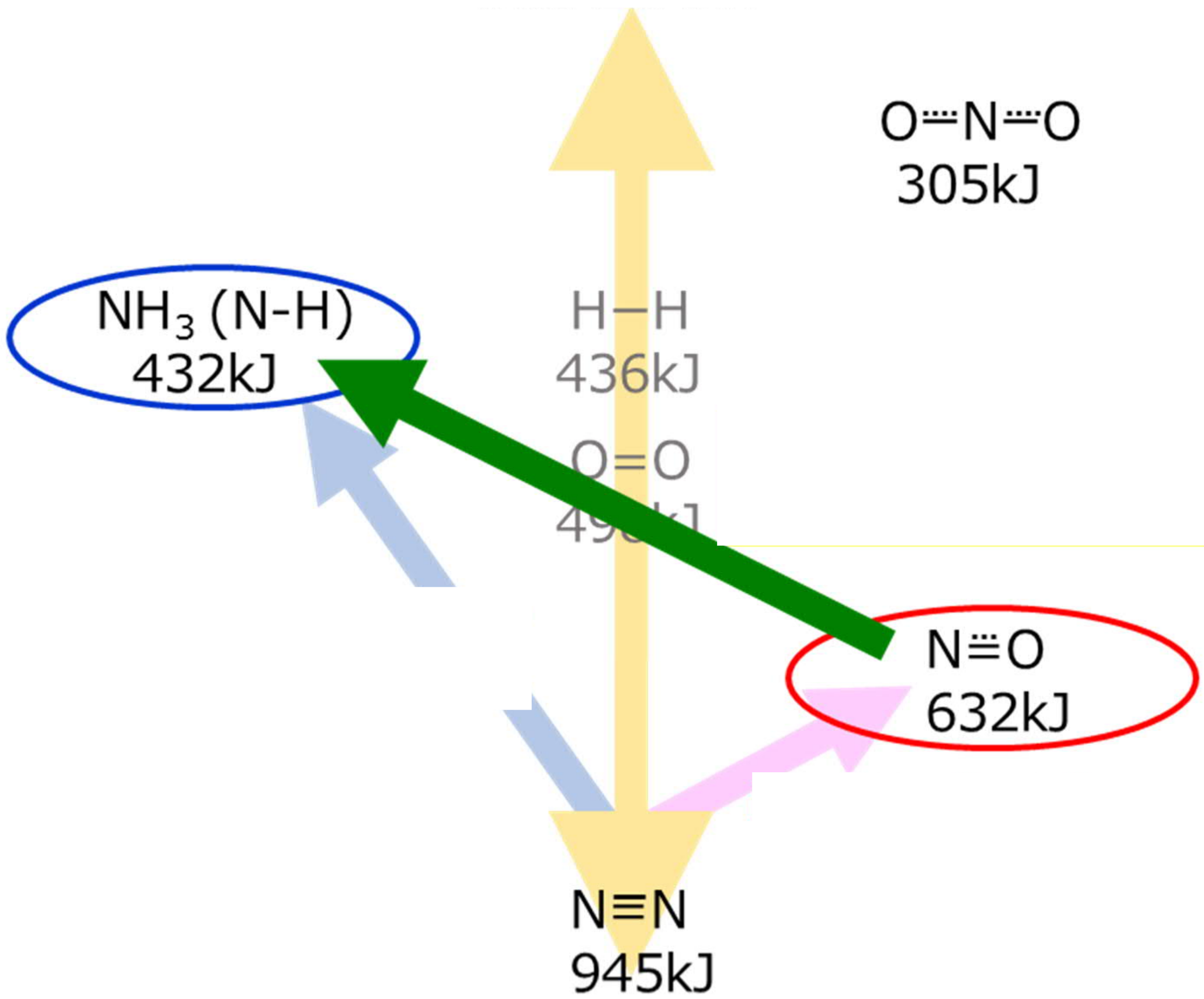
$$NO + NH_3 \rightarrow N_2$$

$$NO + (H) \rightarrow NH_3$$

New Energy and Industrial Technology Development Organization: NEDO
FY2019 Feasibility Study Program on Energy and New Environmental Technology
「Development of ammonia production process from NOx emitted from combustion process」

Why ammonia from NOx ?

