Physicochemical Denitrification Process for Drinking Water Resources at Ambient Conditions

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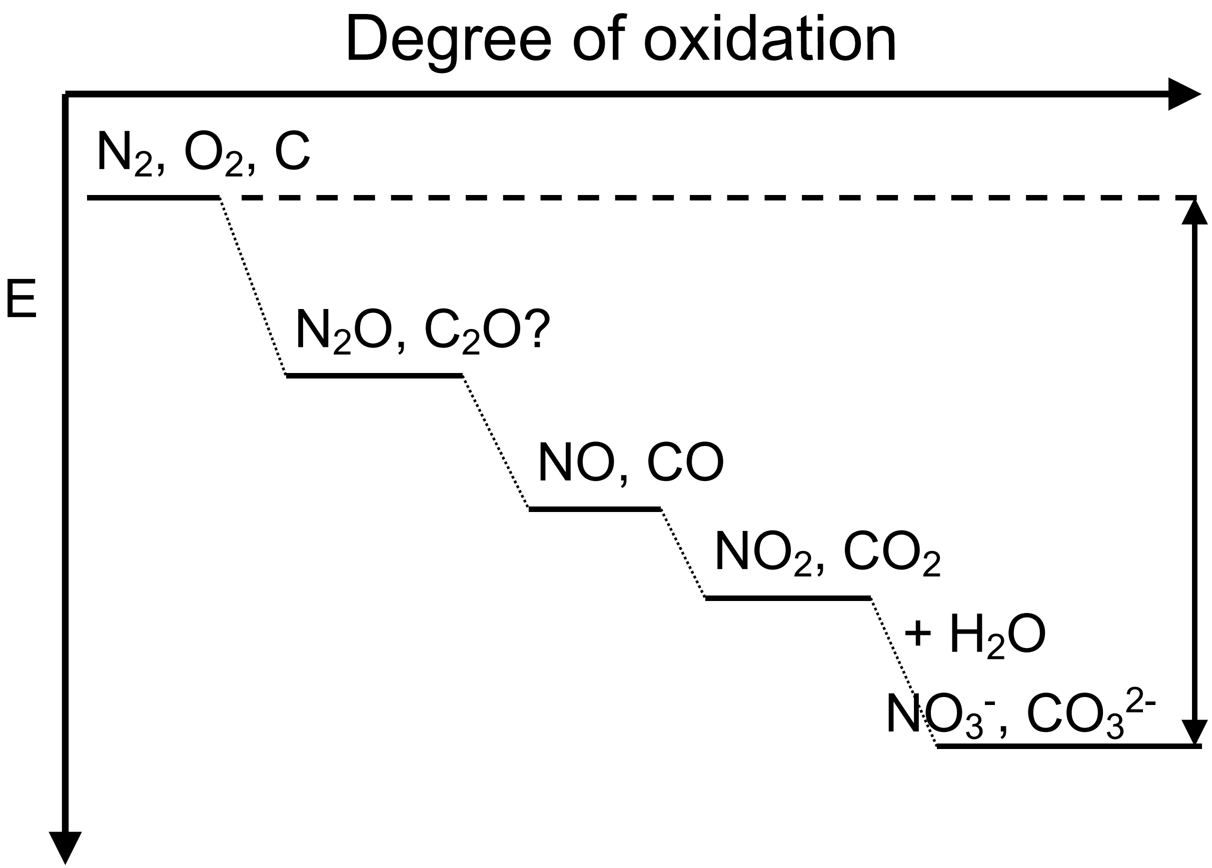
Nitrogen oxide decomposition to N_2 is economically rational

This is absolutely different from CO_2 decomposition which was proposed in the past.

Benefits of nitrogen oxides decomposition technology:

