Development of nano- and meso- inorganic membranes for the environmental applications

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Development of Nano- and Meso-Inorganic Membranes for the Environmental Applications

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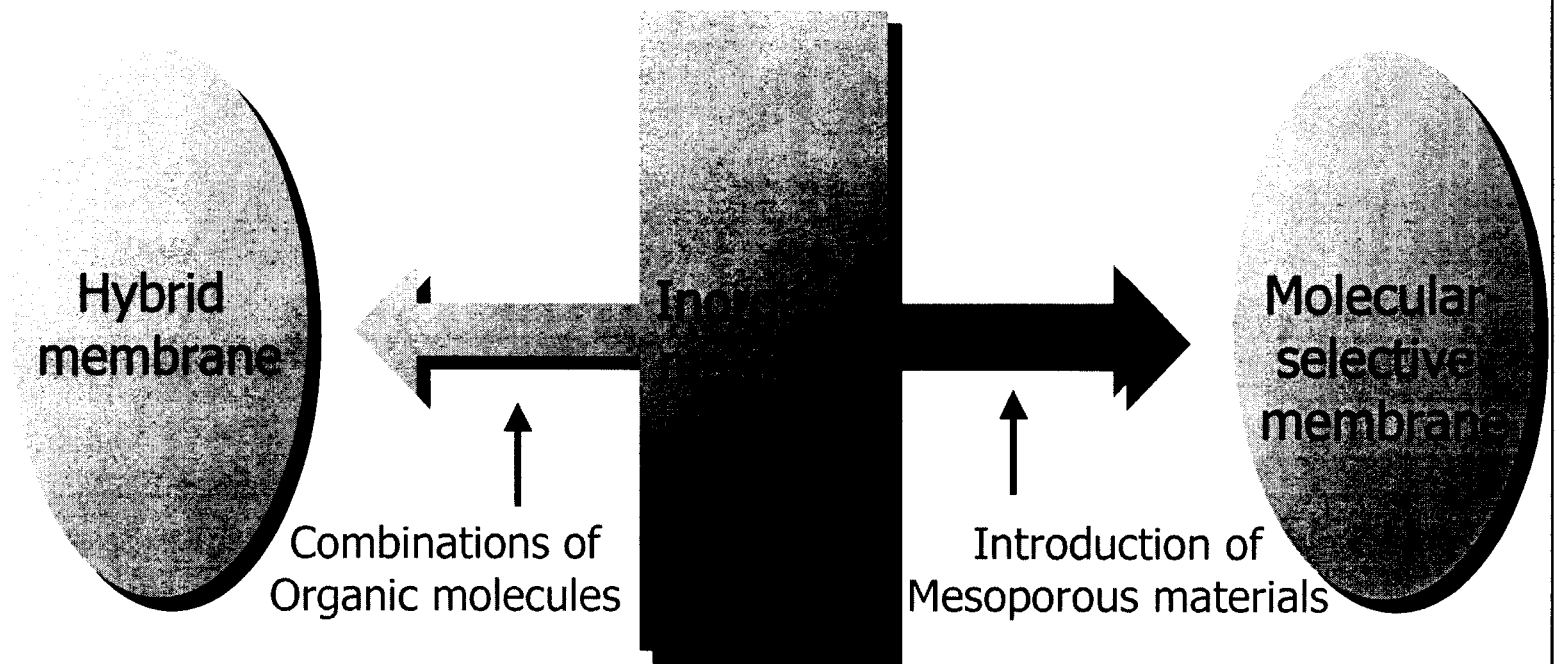
Introduction



Contents

- **Organic-inorganic hybrid membrane**
  - Synthetic methods
  - Applications
- **Mesoporous materials in inorganic membrane**
  - Introduction of mesoporous materials
  - Synthetic methods and characterizations
  - Applications