high reactivity

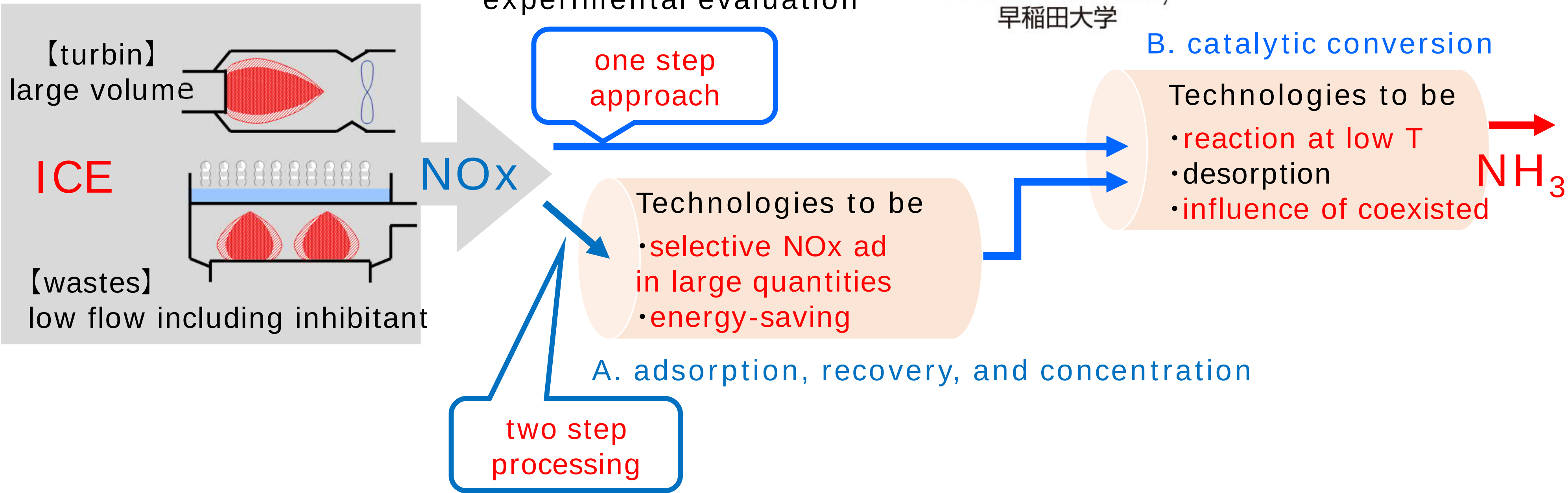


Bonding energies in N-containing molecules

Examples of specific technological developments and study teams

materials preparation and experimental evaluation

WASEDA University
早稲田大学



theoretical analysis and evaluation

東京大学 THE UNIVERSITY OF TOKYO

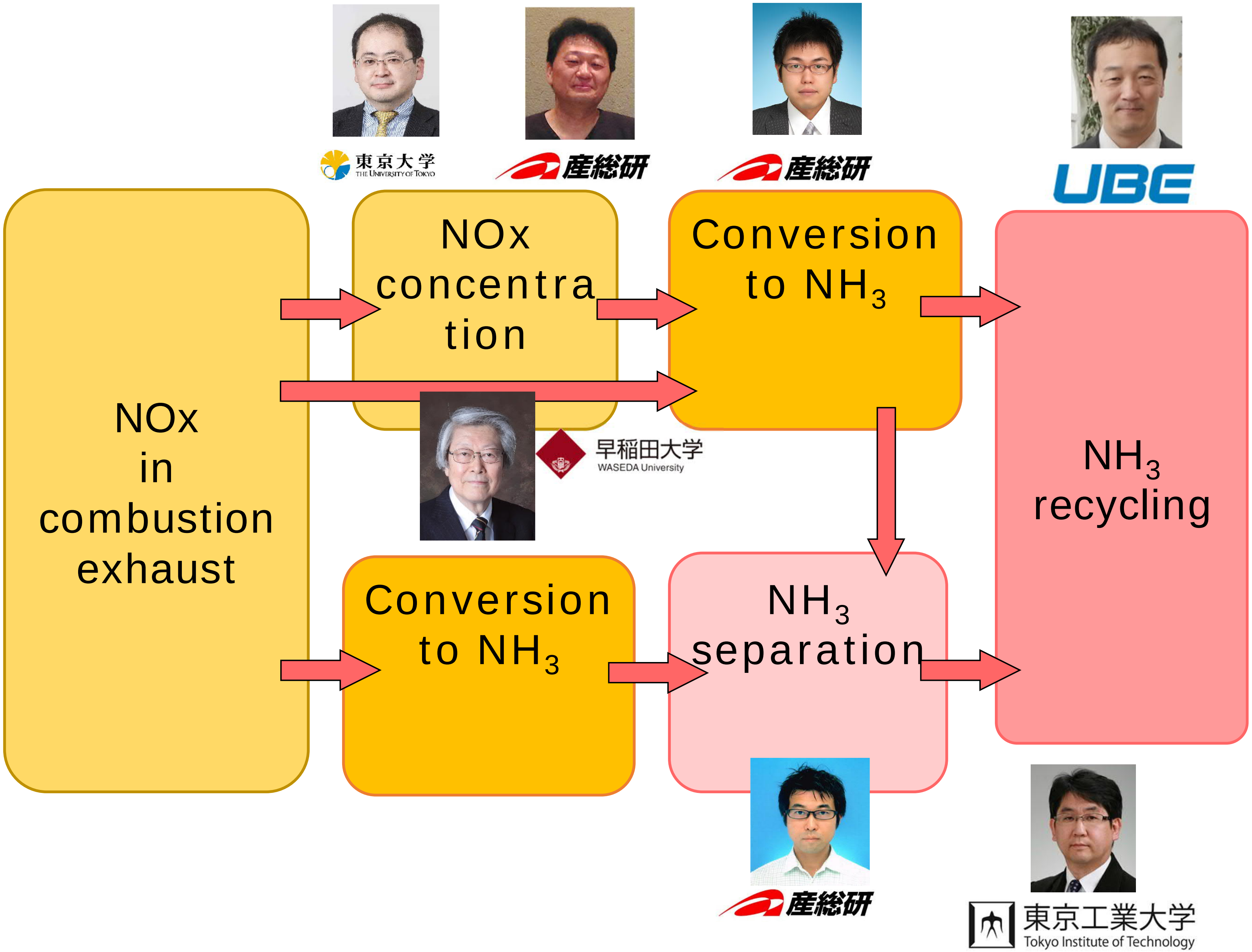
National Institute of Advanced Industrial Science and Technology AIST