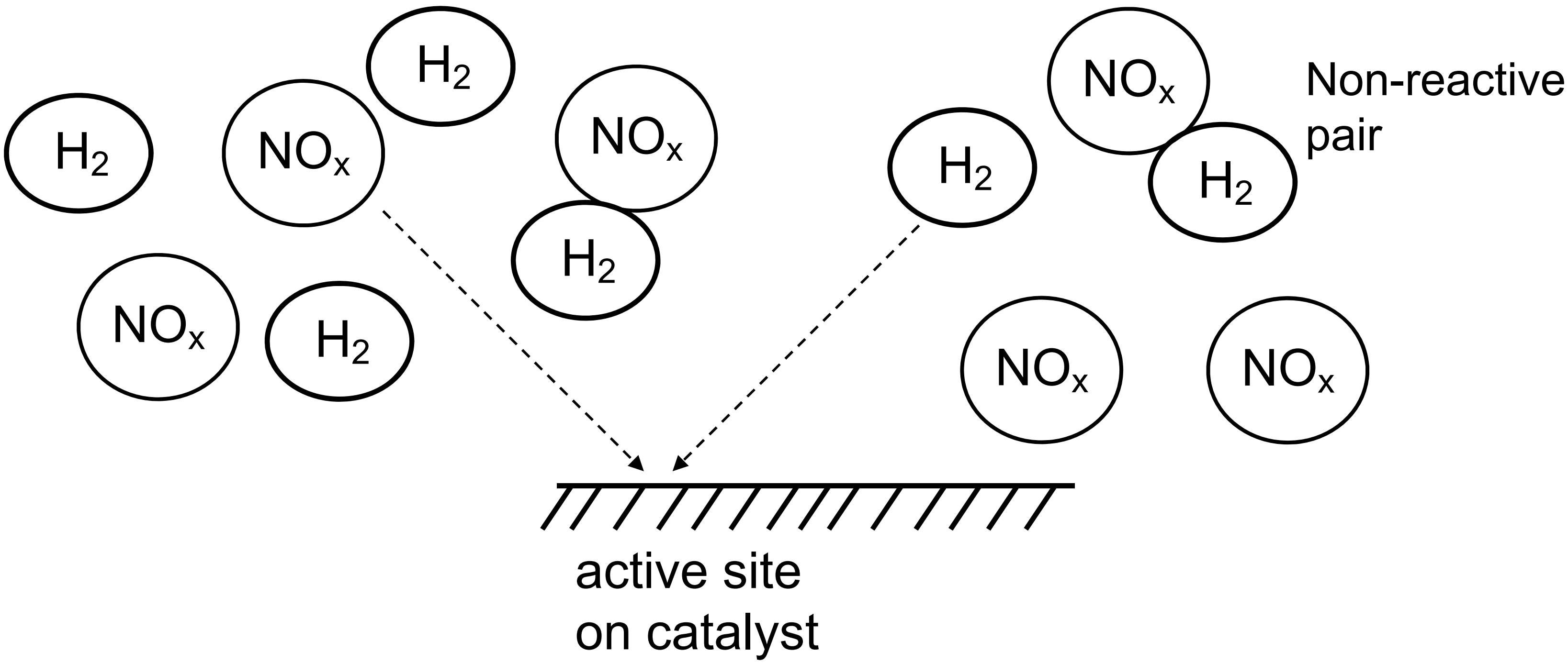
- N_2O decomposition contributes to mitigation of global warming.
- NO decomposition contributes to removal of air pollutant.
- NO_3^-, NO_2^- decomposition contributes to groundwater purification.

Conventional nitrogen oxides decomposition processes are not sustainable. Why?