I. Organic-inorganic Hybrid Membranes

Introduction

Nano-porous inorganic materials support

+

Organic materials Separation skin layer

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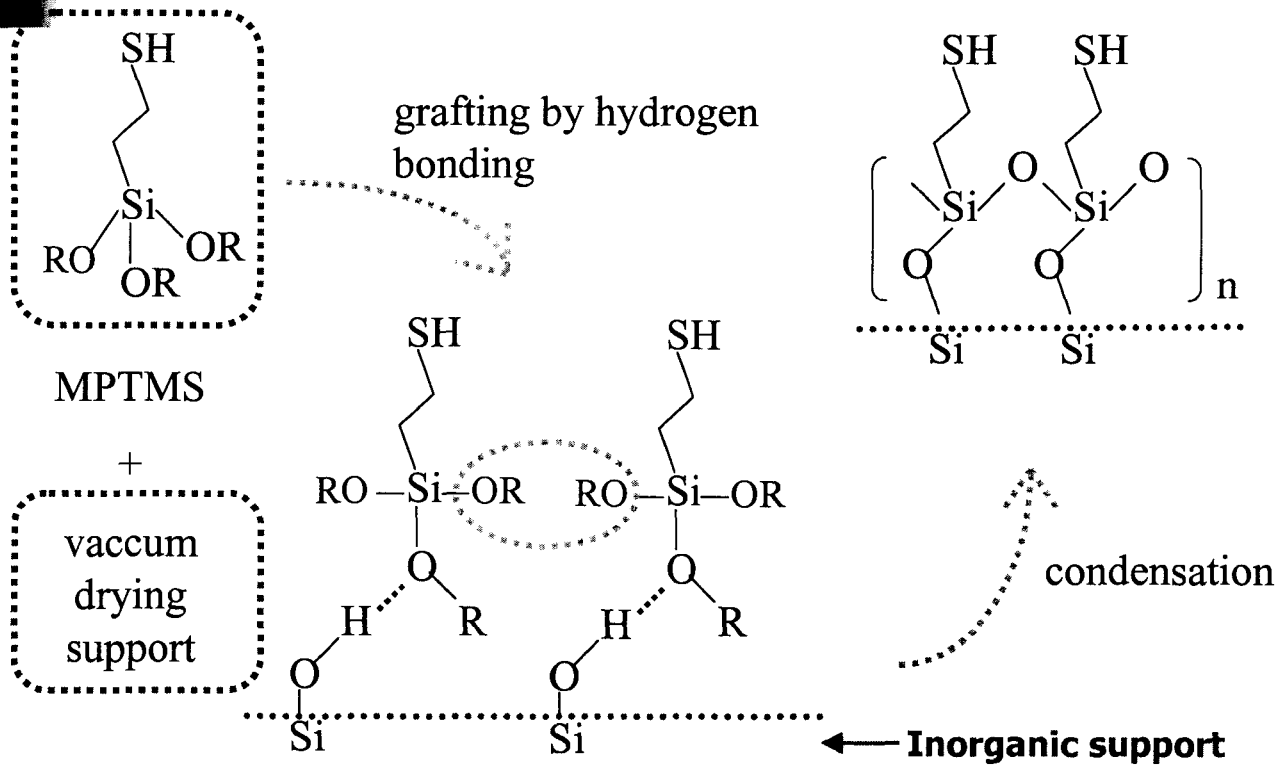
Organic-inorganic Hybrid Membrane

Advantages

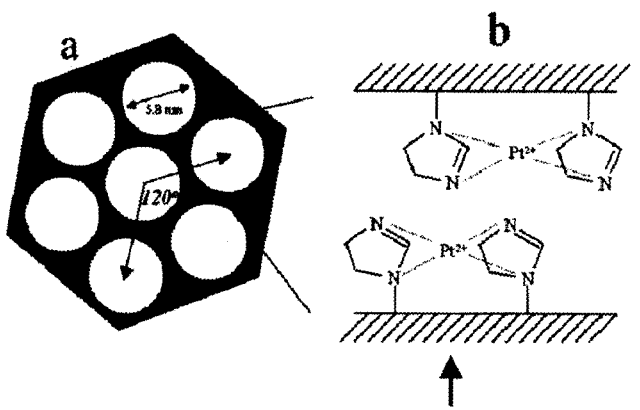
- **Multi-functionality** of inorganic surface
  - Metal chelating ligand → metal recovery
  - Alkylation → hydrophobicity control
- Enhanced **stability**
  - Thermal, mechanical and chemical stability
  - Separation in high temperature and pressure