Tokyo Tech

TOKYO GAS

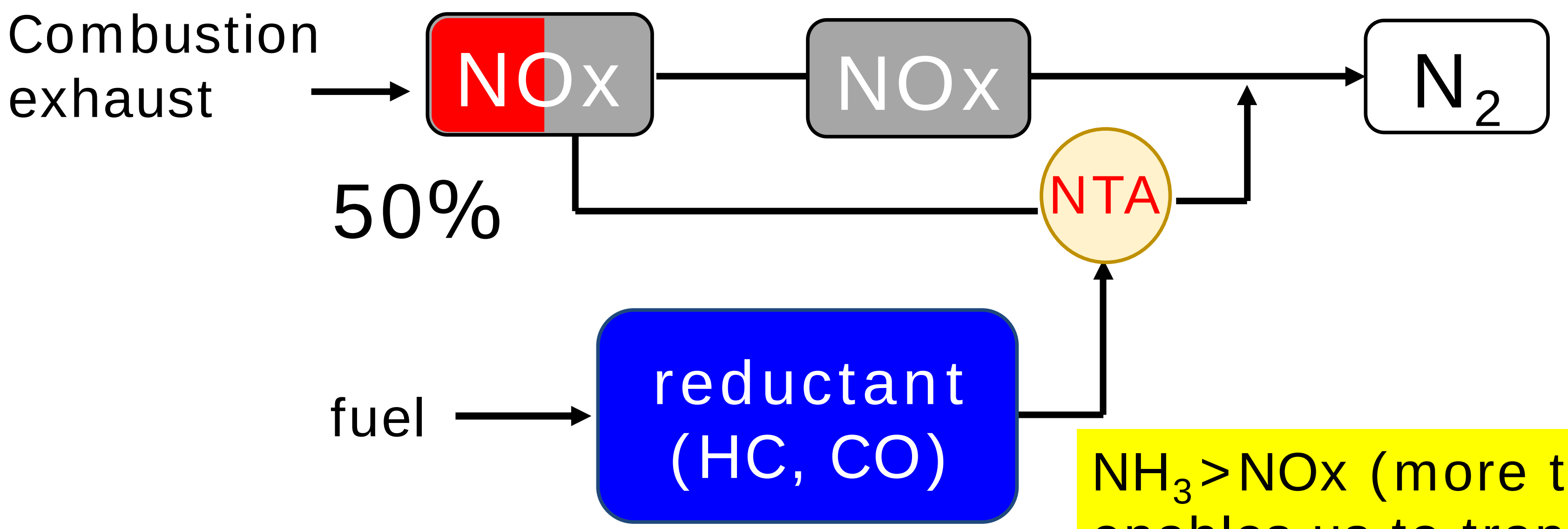
NIPPON STEEL ENGINEERING

The team of gas-phase NTA



【Theme 1. Resource ammoniation of nitrogen compounds in gas phase】

1. Improvement of 1 step NTA ($NOx \rightarrow NH_3$) catalyst
2. NOx adsorption and concentration for 2 step NTA catalytic system
3. NH_3 concentration



NH_3>NOx (more than 50%) enables us to transform NOx completely to NH_3 for resourcing