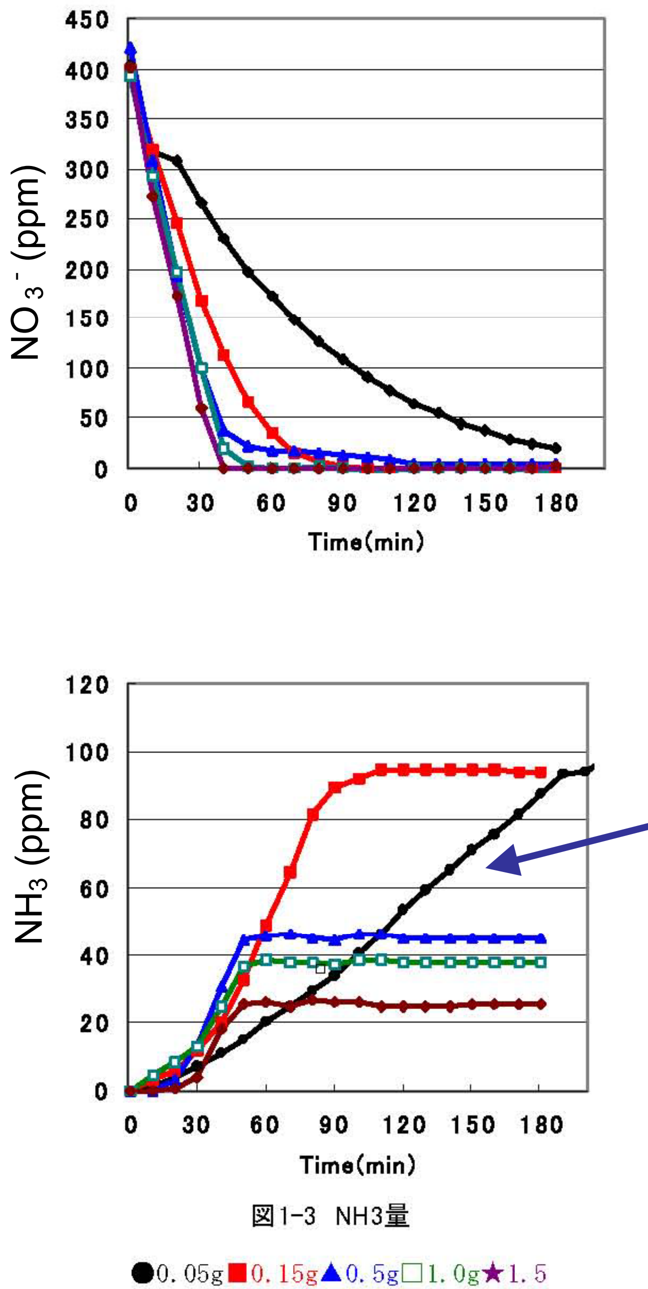


Conventionally this energy was supplied through H_2, noble-metal catalyst or others, resulting in energy-Intensive processes.

Catalytic processes proposed for nitrogen oxide decomposition are “three-body collision”.



- These are an energy-intensive process requiring lots of high quality energy, e.g., H_2, NH_3 or hydrocarbon.
- Head-on collision of NO_x and H_2 is not sufficient to react at ambient conditions.
- Biological process proceeds at more mild conditions, but too sluggish.



RITE PJ:Catalytic decomposition of NO_3^- in flow of H_2

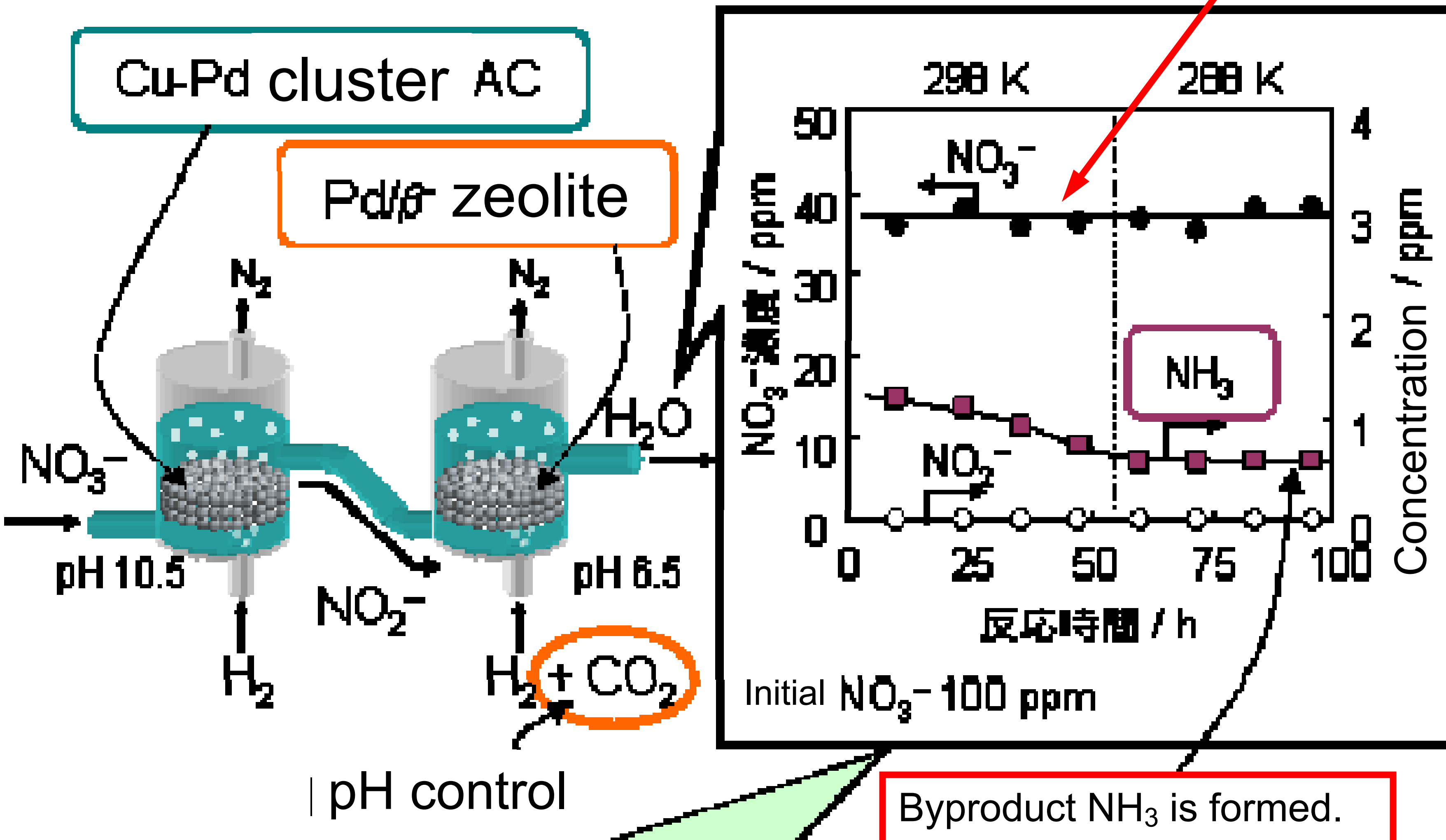
Results:
Large amount of byproducts：NO_2^- and NH_3