Grafting Method

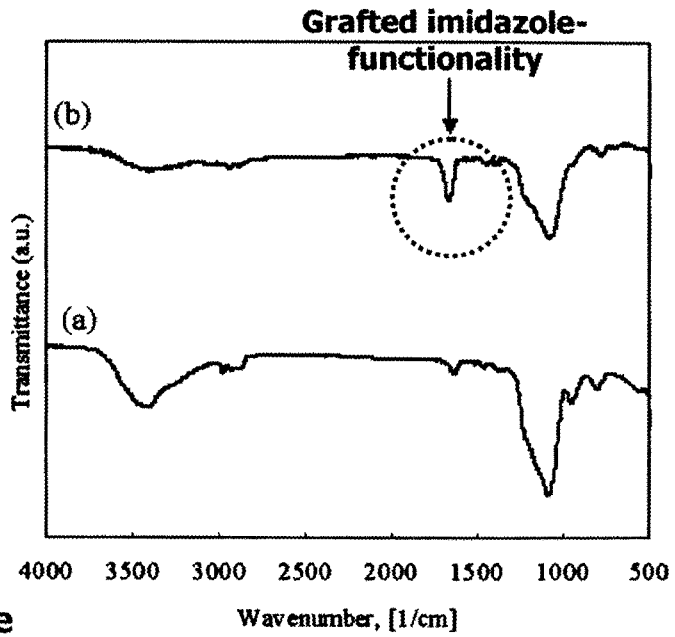


Practical Application

Schematic Diagram

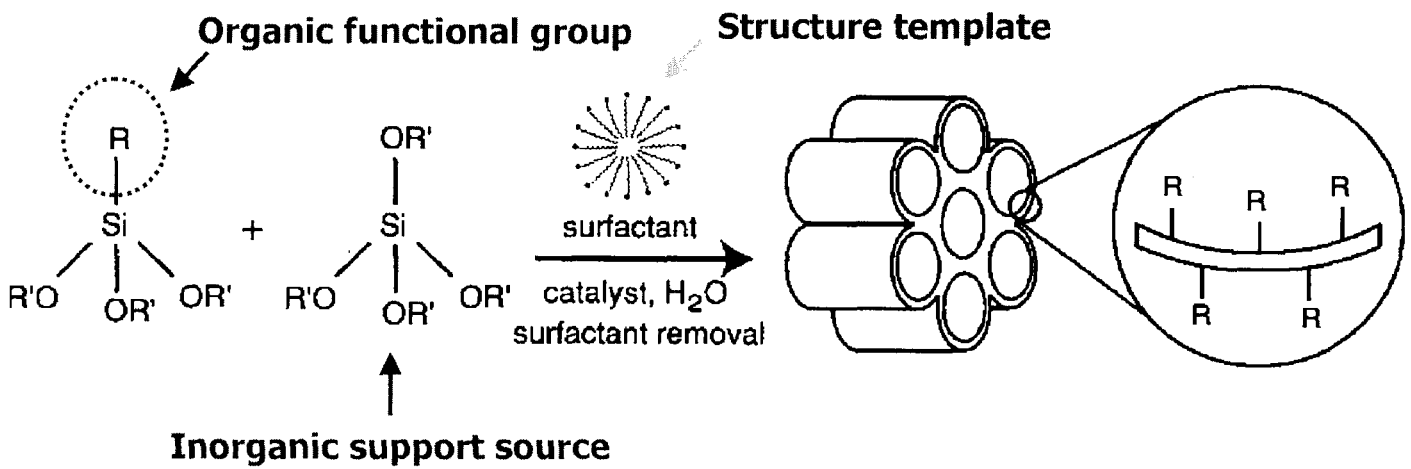


Imidazole-grafted inorganic surface



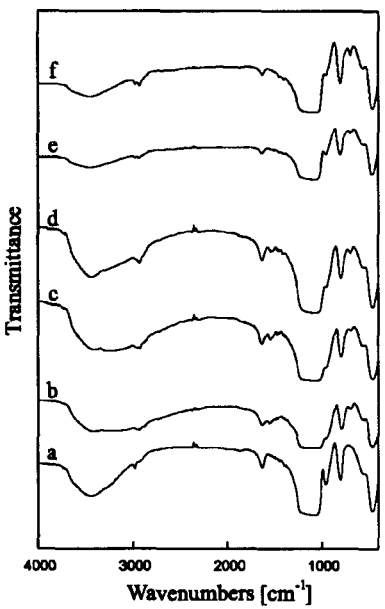
J.Yi, *J. Mater. Chem.*, (2004)

Co-condensation Method

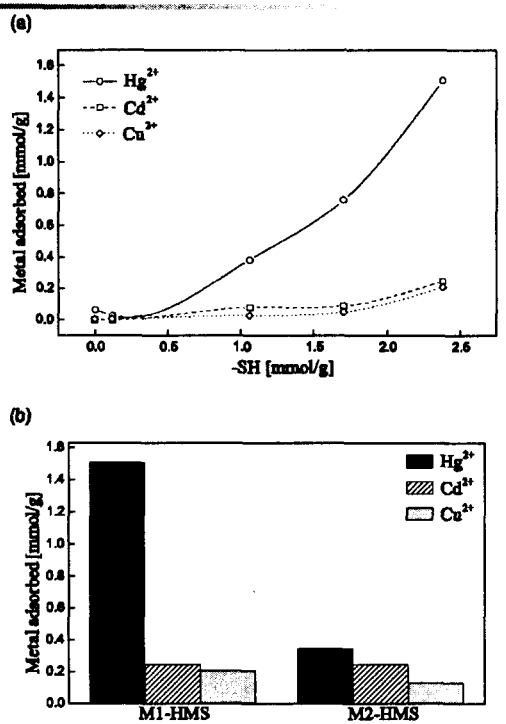