Pilot image in 2029

Demonstration test assumed location: Ube Industries

Exhaust
250 ～1000Nm^3/h
1,000 ～5,000ppm-NOx

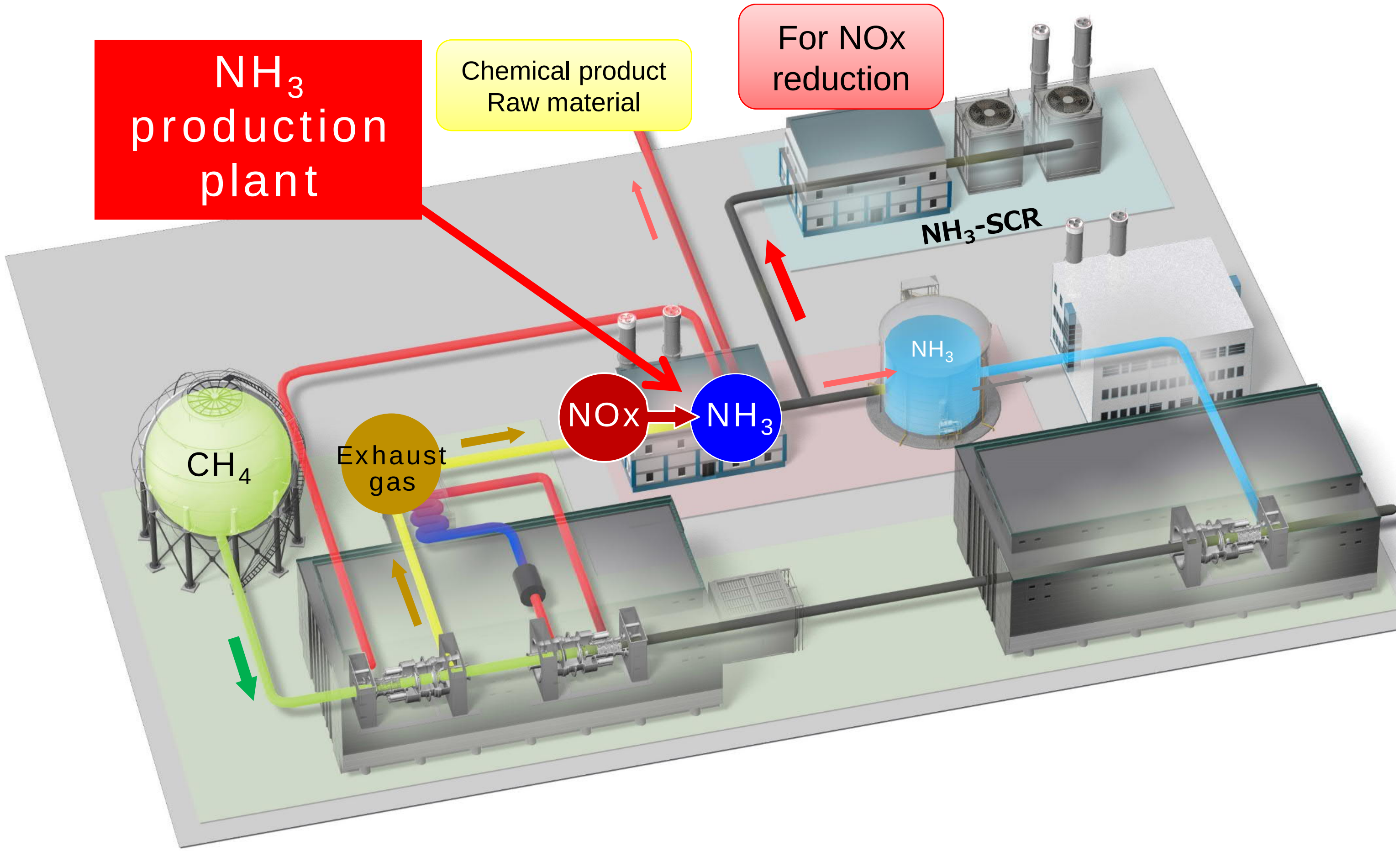
↓

$NOx \rightarrow NH_3$ conversion 50%

↓ 100% circulation

Reductant for NOx

Implementation image in 2050

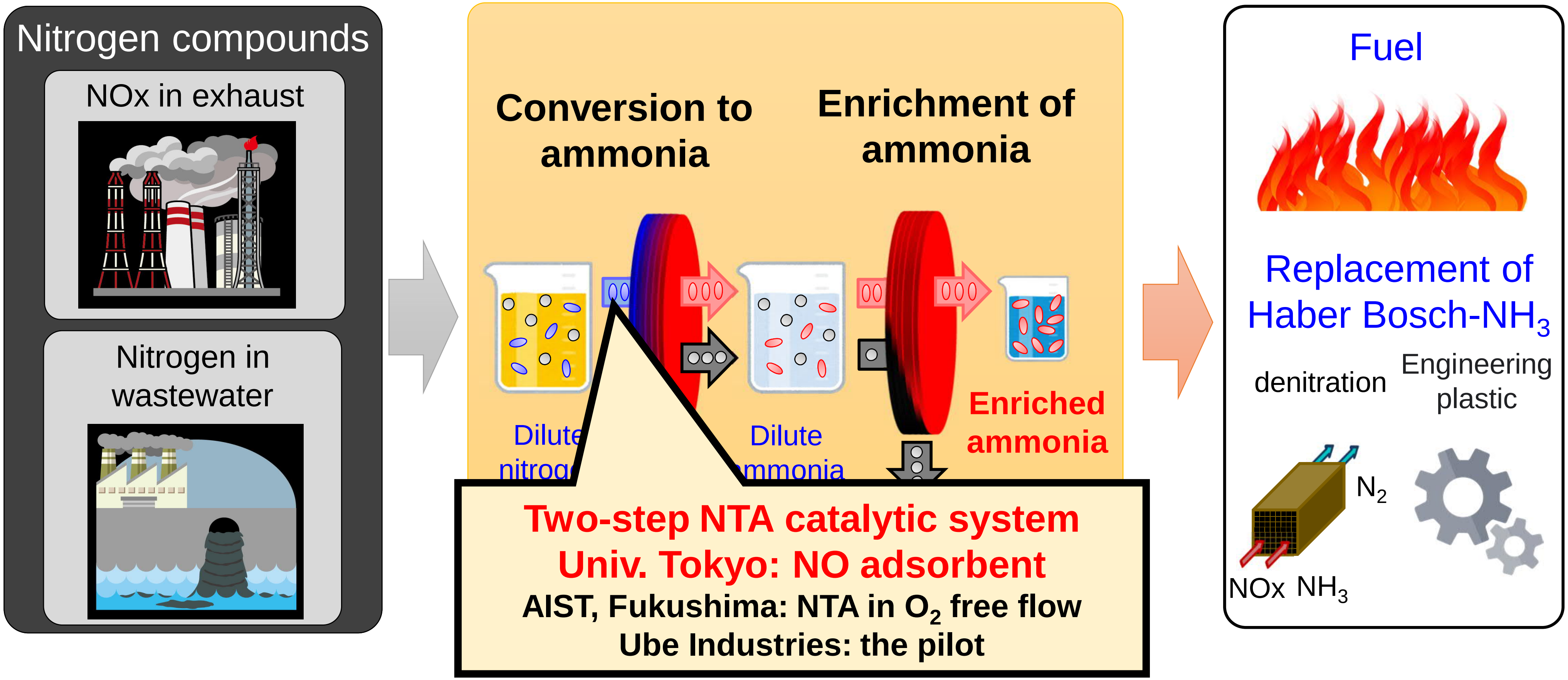


Innovative Circular Technologies for Harmful Nitrogen Compounds/ To Solve Planetary Boundary Issues