Source: RITE report, Japan, March 2005.

Similar unsustainable results have been reported by Hokkaido University and others.

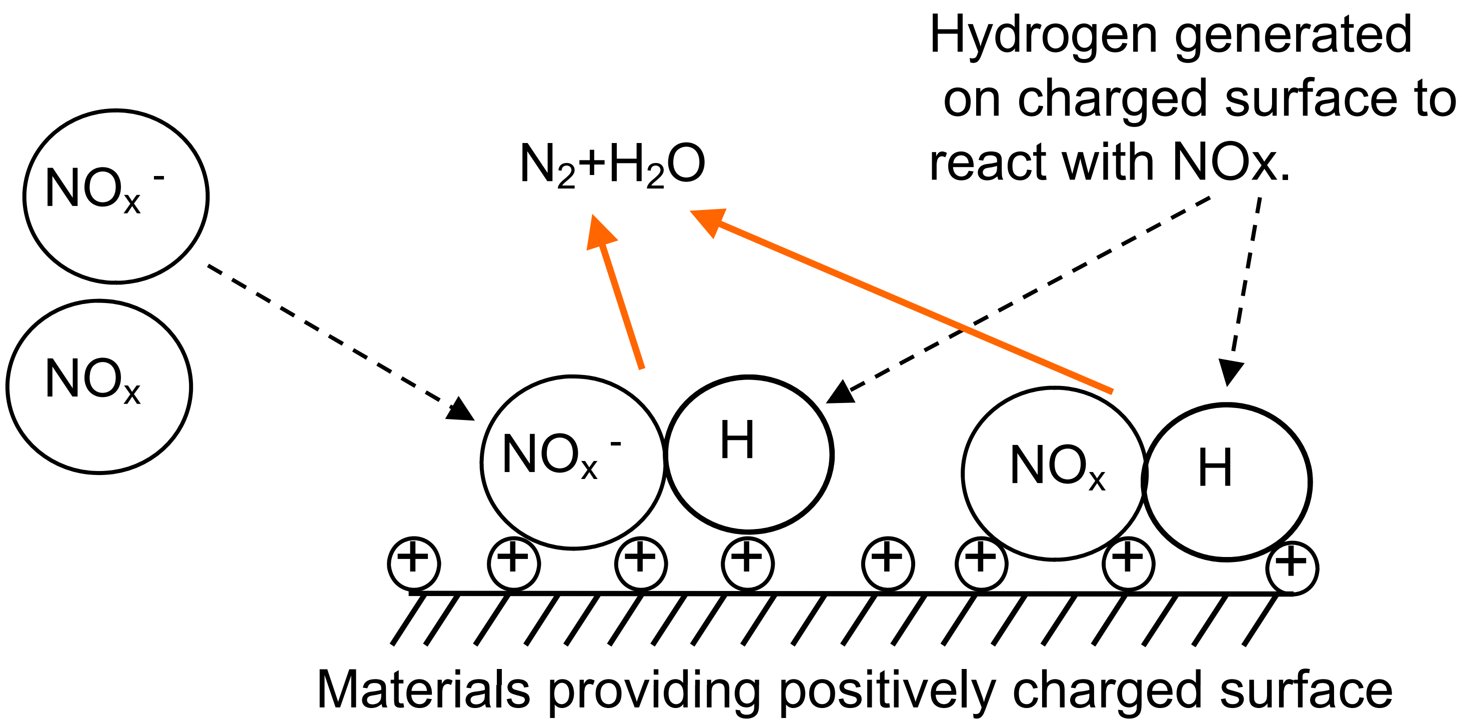
Dr. T. Okuhara (Hokkaido Univ)

40% remained



Source: Chem. Lett. 34 (2005) 1510.