A. Stein, et al., *Adv. Mater.*, (2000)

Practical Application



Co-condensation organic functional group (amino and mercapto group) is confirmed by FT-IR

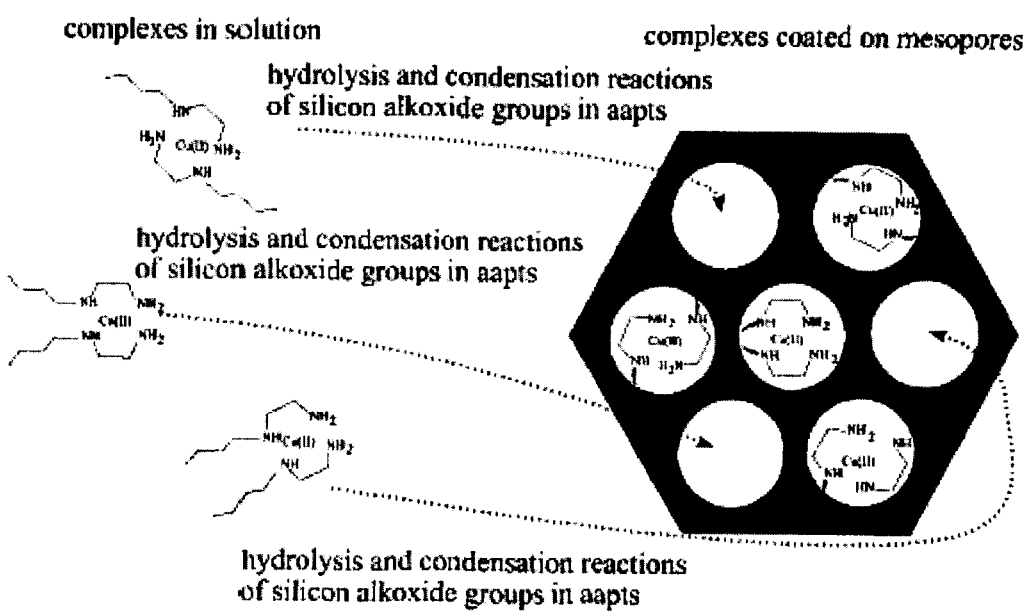


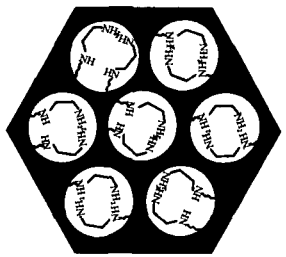
Metal ion affinity is increased by amino and mercapto group co-condensation