Theme 1. Recycling nitrogen compounds in gas phase
to ammonia resource
Highly selective NO adsorption for successive NTA catalyst process
by use of metal species-derived electrostatic field in
hydrophilic/hydrophobic space

Presenter : Prof. Masaru Ogura (Institute of Industrial Science, The University of Tokyo)
PM： Dr. KAWAMOTO Tohru , National Institute of Advanced Industrial Science and Technology (AIST)
Implementing organizations : National Institute of Advanced Industrial Science and Technology (AIST),
The University of Tokyo, Waseda University,
Tokyo University of Agriculture and Technology, Kobe University,
Osaka University, Yamaguchi University, Kyowa,Hakko Bio Co., Ltd.,
ASTOM Corporation, Toyobo Co., Ltd., FUSO Corporation, Ube Industries, Ltd,

Position in the Project



Target of Theme 1 for FY2029：NOx to Ammonia (NTA) reaction at 50% yield, and complete detoxification of exhaust gas

Position of the University of Tokyo: Development of adsorbents and adsorption technology for selective adsorption and concentration of NOx

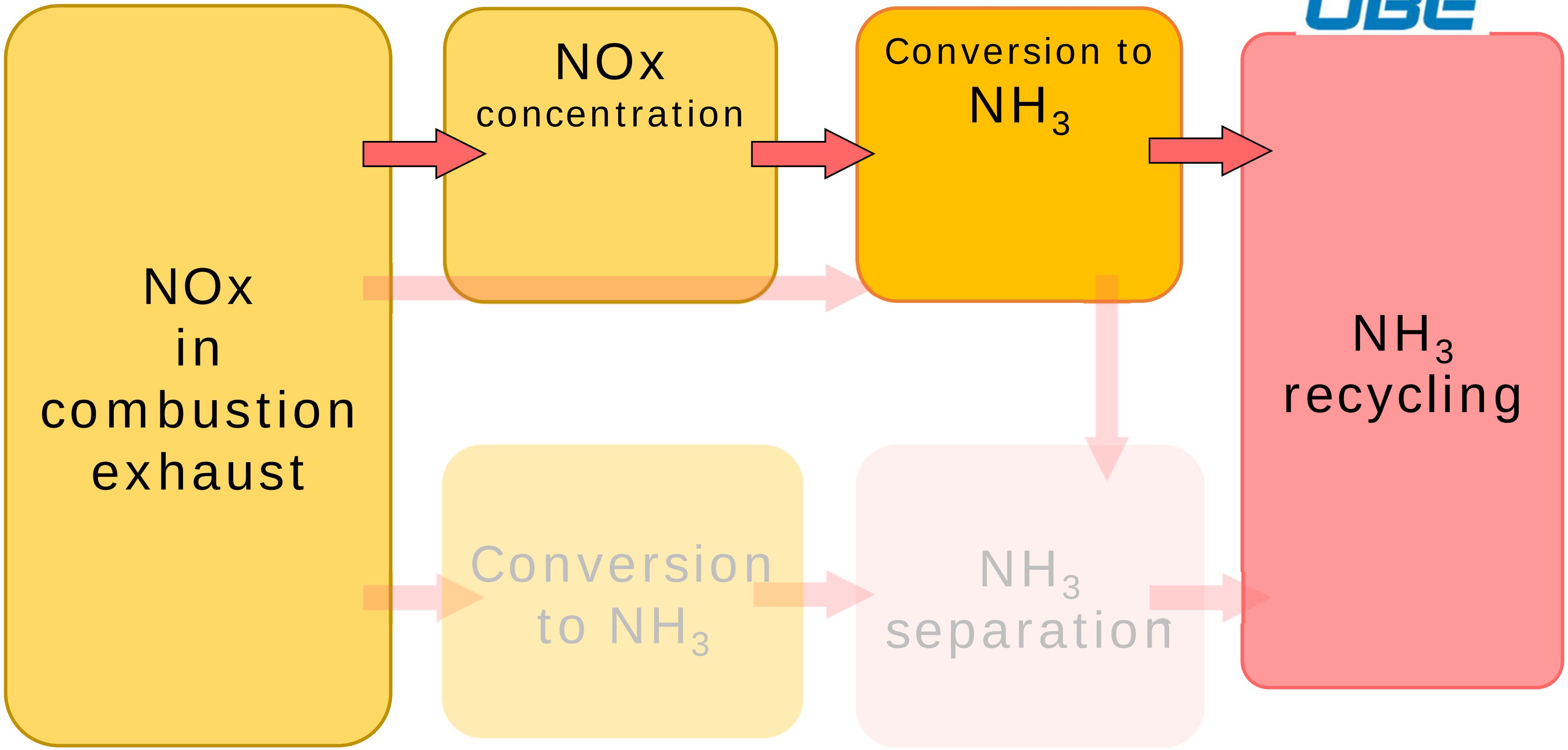
The target for FY2029: Establishment of NO adsorption and concentration materials and basic process for pilot demonstration of NTA catalyst system