Our greener & sustainable idea: spillover-based NO x decomposition



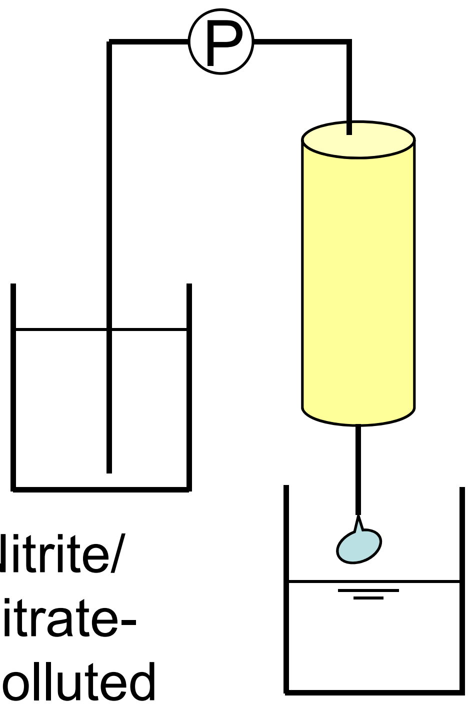
- NO_x decomposition is possible at ambient temperature and pressure.
- Energy input to dissociate NO_x is minimal.

Requisite materials for this greener & sustainable process

Properties of materials:

1. charge-transferable surface
2. serve sufficiently reactive sites even in aqueous conditions.
3. chemically insoluble
4. economical
5. available worldwide
6. non-toxic (for food-level safety, heavy metal free)