J.Yi, et al., *Micropor. mesopor. mat.*, (2001)

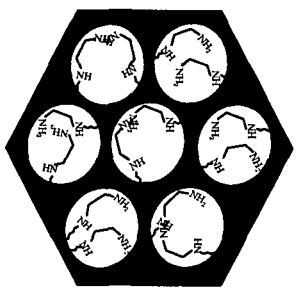
Imprinting Method

A





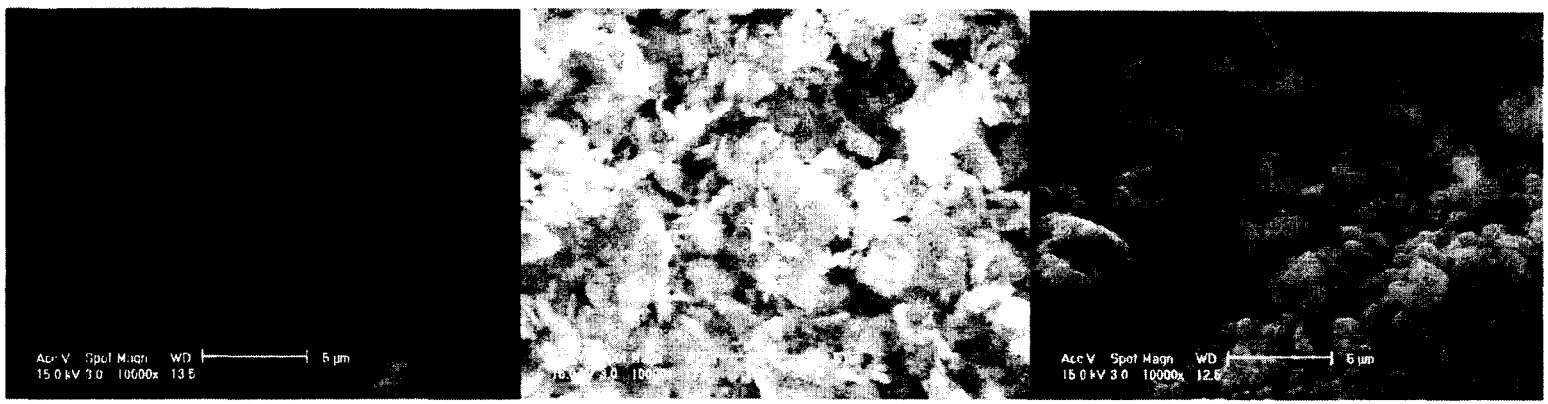
Imprinted



Grafted

J. Ying, et al., *Angew. Chem. Int. Ed.* 1999

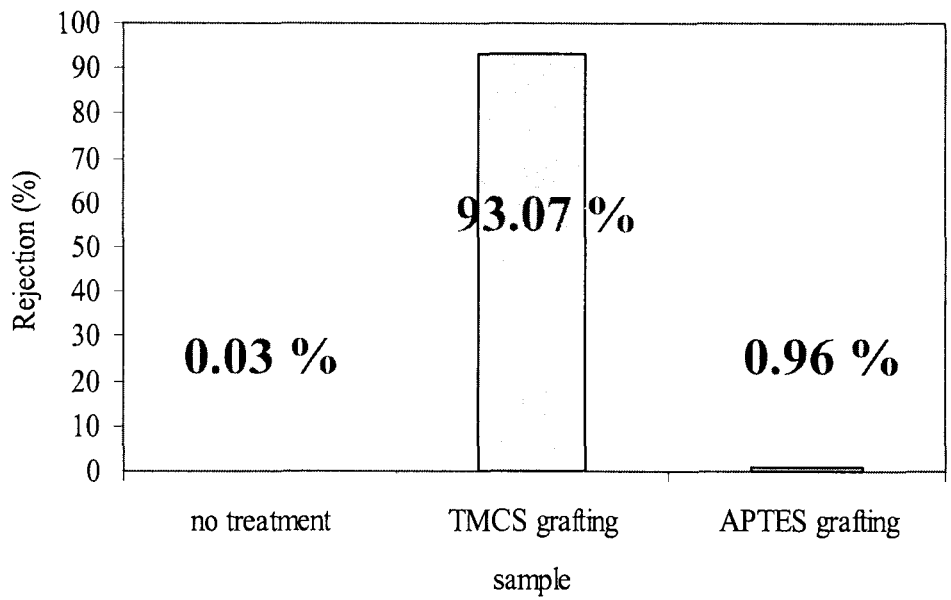
Applications



Bare membrane **TMCS grafted** **APTES grafted**