The team of 2 step NTA system

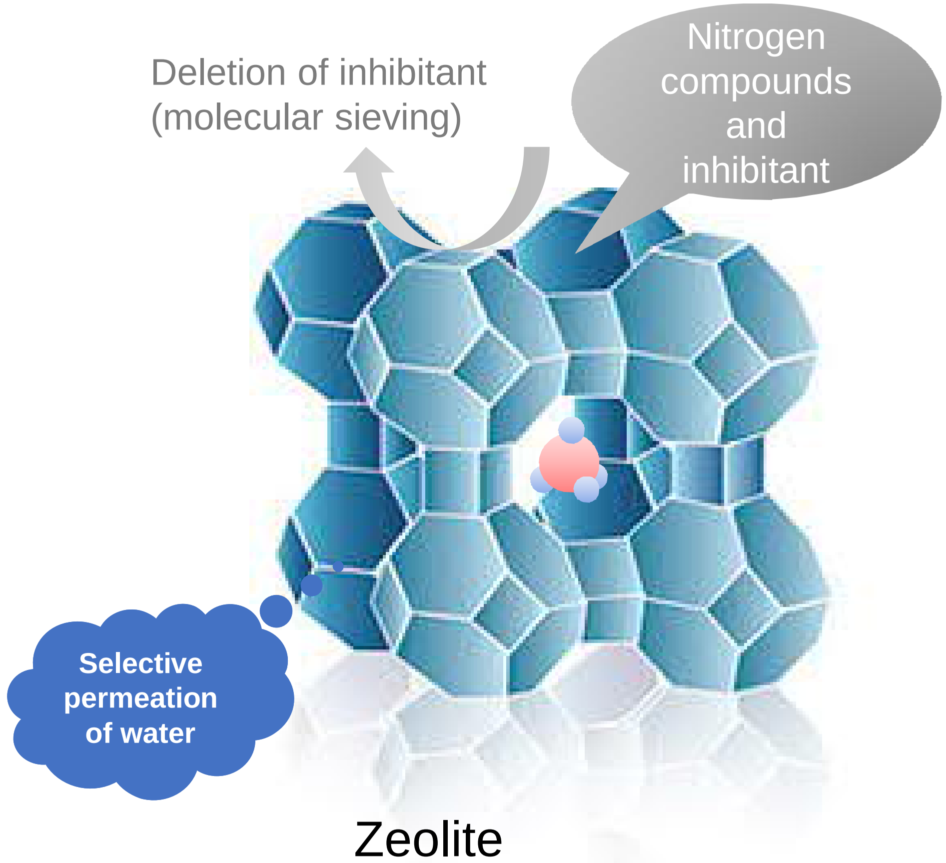
東京大学 THE UNIVERSITY OF TOKYO

産総研

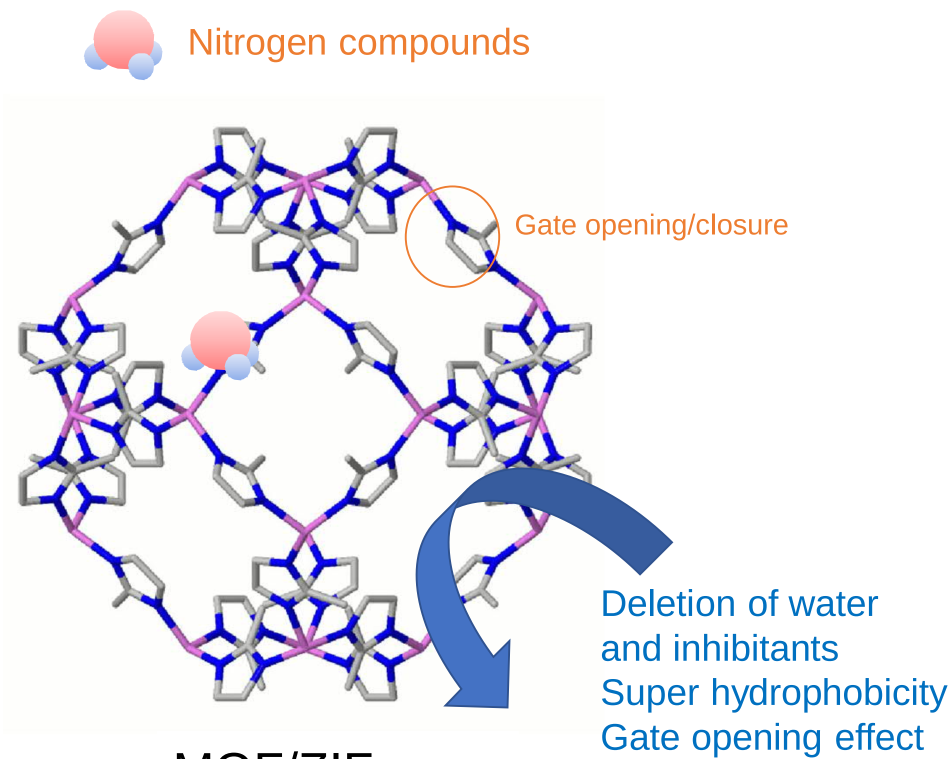
UBE



Design of highly selective adsorbent for NOx contained in flue gas
(low temperature, physisorption type)



