Potentiostatic Anodization for Resource Recovery and Purification in Water

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01 Iron Oxide Nanotubes for Phosphate Recovery in Water.

02 Photocatalytic Metal Membrane with Self-organized Reactive TiO_2 Nanotubes.

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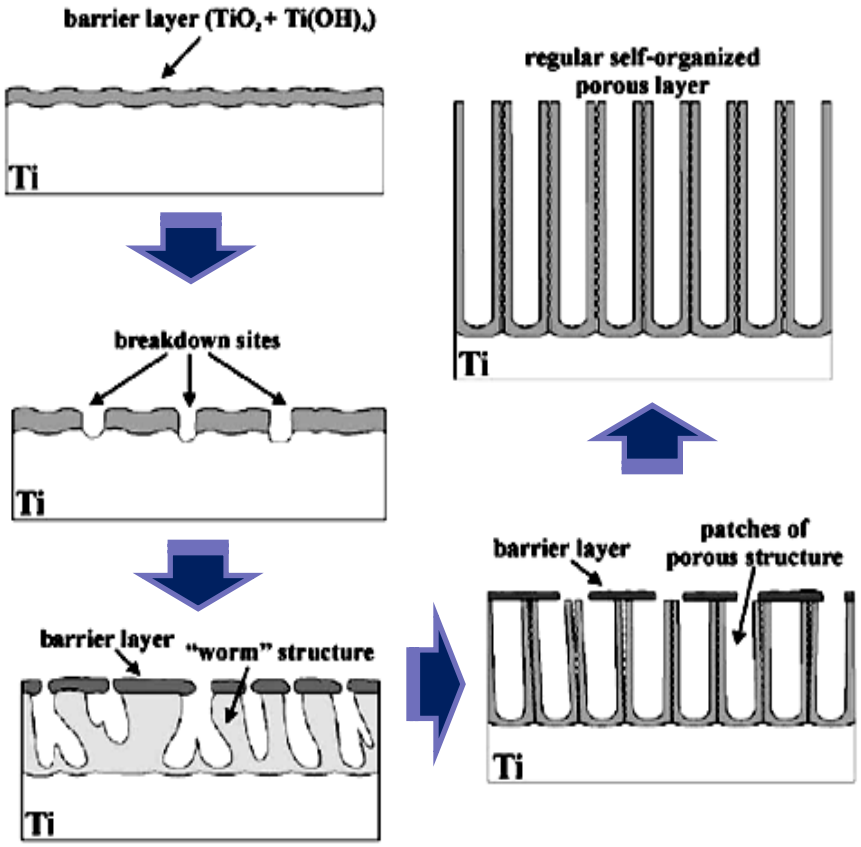
Anodization

- Useful method for modifying the surface structure to obtain nanoporous array.
- The surface of valve metal is instantaneously covered with a native oxide film when these metals are exposed to oxygen containing environment.

Nanotube Formation



- High surface area.
- Short solid-state diffusion path for catalysis and energy application.
- Fabrications are simple and cost effective.

Iron Oxide Nanotubes for Phosphate Recovery in Water

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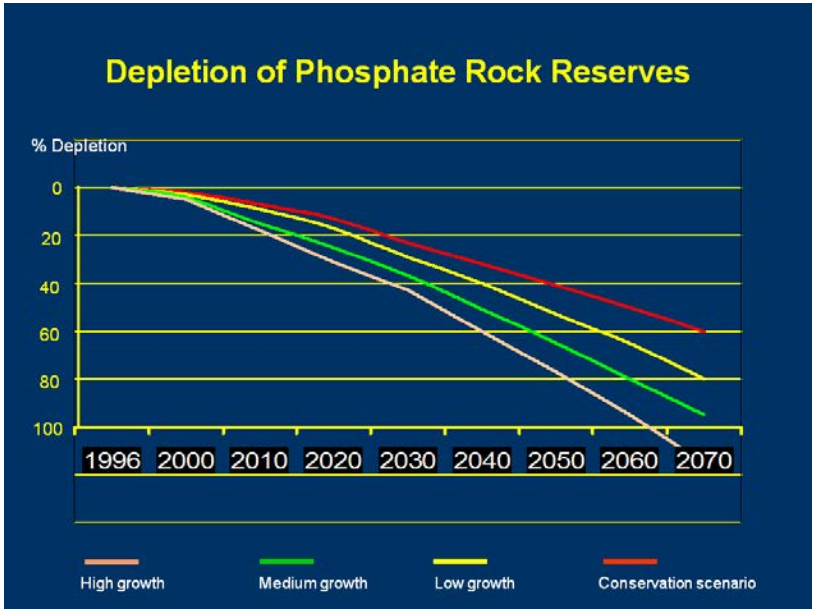
Phosphorus

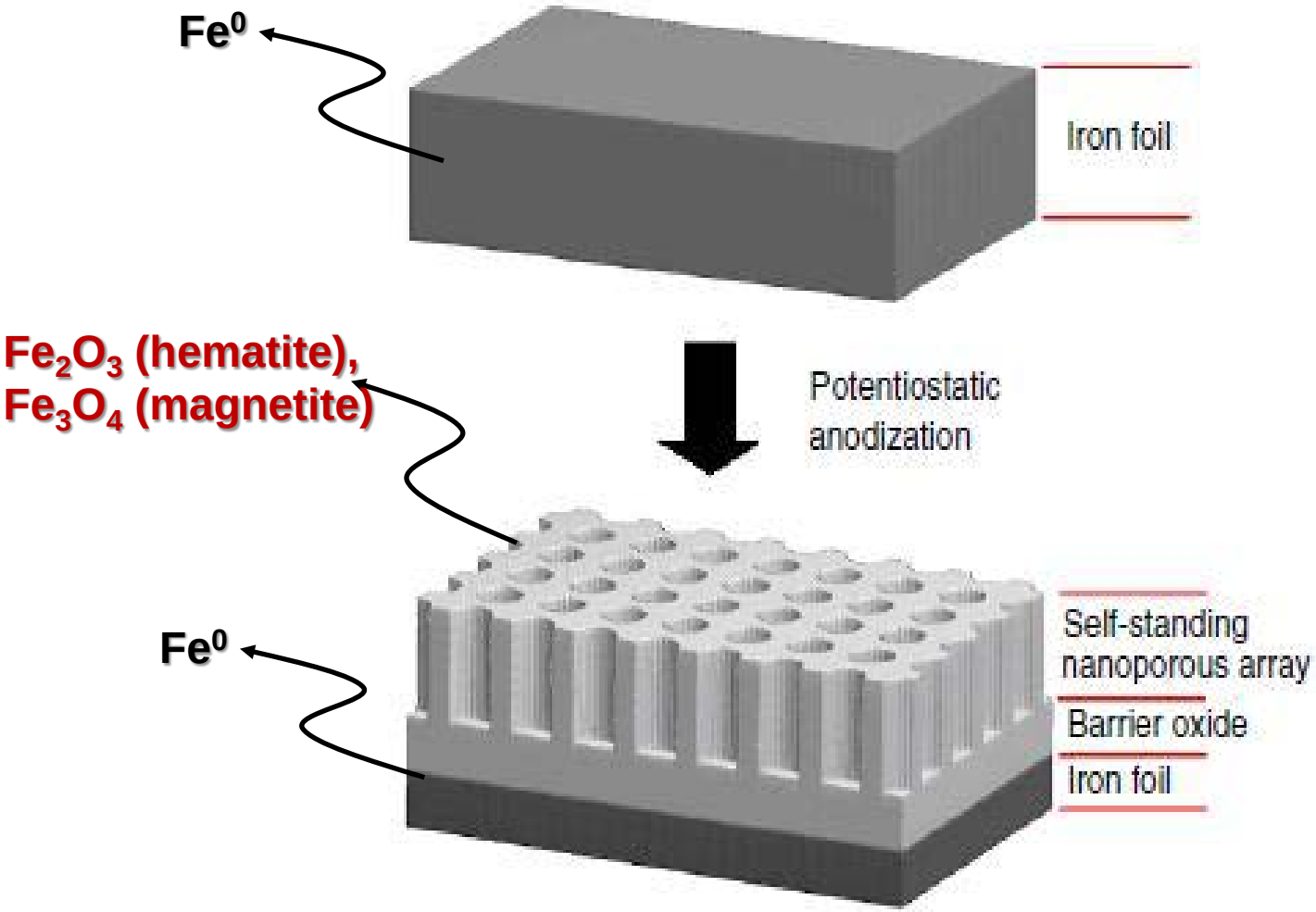


Dees Lijmbach (Chris Thornton)
"Phosphate removl and phosphate recovery:
towards sustainable development" COPPERAS-November 2000

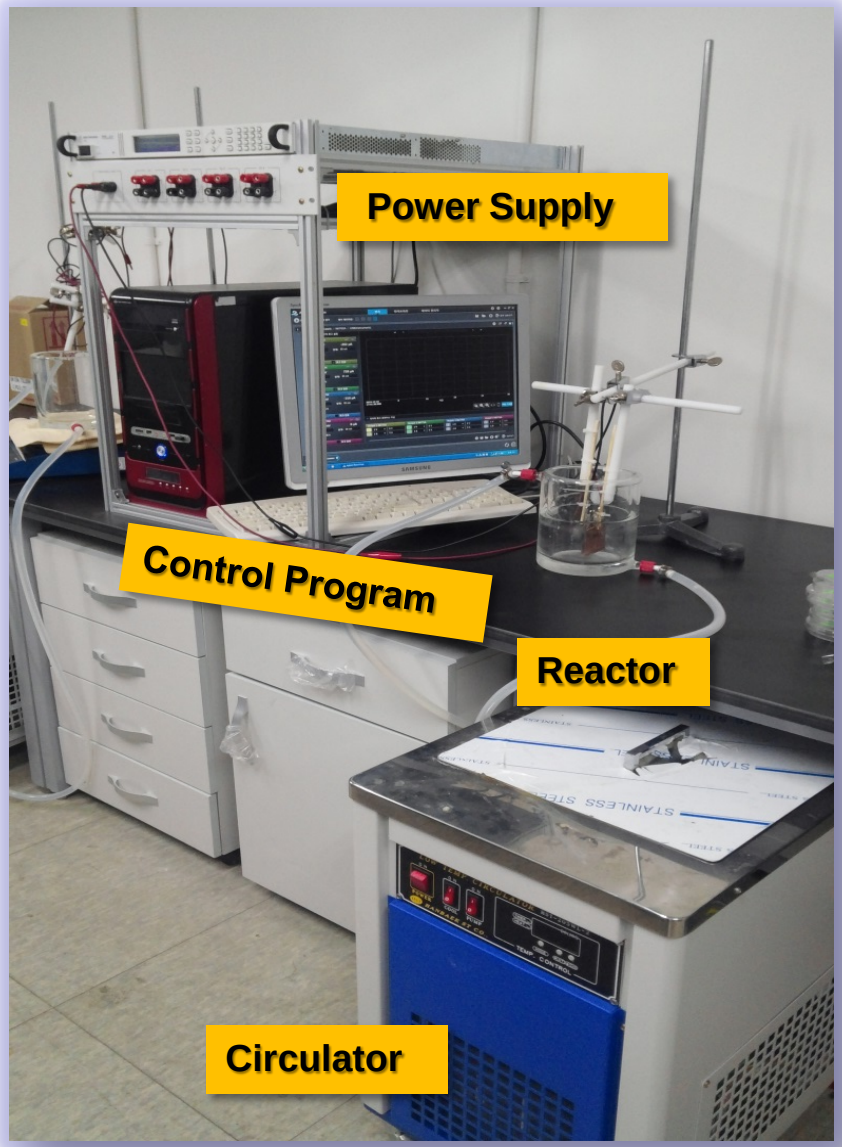
Others: Lithium Ion Battery, Developer, Ceramics, Cosmetics, Cement, Artificial teeth *etc*.

- Phosphorus is an essential component for food production and industrial growth.
- The global supply of this non-renewable resource is limited.
- Most researches were focused on the removal not recovery.
- Recovered phosphate can be reused at various demands.

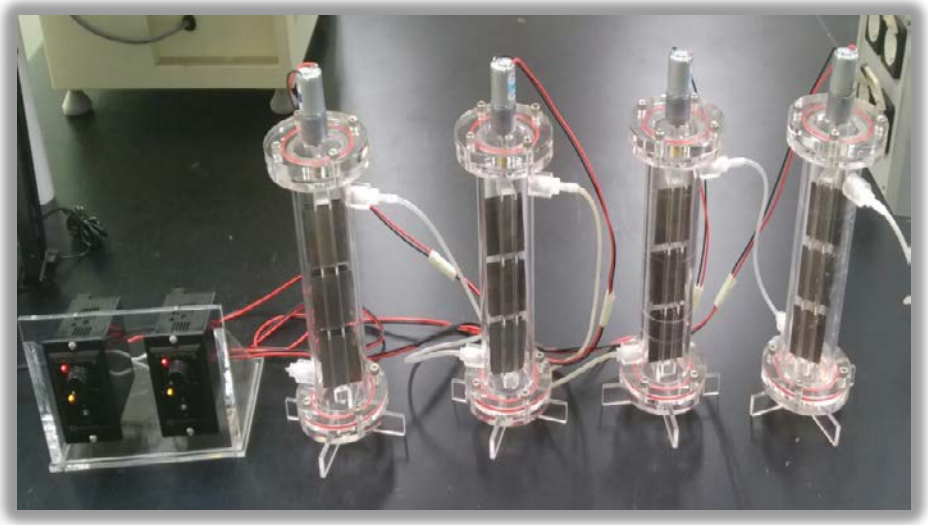
Schematic diagram of Iron Oxide Nanotubes



An anodization apparatus



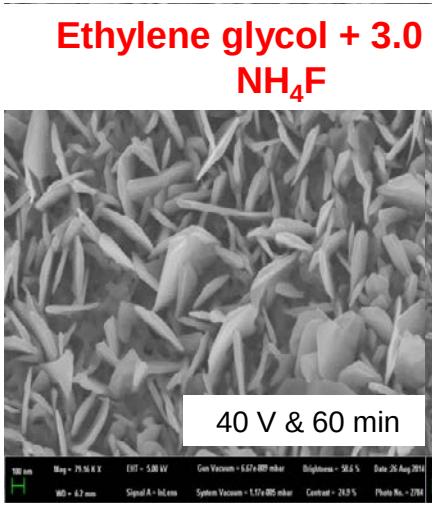
A lab-scale column for continuous adsorption