J.Yi, manuscript in preparation

Applications

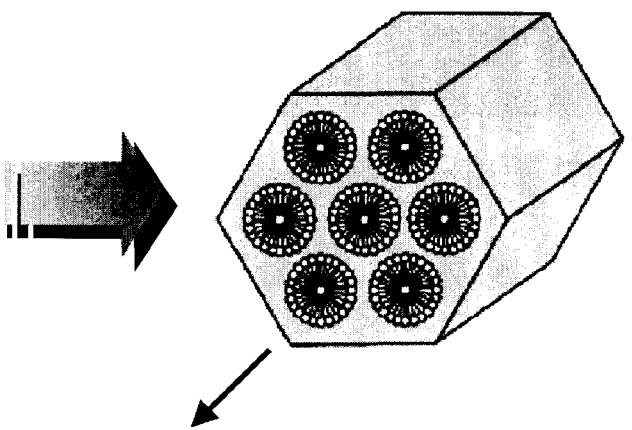


J.Yi, manuscript in preparation

II. Mesoporous Materials in Inorganic Membranes

What are Mesoporous Materials?

Surfactant + Inorganic precursor

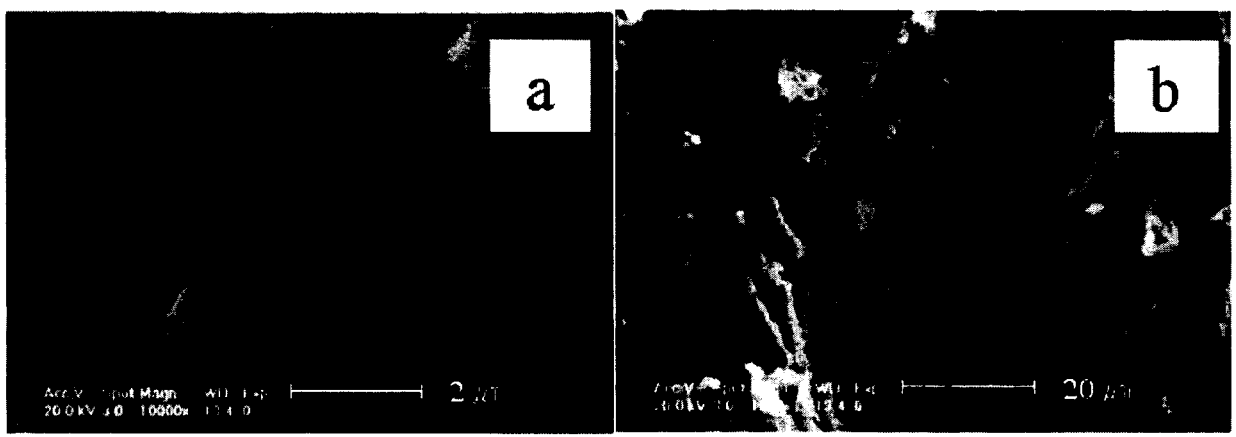


Structure templates
Non-ionic (ex. P123), cationic (CTAB), etc.