Zeolite
Hydrophobic/hydrophilic



MOF/ZIF
Hydrophobic/gate

【items】

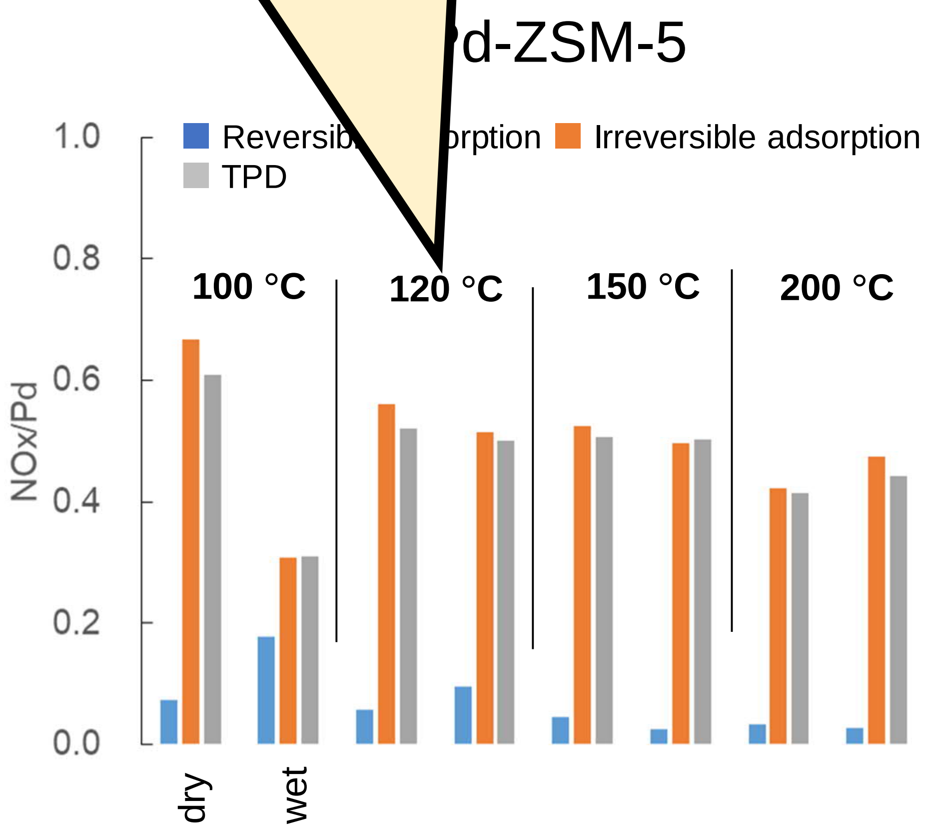
- Design of an adsorbent that can selectively recover and concentrate NO in exhaust gas
- Design of a catalytic system by combination of the adsorbent with the NTA catalyst (AIST Fukushima)

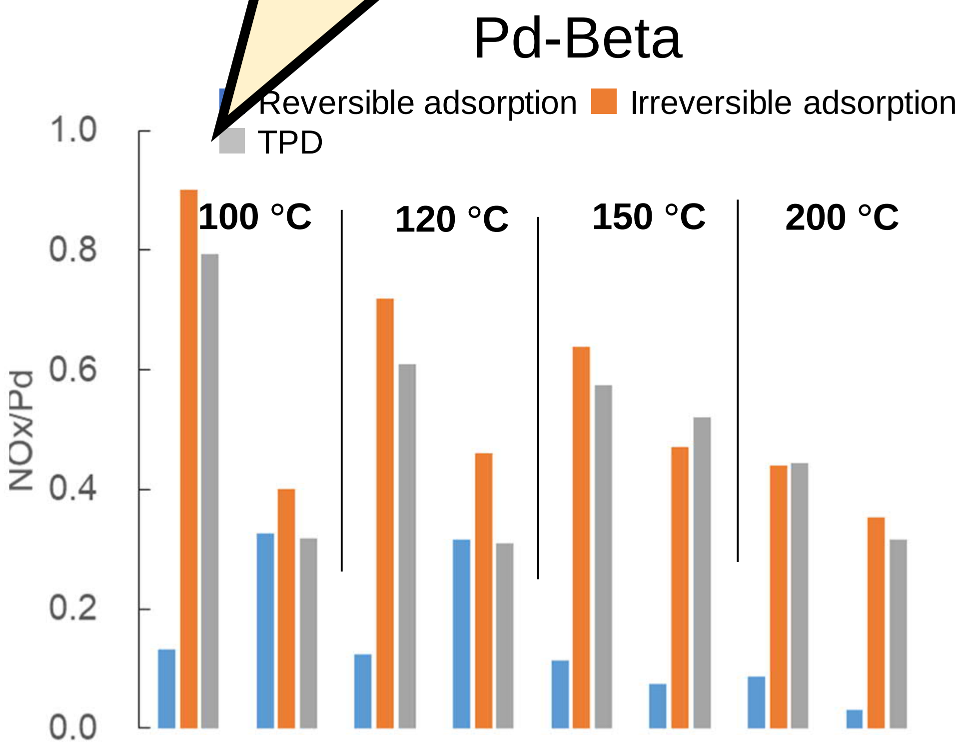
Achievement 1: NO adsorption on zeolite under wet conditions

- Discovery of a material with sufficient NO adsorption capacity in the presence of water vapor (zeolite-based)