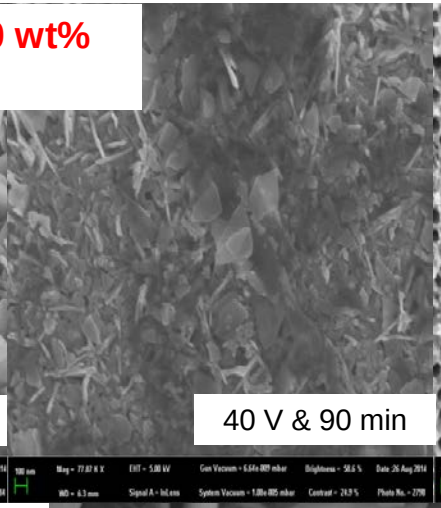


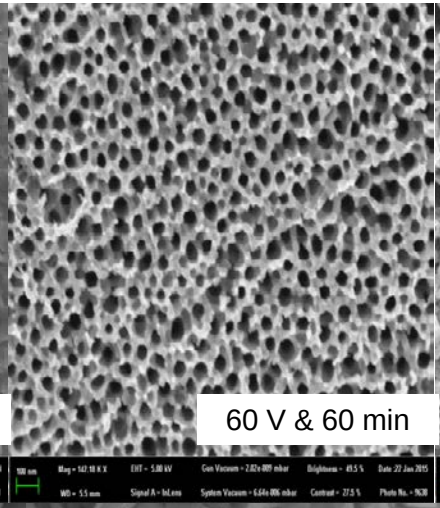
Device for desorption

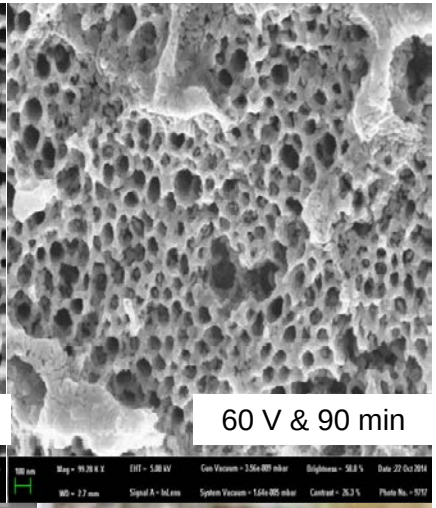
FE-SEM images of INTs

Ethylene glycol + 3.0 wt% NH_4F

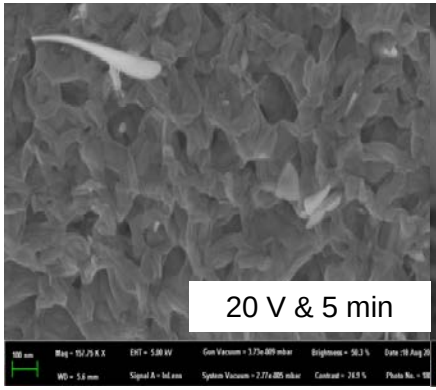


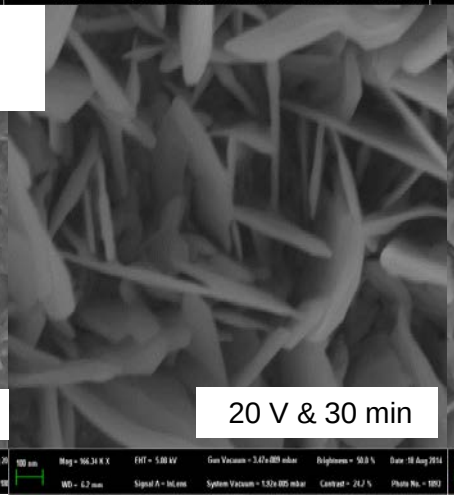


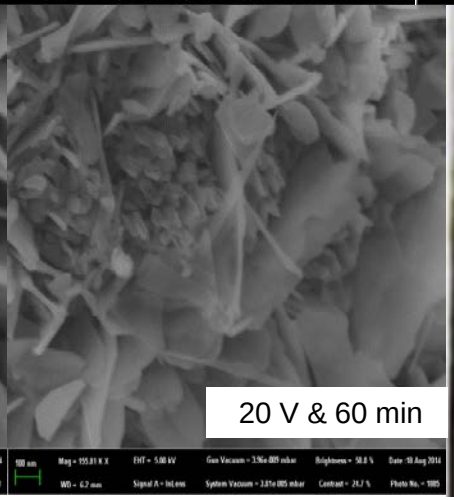


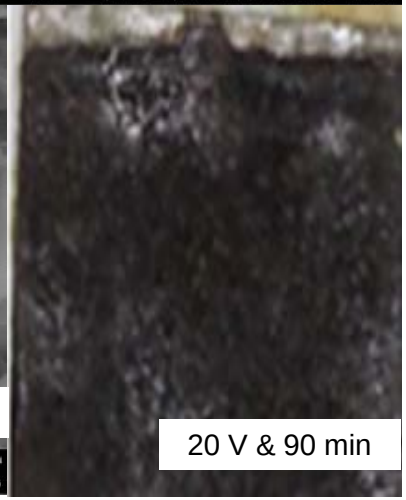


1M Na_2SO_4 + 0.5 wt% NH_4F



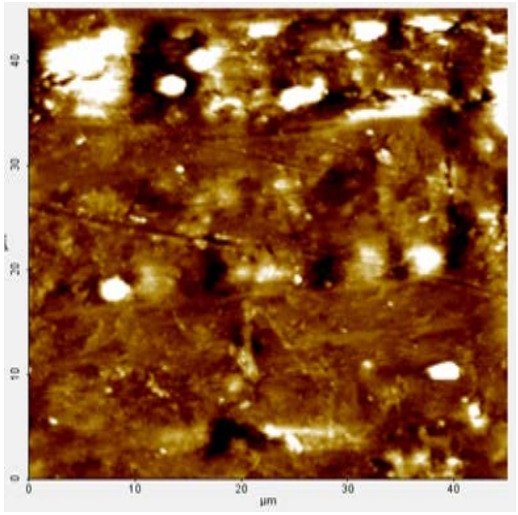


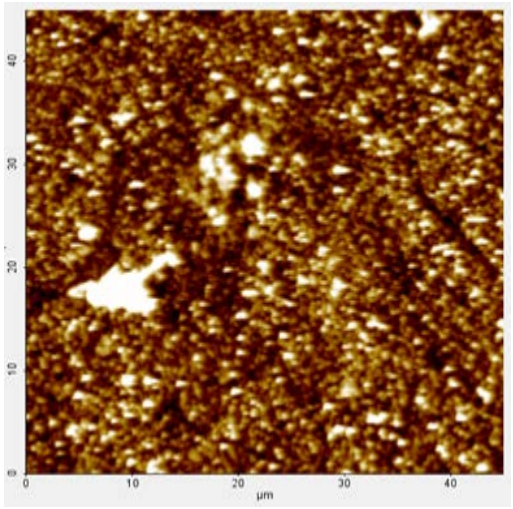




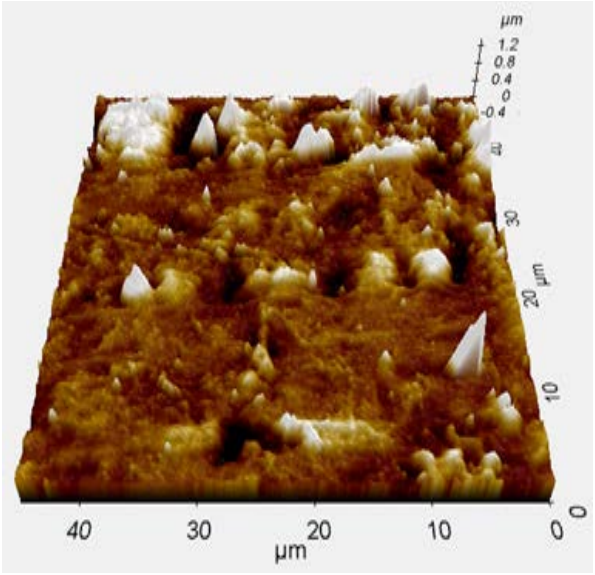
AFM 2D and 3D images

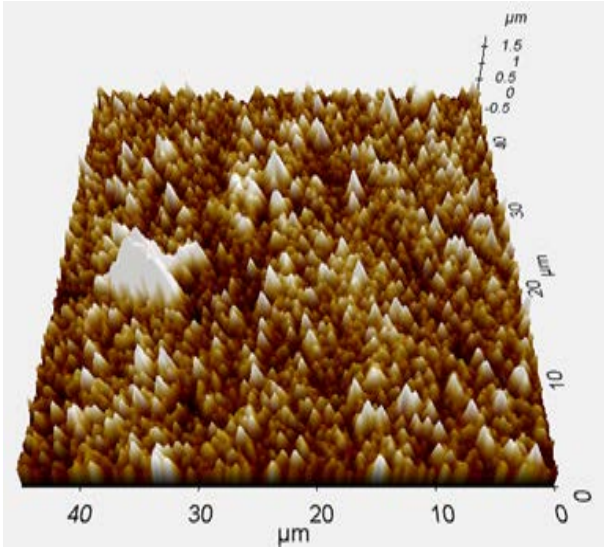
2D





3D

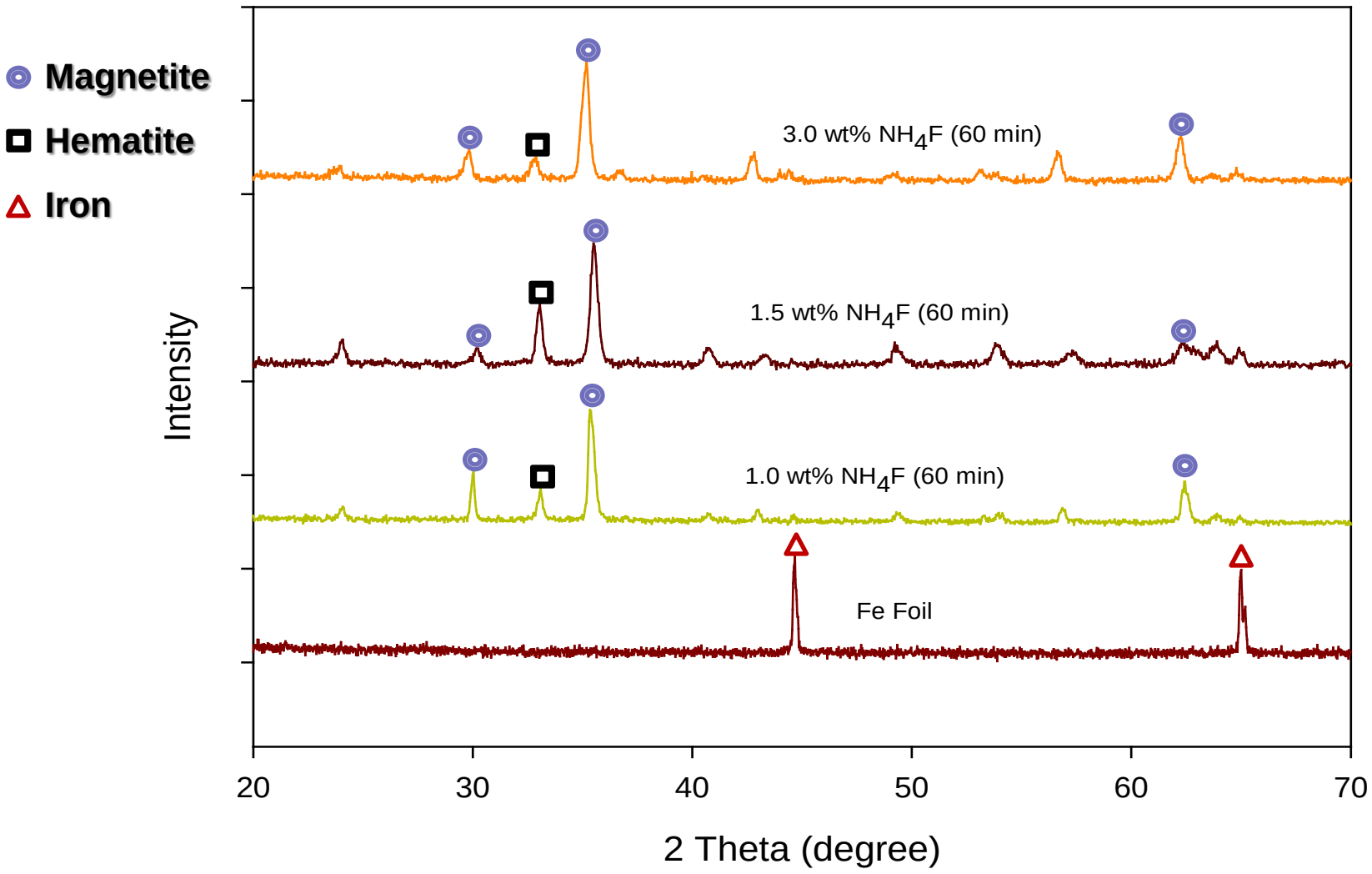




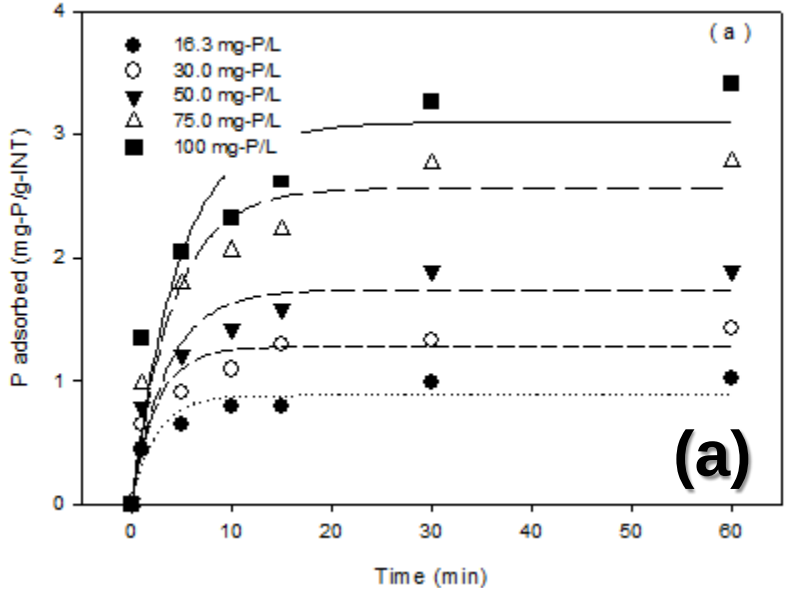
(a) Fe foil

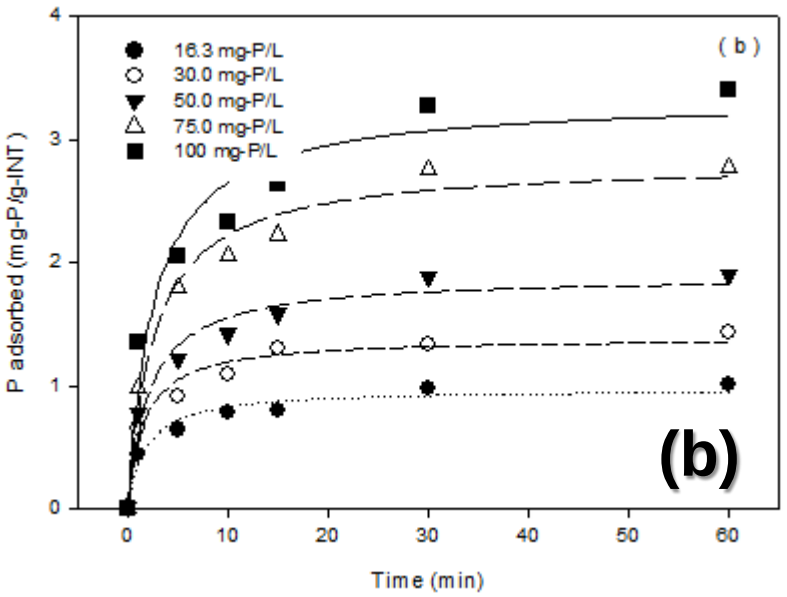
(b) INTs

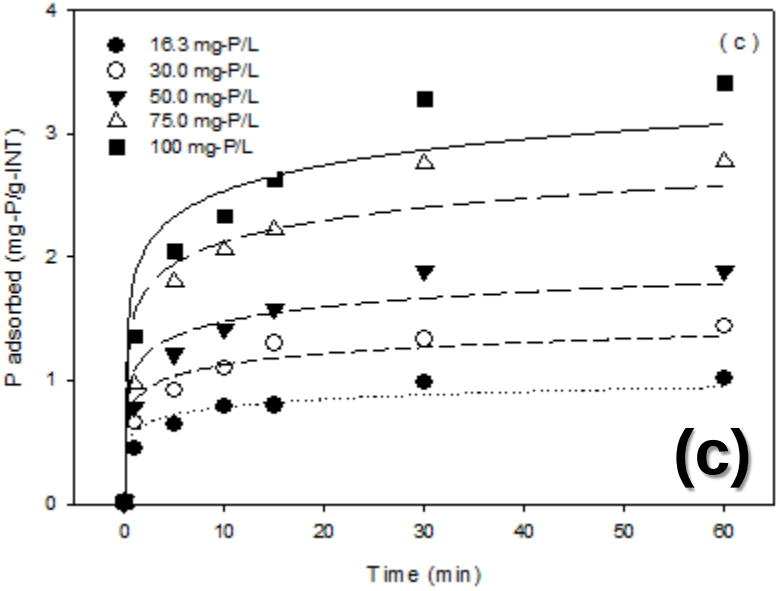
XRD pattern


Magnetite
Hematite
Iron
3.0 wt% NH4F (60 min)
1.5 wt% NH4F (60 min)
1.0 wt% NH4F (60 min)
Fe Foil
Intensity
20
30
40
50
60
70
2 Theta (degree)

Kinetic Model Analyses for Adsorption





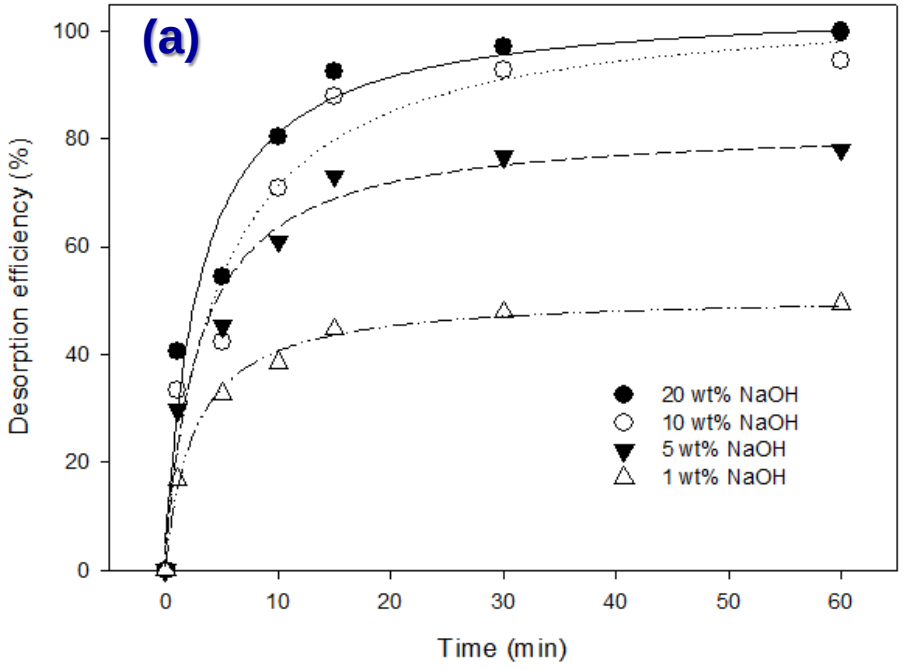


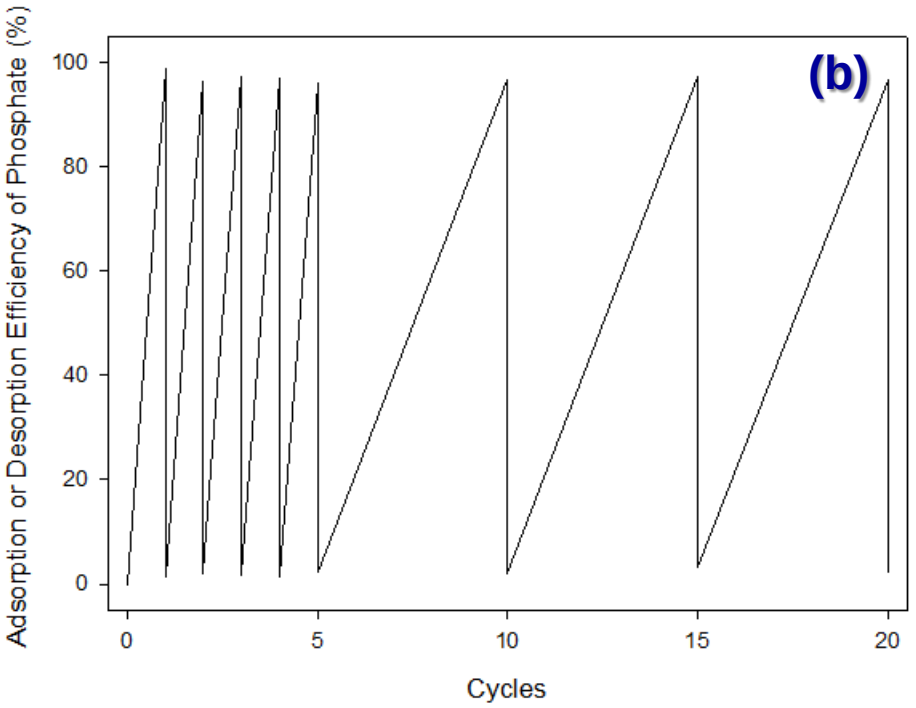
(a) Pseudo first-order model

(b) Pseudo second-order model

(c) Elovich model

Desorption and Reusability



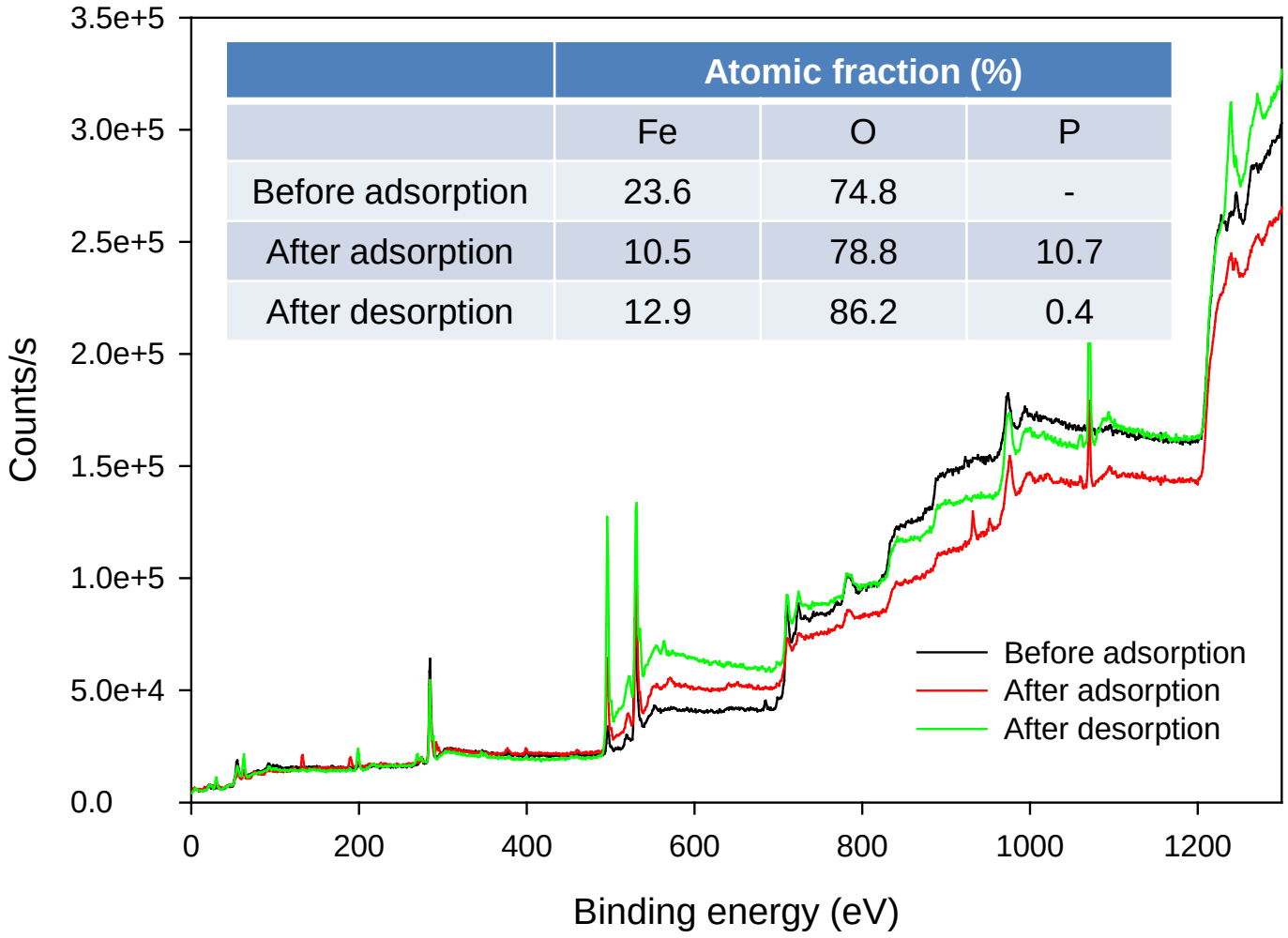


(a) Desorption efficiency of phosphate-adsorbed INTs depending on various concentrations of NaOH.

(b) Repeated adsorption and desorption for reusability.

X-ray Photoelectron Spectroscopy (XPS) of INTs

	Atomic fraction (%)		
	Fe	O	P
Before adsorption	23.6	74.8	-
After adsorption	10.5	78.8	10.7
After desorption	12.9	86.2	0.4



Photocatalytic Metal Membrane with Self-Organized Reactive TiO_2 Nanotubes.

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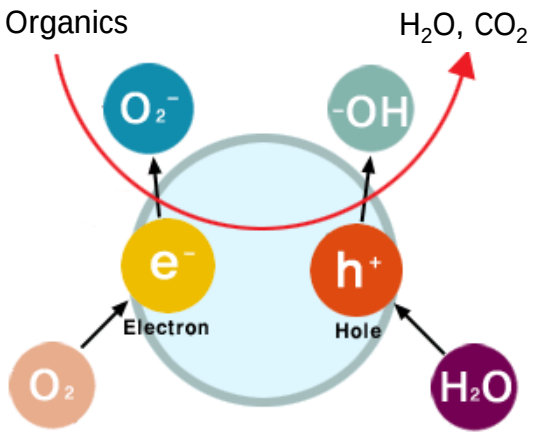
TiO_2

- Water and wastewater treatment systems using TiO_2 photocatalytic reaction have been widely developed.

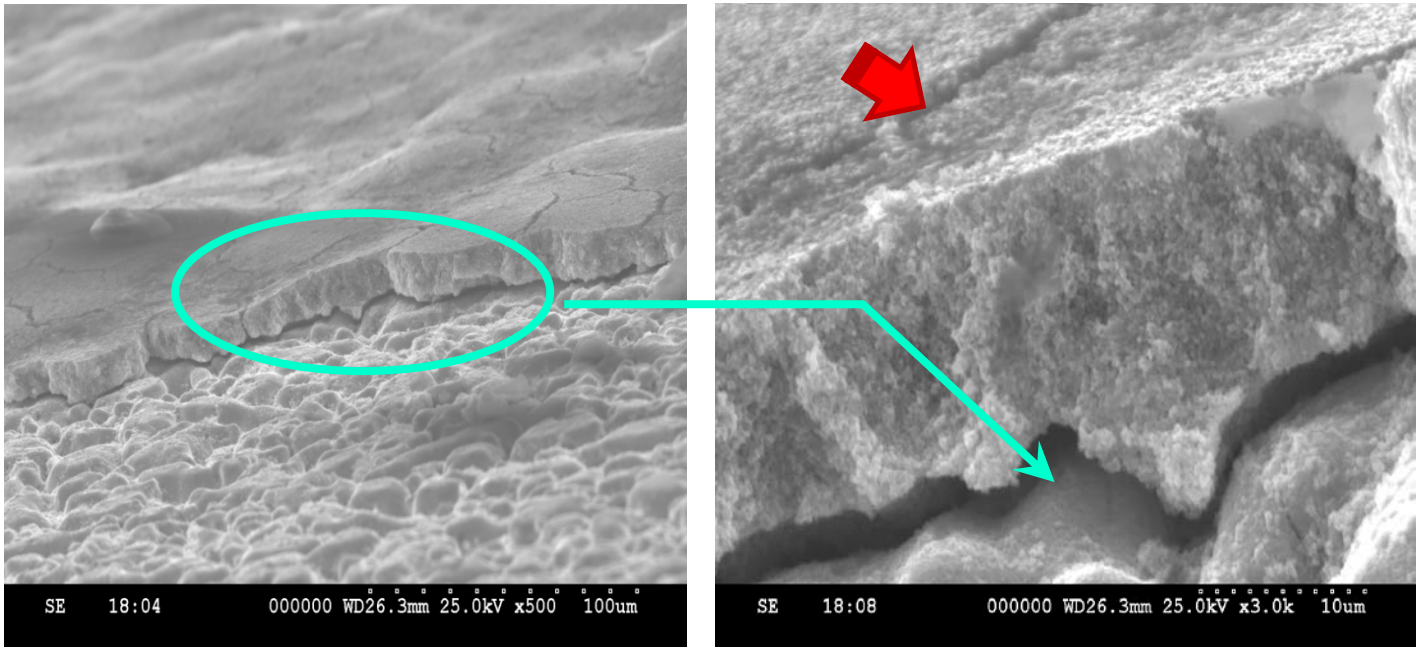
  - High oxidation-reduction potential for refractory organics decomposition.
  - Reduction of excess sludge.
  - Low cost & Non-toxic.



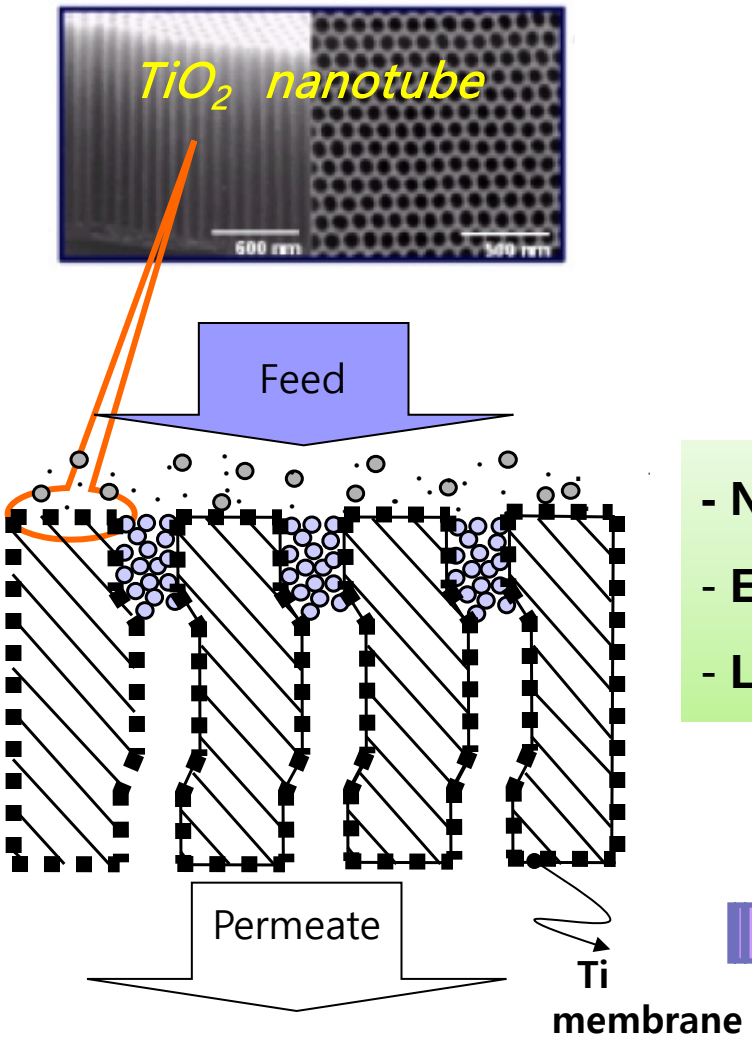
- Problem : Separation between TiO_2 particles and purified water.