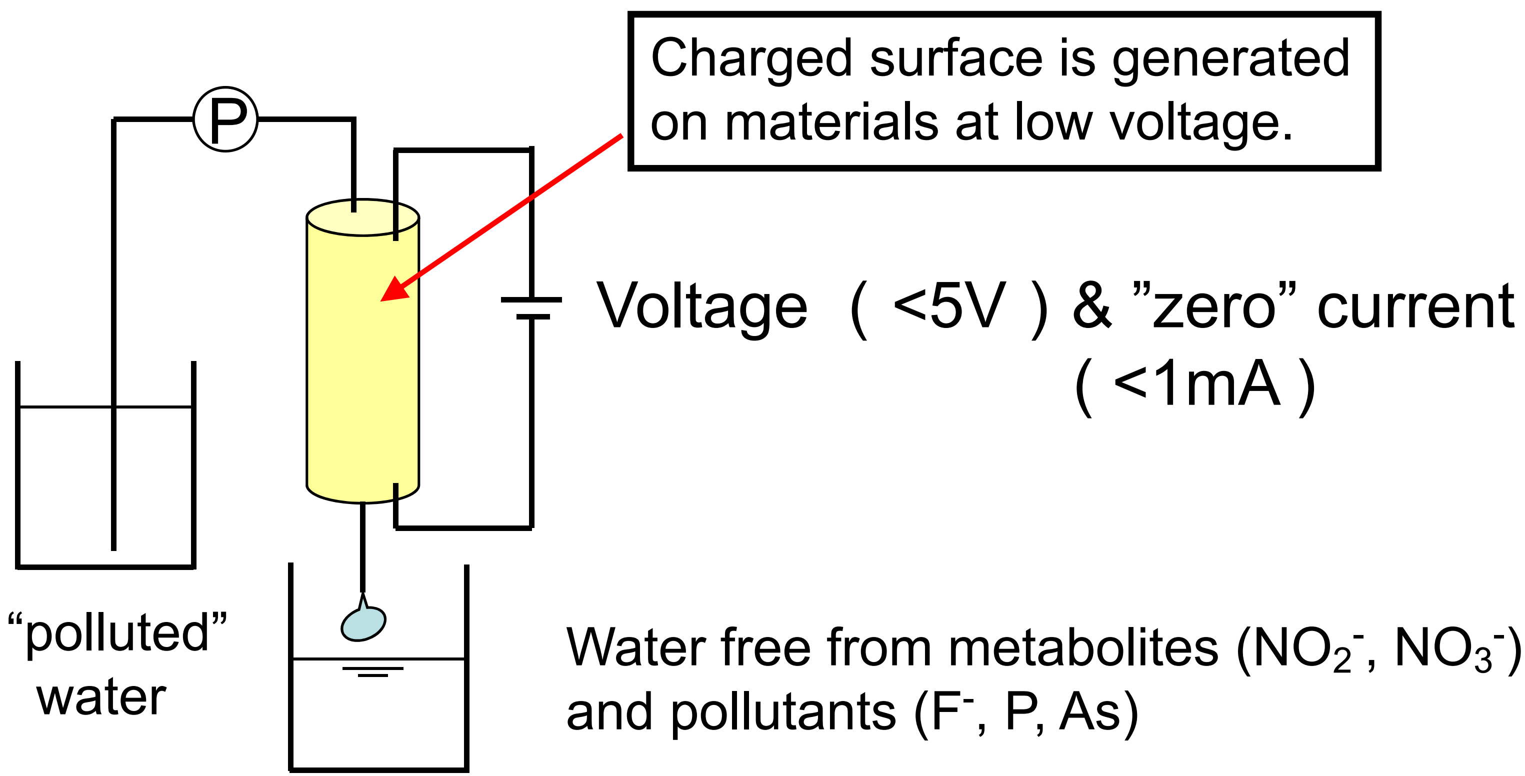
Conventional adsorption process



Cost-effective NOx decomposition process has not been known using conventional adsorption process and well-known materials such as activated carbon and ion exchange resin.

Effluent is not free from NO_2^- or NO_3^-.

Our simple device to generate metabolites-free water with minimal energy at ambient conditions: conceptual drawing



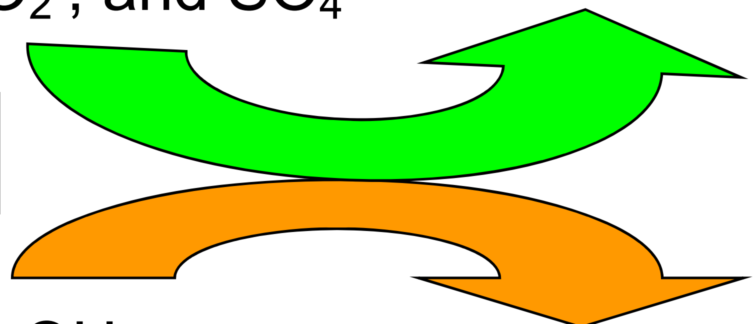
Notes: No use of organics, bacteria, NH_3, or H_2 as reductant of NO_x^-.

Postulated Mechanism for Decomposition of N and S Oxides

Feed containing H^+, NO_3^-, NO_2^-, and SO_4^{2-}

$N_2(\uparrow)$, S (fixed on materials)

at anode



H, OH^-

H_2O

Process at anode : dissociation of water and charge transfer

$$H_2O \Rightarrow H + OH \Rightarrow H^+ + OH^-$$

- $H + NO_3^-, NO_2^- \text{ or } SO_4^{2-} \Rightarrow N_2 \text{ or } S + H_2O + e^-$

  (decomposition of oxoanions)
- $OH^- + H^+ \Rightarrow H_2O$

  (neutralization of acidic water)

Treatment of goldfish bath water

Ions	Feed (ppm)	Feed 1.1L (ppm)	Feed 1.76L (ppm)
PO_4^{3-}	2.95	<0.01	2.39
Cl^-	23.5	97.0	48.5
NO_3^-	143	0.66	0.67
SO_4^{2-}	68.5	5.44	111
p H	3.84	6.90	6.77