Unique adsorption characteristics in the presence of water vapor

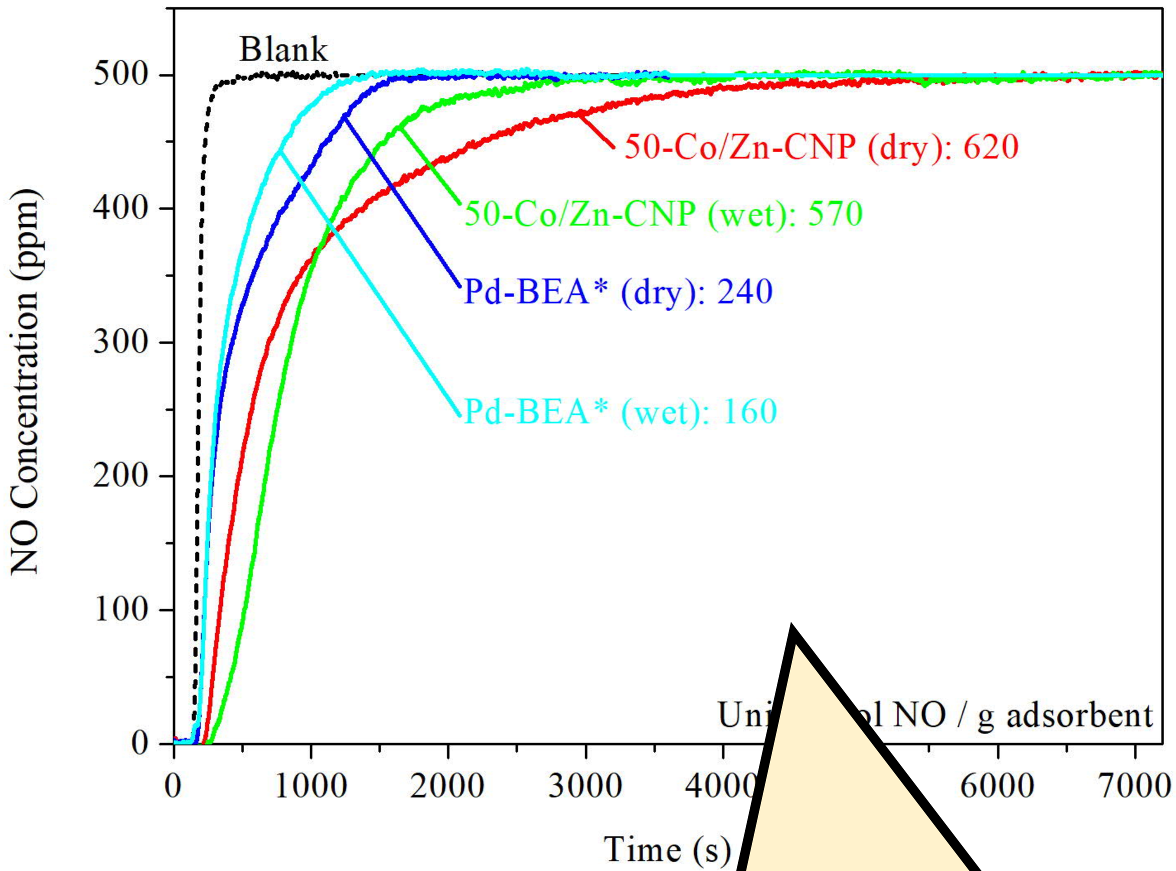
Quite high adsorption capacity



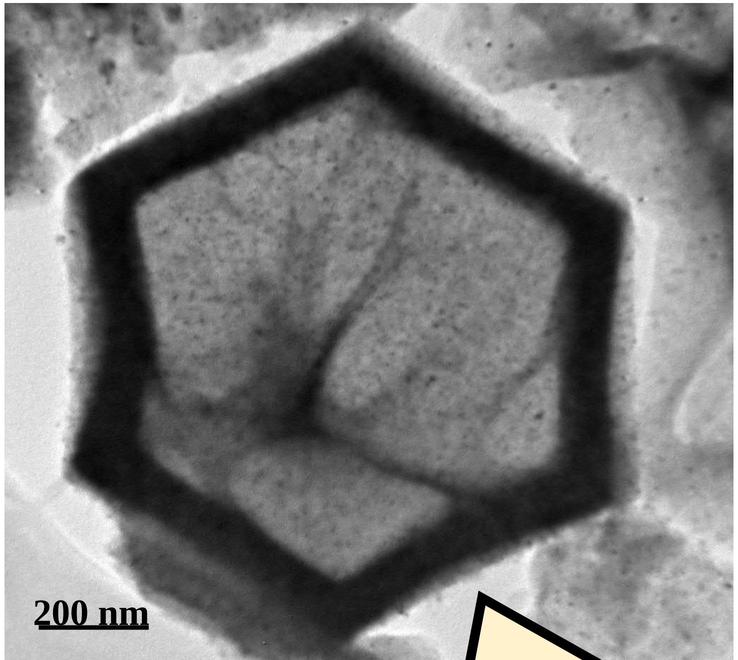


adsorption: NO 500ppm, O_2 10%, (wet H_2O 5%)/N_2 200 mL/min at 100-200 °C
TPD: O_2 10%/N_2 200 mL/min, heated to 500 °C (10K/min)

- Discovery of materials with sufficient NO adsorption capacity in the presence of water vapor (ZIF-based)



Unique adsorption properties in the presence of water vapor, more than 3 times higher than zeolite adsorbent
→Realization of selective adsorption



Succeeded in creating a unique core-shell structure

Ge *et al.* submitted
Ogura, patented

Summary, Univ. Tokyo

Position in the project

Development of adsorbents and adsorption technologies for selective adsorption and concentration of NO in exhaust

Target for FY2029

Establishment of materials and basic processes for pilot demonstration of NTA catalyst system

R&D items

Development of ultra-selective NO adsorbent for NTA using metal species-derived electrostatic field in hydrophilic/hydrophobic space

Achievements by the University of Tokyo

- Discovery of materials with sufficient NO adsorption capacity in the presence of water vapor, temperature specific and capacity variable by zeolite type selection (Zeolite type)
- Discovery of materials with sufficient NO adsorption capacity in the presence of water vapor, showing more than three times the adsorption capacity of the zeolite type (ZIF type)

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM