

SPEC902a

Matériaux pour la dépollution

4.5 h Course/Discussion

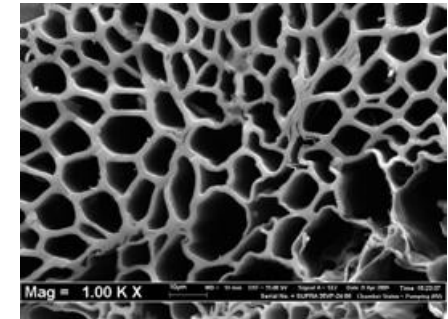
**Knowledge required : SYNT802 & SYNT902
(Materials Chemistry)**

Families of materials for depollution

➤ Different families : carbonaceous materials, (organic)polymers, inorganic materials

• Carbonaceous materials

- Activated carbons (powders, pellets, tissues) : C (S, N, P, O...)
- Functionalised carbon based materials
(introduction of specific functional groups on the surface)
- Activated carbons with supported metals (catalytical properties)
- Carbons obtained by replication of three-dimensional aluminosilicates (hierarchical porosity)



SEM image of an activated carbon

• Polymer materials

- Synthetic resins : styrene/divinylbenzene copolymers, polystyrene
 - cation exchange resin: anionic surface groups : $-\text{SO}_3^-$, $-\text{CO}_2^-$, $-\text{PO}_3^{2-}$...
 - anion exchange resin: cationic surface groups : $-\text{NR}_3^+$, $-\text{NH}_2$, $-\text{NHR}$...
- Biopolymers and polymers prepared from natural resources
(Functionalised cellulose, chitosan, alginate ... $\Rightarrow$ adsorption of heavy metals)



styrene/divinylbenzene copolymer resin

Families of materials for depollution

• Oxides and related materials

→ Dense oxides (non porous micro or nanometric Al_2O_3 , SiO_2 , TiO_2 for photocatalysis)

→ Oxyhydroxides ($\text{AlO}(\text{OH})$, $\text{FeO}(\text{OH})$: arsenate capture : AsO_4^{3-})

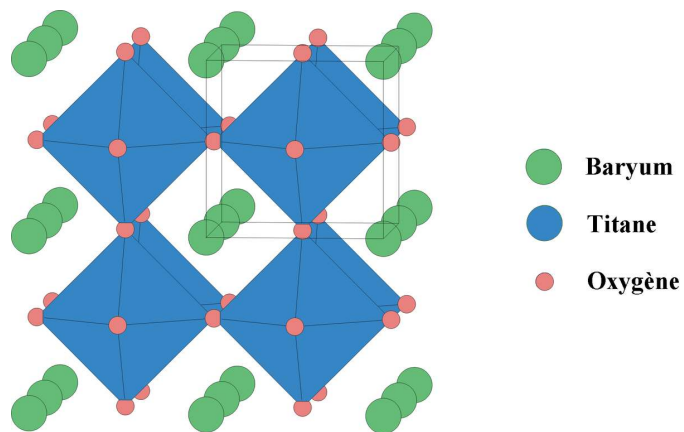
→ Mixte Oxides of perovskite structure ($\text{A}^{\text{II}}\text{B}^{\text{IV}}\text{O}_3$: catalytic decomposition of NO_x)

→ Clays (Si, Al, O, layered compounds)

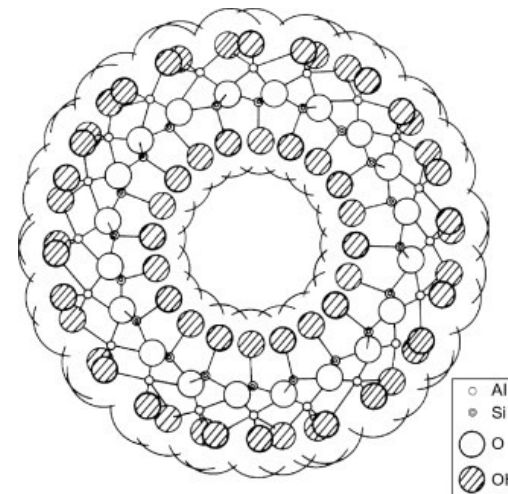
→ Allophanes (Si, Al, O, hollow porous spheres)

→ Zeolites (Si, Al, O, three-dimensional hierarchical porosity, microporous material)

→ Mesoporous solids (SiO_2 , Al_2O_3 , TiO_2)



BaTiO_3 perovskite



Allophane
(imogolite)

Families of materials for depollution

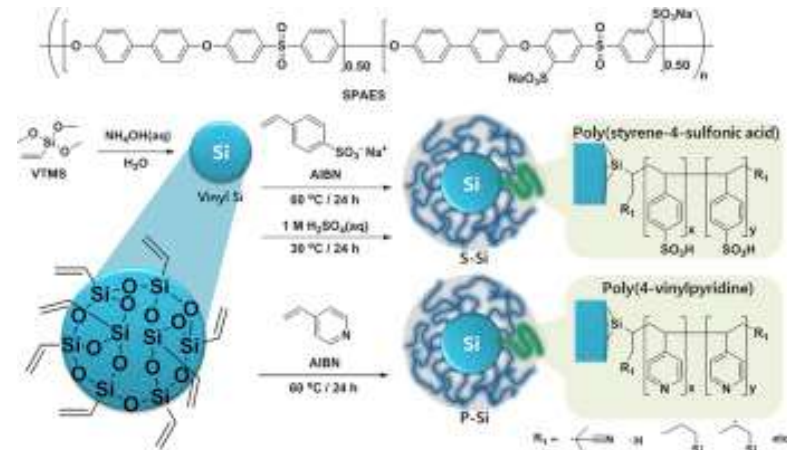
• Oxides and related materials

- **Monoliths** (dense ceramics with honeycomb porosity: catalytic oxidation of NO_x for automotive exhaust gas pollution control)
- **Oxides (zeolites, mesoporous) with supported metals** (Pt, Pd, Rh, Co) : catalysis
- **Hybrid organic – inorganic materials = grafted oxides**
grafting of molecules possessing specific surface groups ⇒ Combination of organic/inorganic properties



DDR membrane element

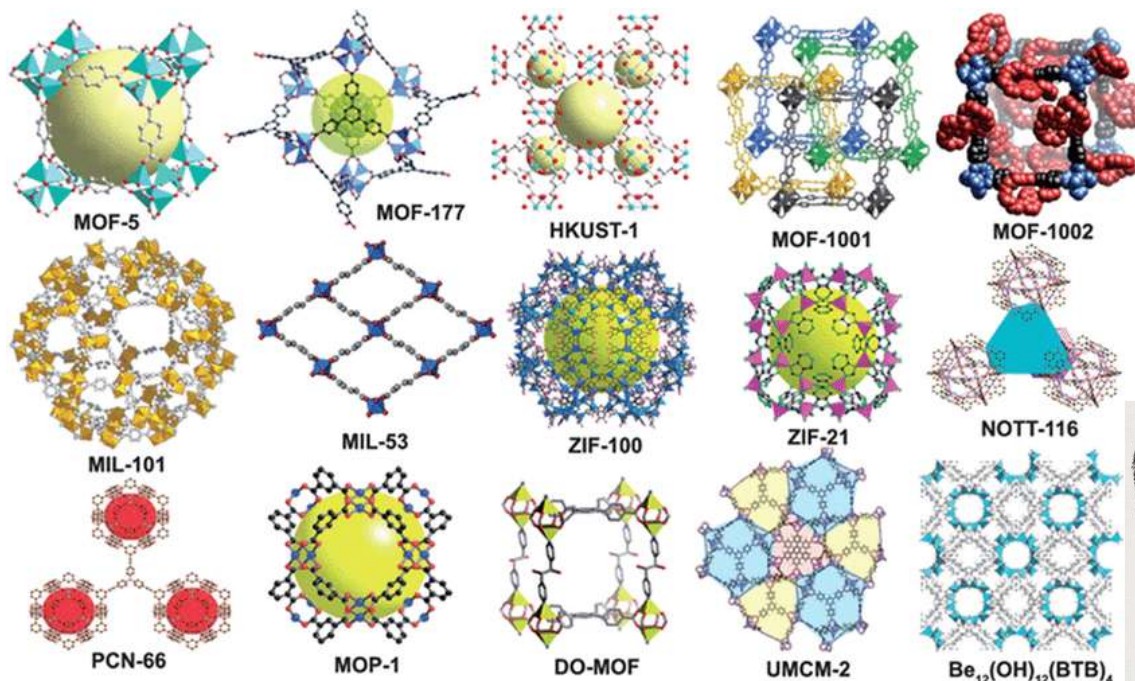
Deca-Dodecasil 3 Rhombohedral zeolite



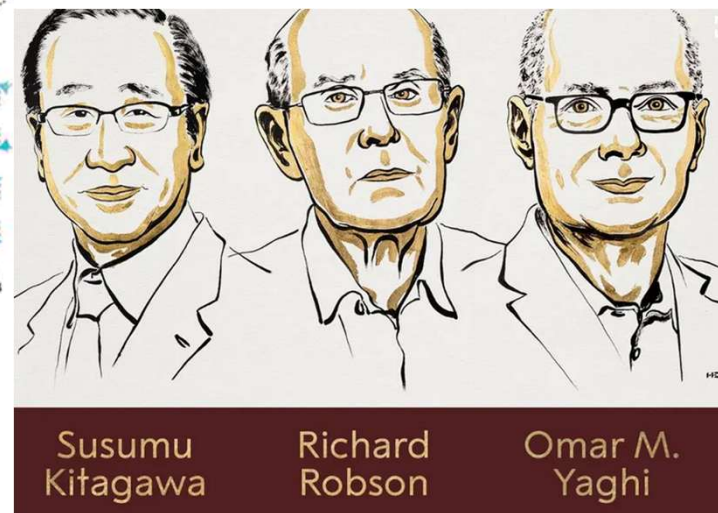
Families of materials for depollution

- **Metal Organic Frameworks (MOFs) :**

- crystalline porous polymers made of metal clusters (SBUs), coordinated to organic ligands
- materials with ultrahigh porosity (up to 90% free volume), very high surface areas ($> 2000 \text{ m}^2/\text{g}$)



⇒ Gas adsorption (CO_2), separation, storage



Nobel Prize in Chemistry 2025

Required characteristics

- ↳ **Stability** in the environment to be depolluted (T, pH, chemical reactivity)
- ↳ **Accessible porosity** (open porosity)
- ↳ **Matching of porosity** (micro/meso/macro) **to contaminant size**
- ↳ **Matching of surface characteristics** (charges, reactive sites dispersion) with targeted pollutants (favorable attractions)
- ↳ **Selectivity** (selective adsorption of targeted pollutants)
- ↳ **Recyclability** (reversibility of process)
- ↳ **Material availability**
- ↳ **Reasonable manufacturing/sourcing costs**

Objectives

⇒ Screening of various materials for depollution

- Mesoporous solids
- Organic/inorganic hybrid materials
- Zeolites
- Clays, allophanes

⇒ Main features (cf SYNT802/902)
structure, composition, synthesis,
properties....

⇒ Applications for pollution control
study of different cases