Volume of reactor = 0.1L

Total volume of feed = 1.76L

Feeding time = 4 h

SV= 1.76L/4h/0.1L = 4.4

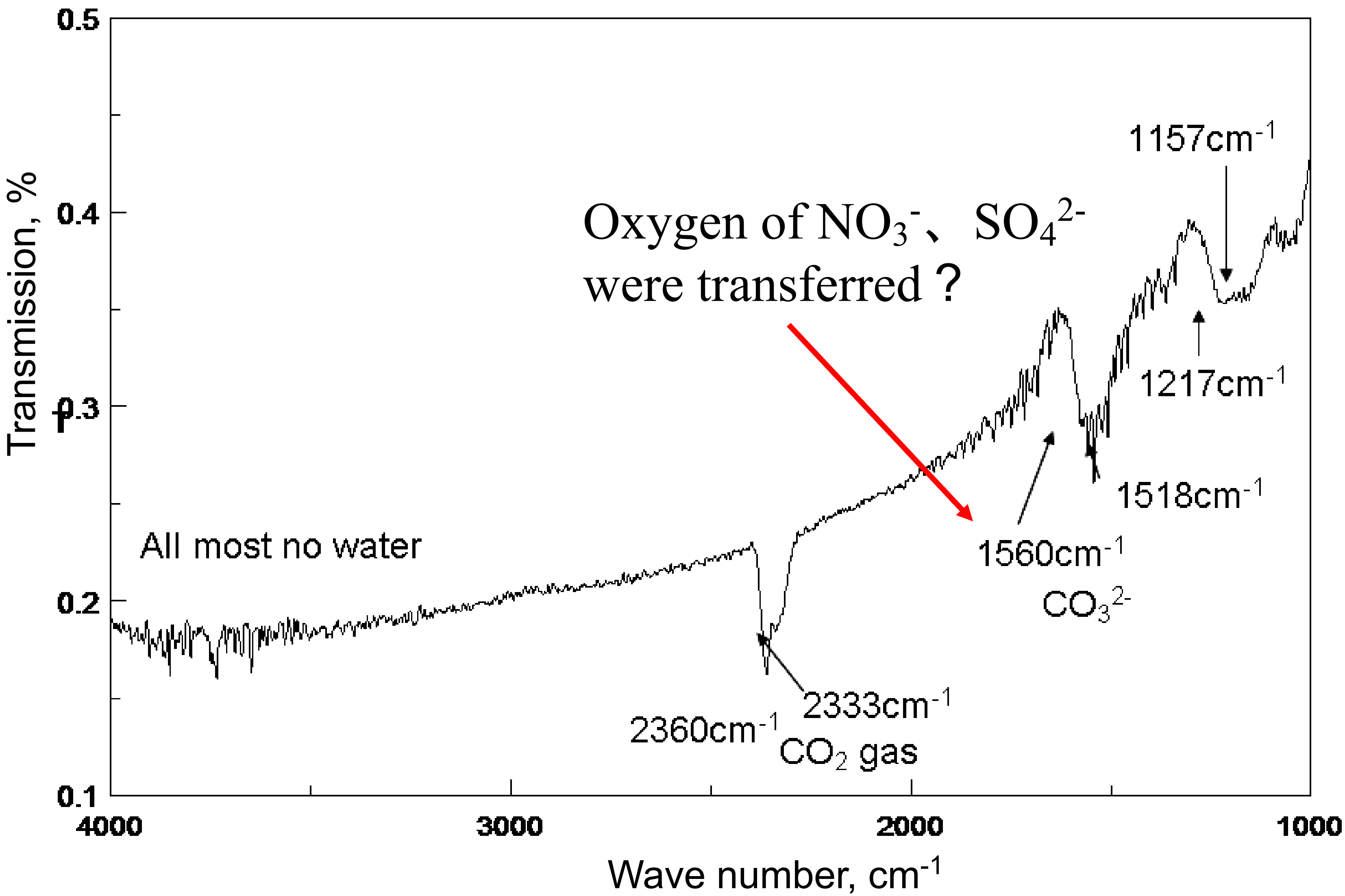
Materials balance of water treatment

Constituent	uptaken (mequiv.)	released (mequiv.)
SO_4^{2-}	1.11	-
HPO_4^{2-}	0.12	-
NO_3^-	4.04	-
Cl^-	-	2.71
Heavy metals	< 0.05	< 0.01
Total	5.27	2.71