  - Requires post-TiO_2 particles recovery process.
  - Causes engineering difficulties in automatic operation.

- Although several immobilization methods were tried to improve the treatment performance, there are not satisfied aspects due to TiO_2 particle exfoliation and activity decrease in long-term operation.



Characteristics of proposed technology



Ti membrane

anodization

Nanostructured photocatalytic TiO_2 membrane

- No requirement of catalyst separation process
- Enhancement of adsorption
- Long retention time for photocatalytic reaction

Minimize membrane fouling & Maximize degradation efficiency of contaminants

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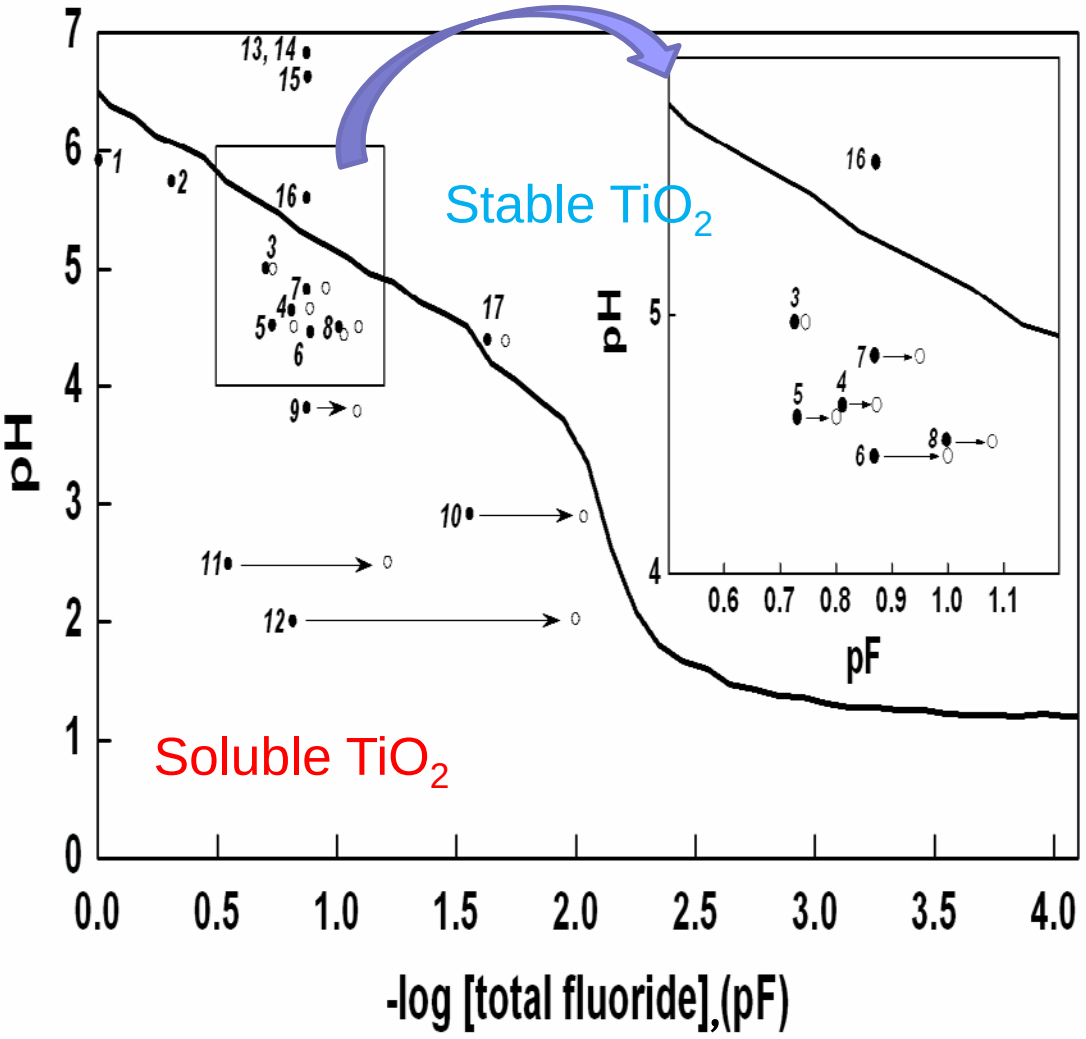
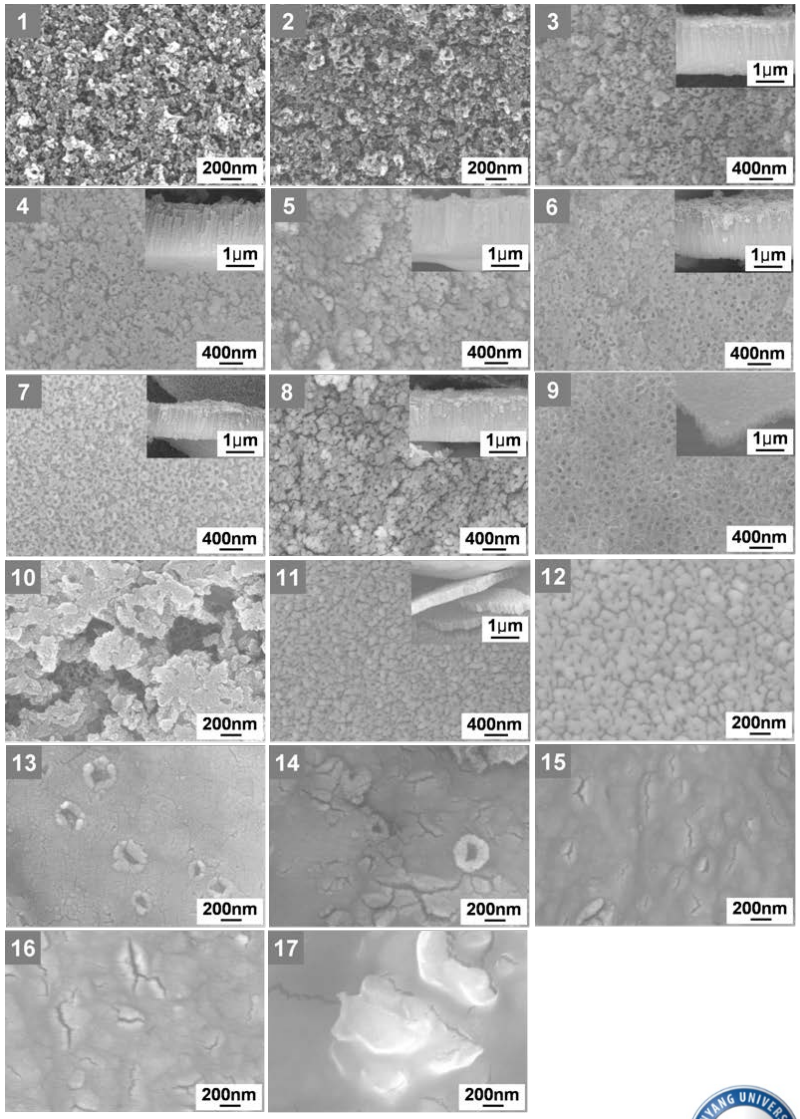
FE-SEM images





pH vs. pF curve in various electrolyte

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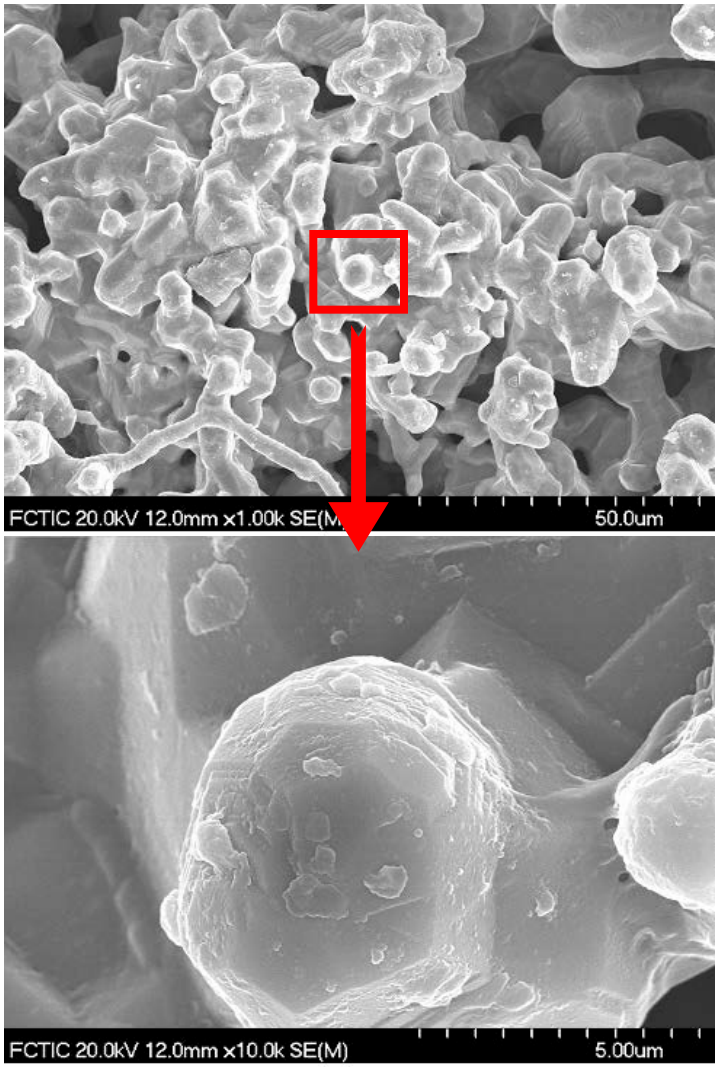
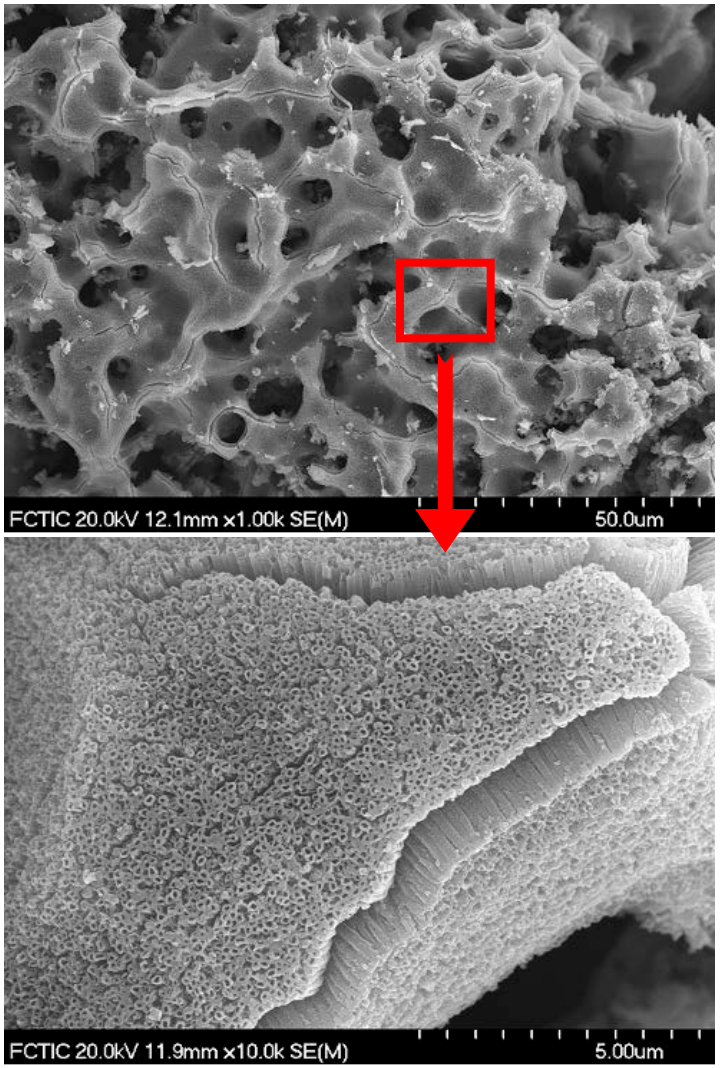
L 150 mm
D 15 mm

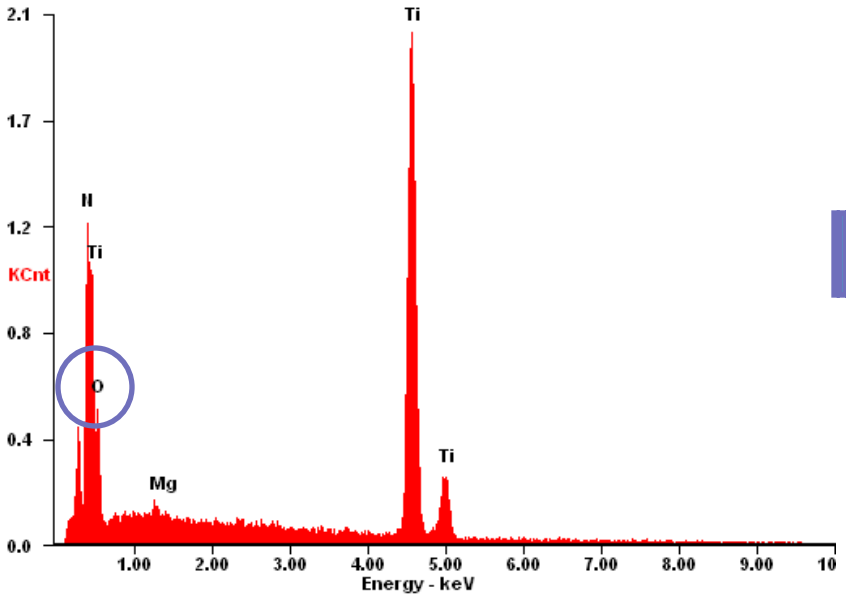
Before anodization



After anodization

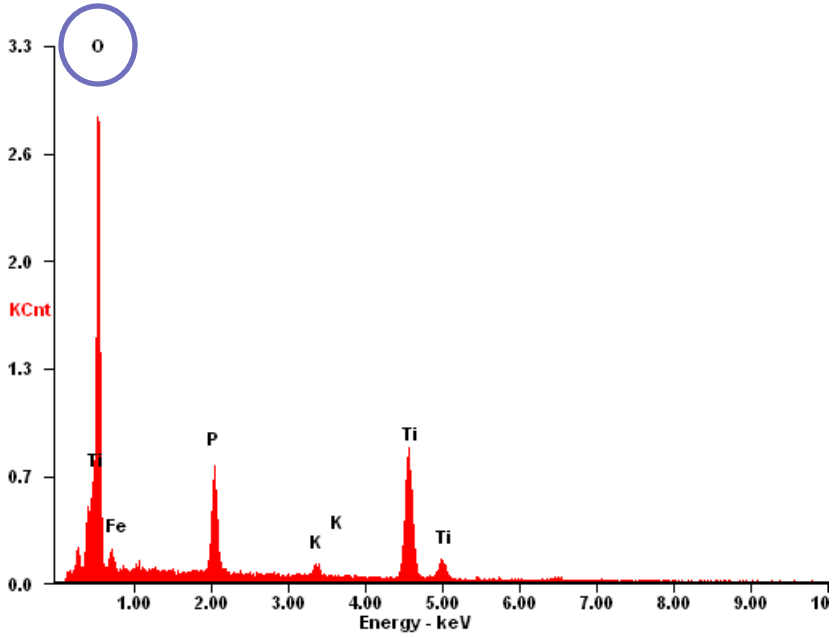


Energy Dispersive X-ray spectroscopy (EDX)