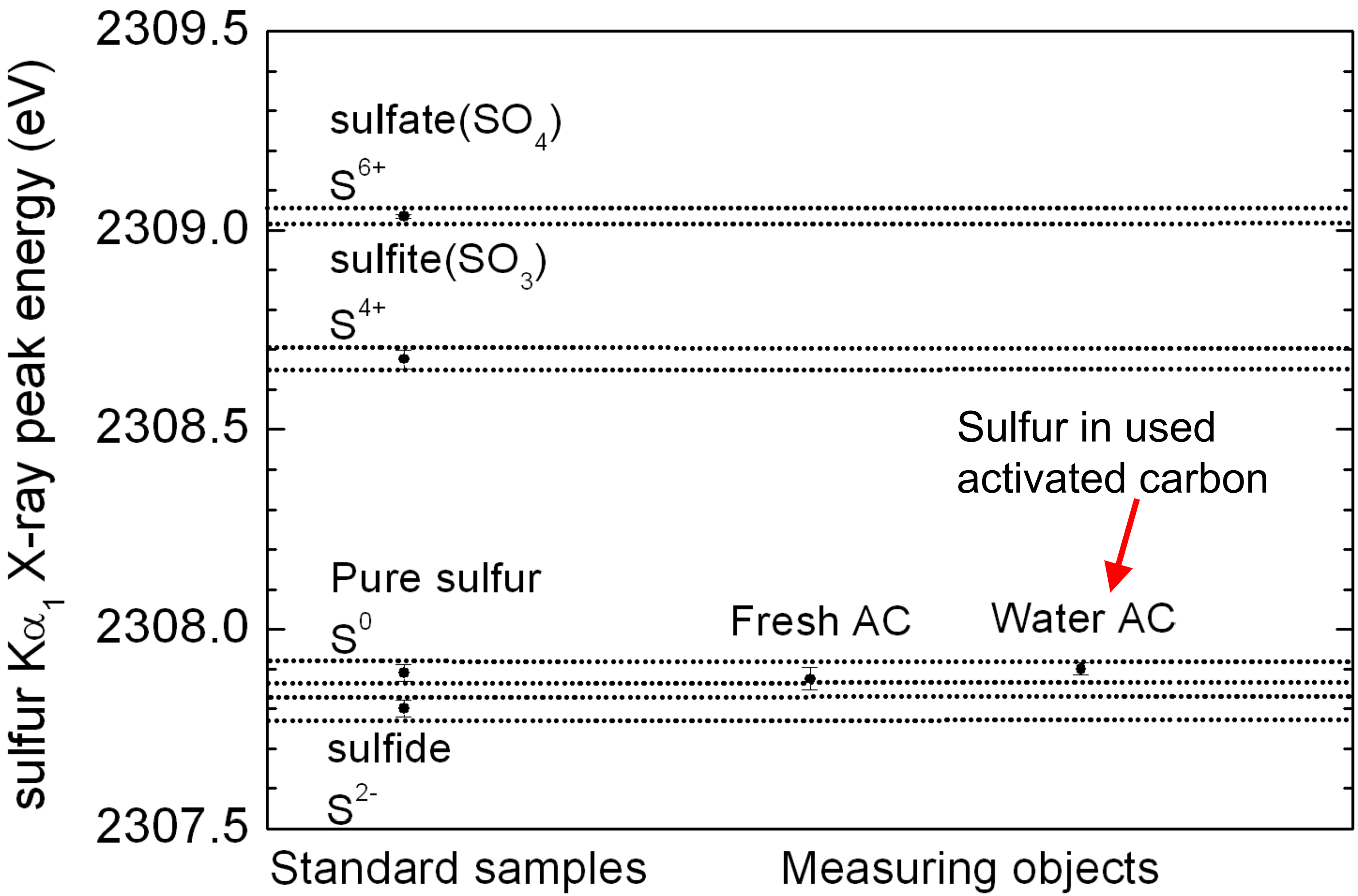
Totally different ⇒ not simple ion exchange

(Other anions (CO_3^{2-}, OH^-, H^+) may be involved in this treatment process. Open for study)

FTIR spectrum of material used at anode



Speciation of sulfur in activated carbon by wave-dispersed PIXE



Sulfate was reduced to elemental sulfur.

Conclusion (a)
Operational features

1. Contact time of water with material is very short (<10min).

2. Decomposition of nitrate/nitrite and sulfate is feasible without side reactions to form NH_3.

3. It works at room temperature and at normal pressure.

4. Driving energy is minimal.

Conclusion (b)
Requisite materials in this process

This innovative process does not require:

1. bacteria
2. organic fertilizer or chemicals
3. hydrogen gas

or

4. expensive noble metal-loaded catalysts

Conclusion (c)
Quality of treated water

1. Treatment lowers concentration of NO_3^- from 140ppm to 0.7ppm.
2. Mineral composition of treated water remains the same as before treatment.
3. NH_3 will be never admixed into treated water.
4. Device possesses large neutralization capacity. Acidic groundwater of pH 4 can be neutralized to 7.
5. All the treated water can be utilized.   Only 30-40% for conventional reverse osmosis separation method