Pure Ti membrane

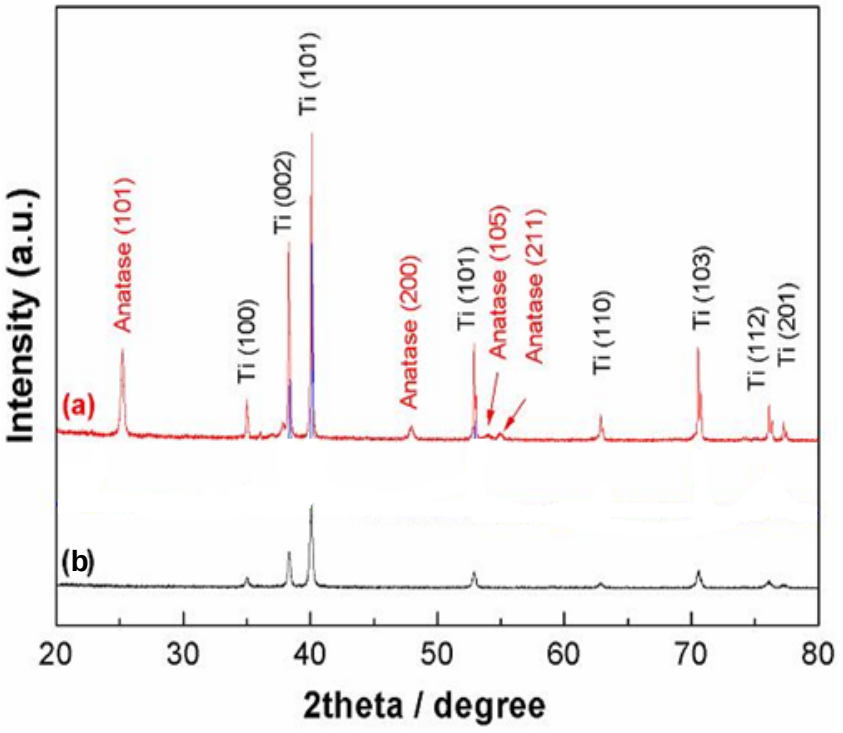
Oxygen content 9 wt%



TiO_2 membrane embedded with nano tube

Oxygen content 41 wt%

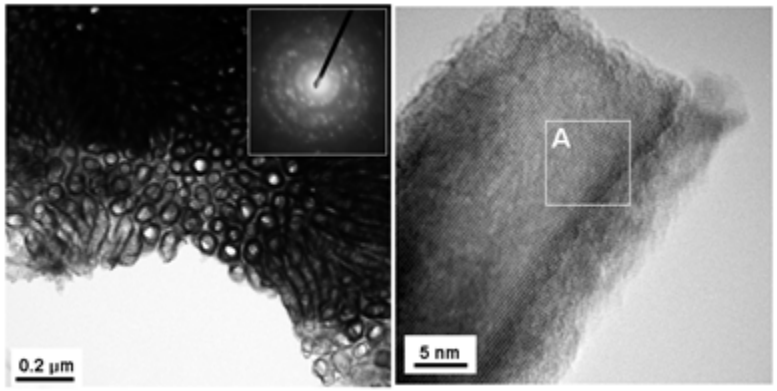
X-ray diffraction (XRD) patterns



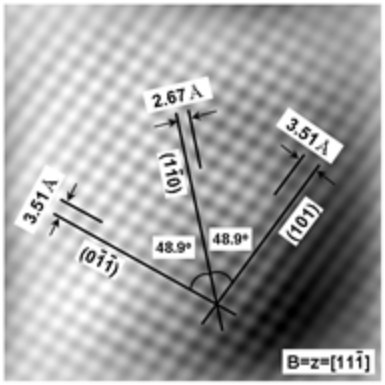
(a) Anodization and annealing

(b) Untreated Ti membrane

TEM analysis



(a) cross section (b) a part of nano tube



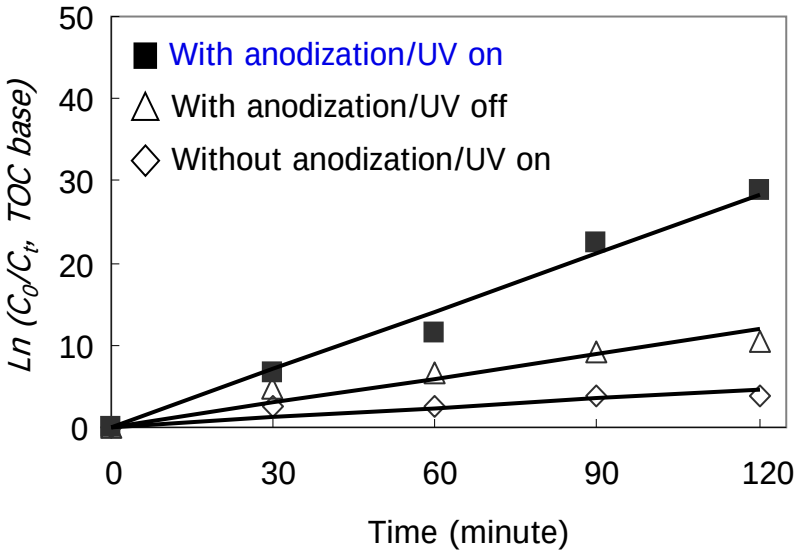
(c) Crystal fringe distance

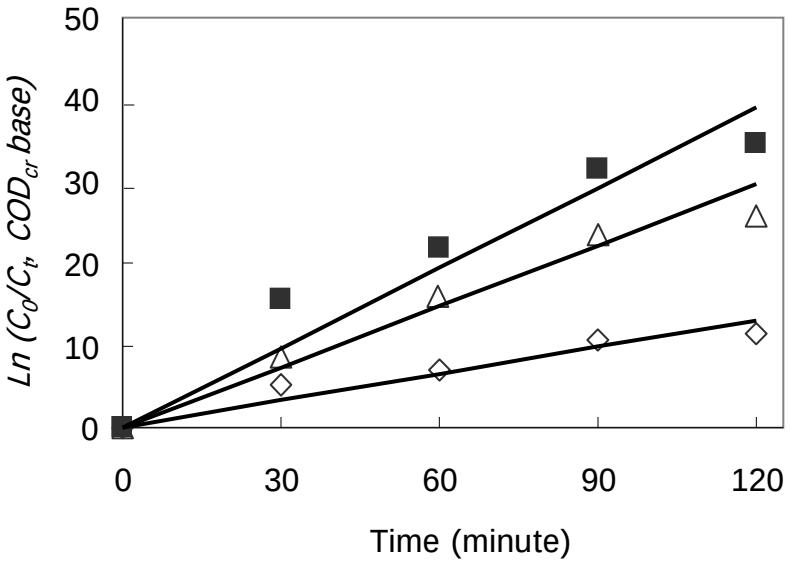
Crystal fringe distance

: 3.51 Å corresponding to spacing of (101) of the anatase phase TiO_2

Photocatalytic activities

Organics removal



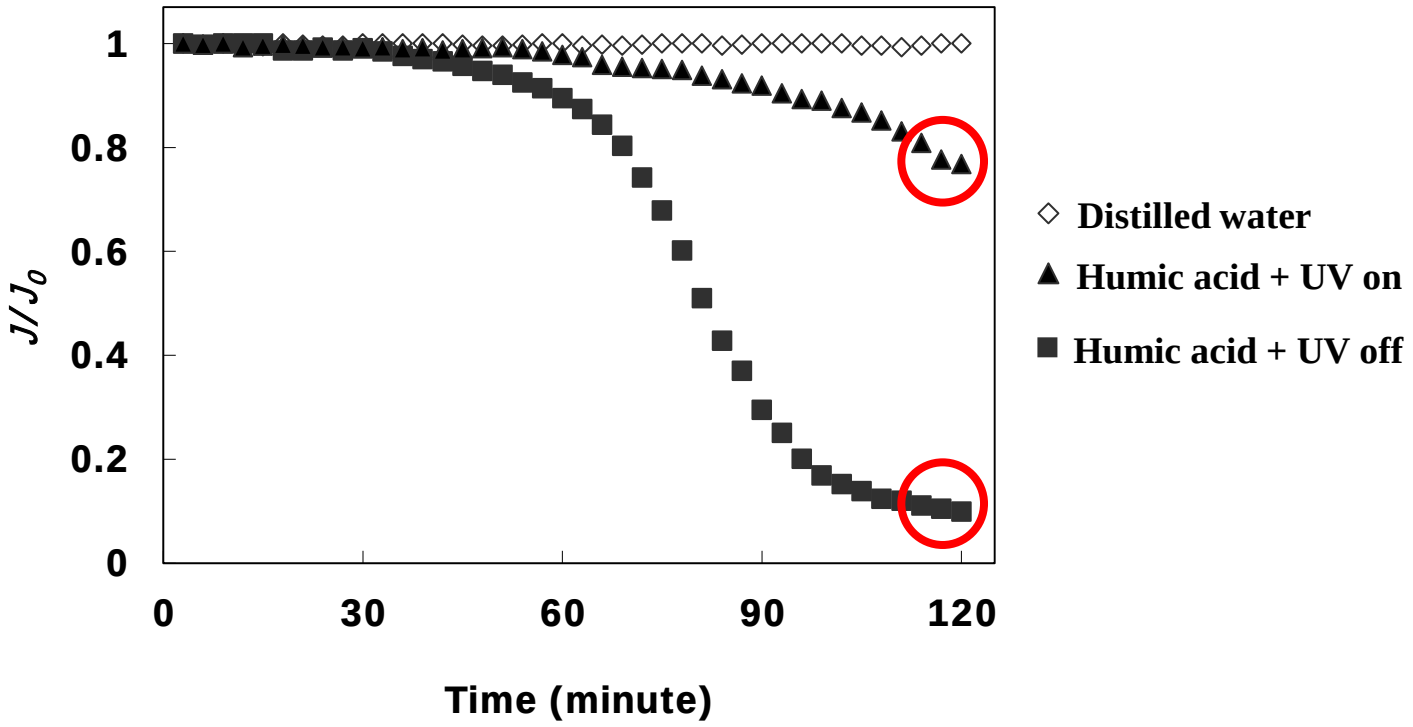


Rate constants :

TiO_2 membrane with UV > TiO_2 membrane without UV

> without anodization with UV .

Permeation flux ratio (J/J_0) of anodized TiO_2 metal membrane

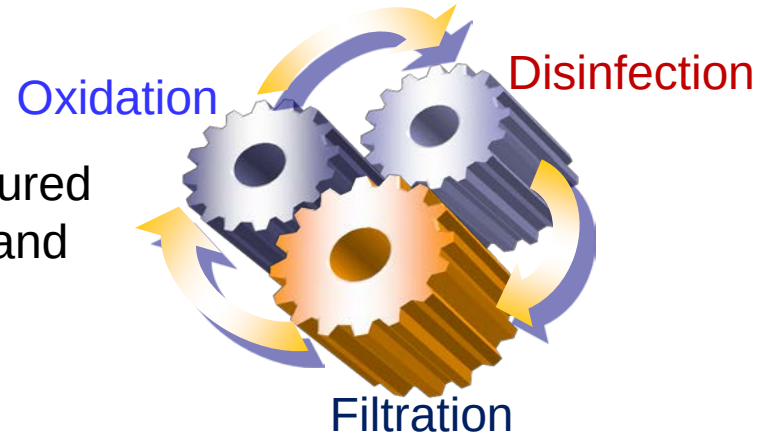


Permeation flux ratio with UV-on showed about 8 times higher value than that of UV-off at 2 hrs filtration.

Conclusion

- The use of nanomaterials in water and wastewater treatment has attracted a growing amount of attention due to the excellent electrical, magnetic, and catalytic properties of nanomaterials.

- In phosphate recovery, INTs are useful to recover phosphates in wastewater because additional collection of adsorbents is unnecessary and industrial byproducts can be used as raw materials to prepare INTs.



- Anodization enabled the fabricated nano-structured TiO_2 metal filter with dual functions of filtration and oxidation, at the same time.

- With this new technology combined with NT and ET, we are hoping for a marked improvement on phosphate recovery and treatment efficiency compared to the conventional methods.

Acknowledgements

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