Highly ordered pore structure in mesoporous materials

What are Mesoporous Materials?

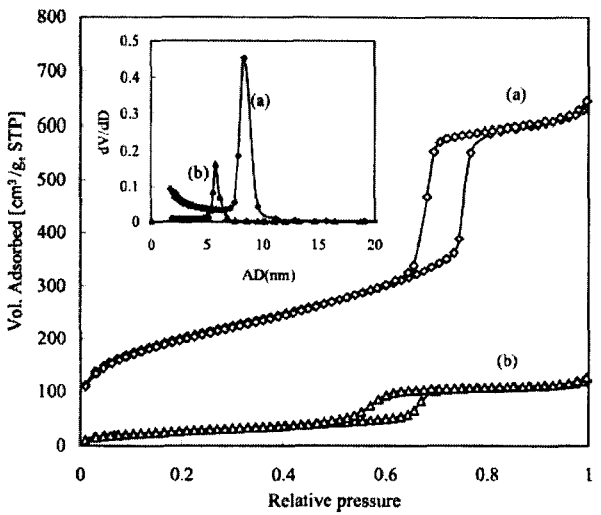
Ex. SBA-15



J.Yi, *J. Mater. Chem.*, (2004)

Why Mesoporous Materials?

Unique pore size and large surface area



Average pore size : 5~ 10 nm

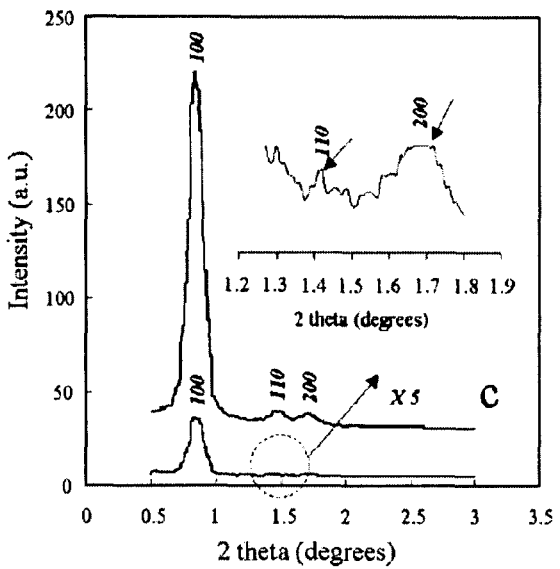
Average surface area : ~700m²/g

Selectivity is increased by large surface area and high pore volume

J.Yi, *J. Mater. Chem.*, (2004)

Why Mesoporous Materials?

Ordered pore structure
(diffraction pattern)



Crystallinity of mesoporous material is confirmed by Small angle X-ray Diffraction.

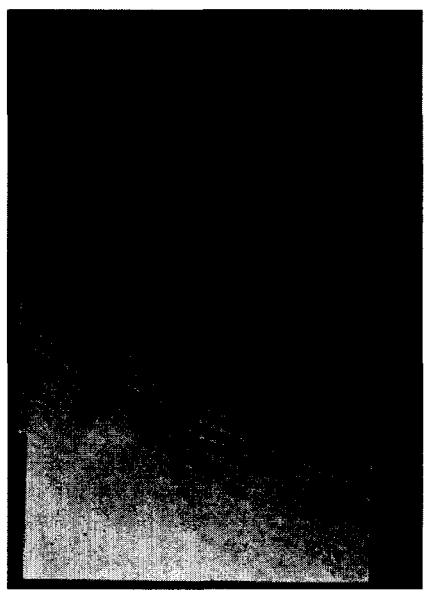
In this case, hexagonal symmetry is confirmed.

J.Yi, *J. Mater. Chem.*, (2004)

Why Mesoporous Materials?

Ordered pore structure (TEM images)

Hexagonal pore arrange →



← **2-D pore structure**

J.Yi, *J. Mater. Chem.*, (2004)

Practical Application Methods

- Mesoporous film coating on ceramic supports
  - Dip-coating or spin casting using mesoporous silica sol solution
- Deposition of mesoporous silica particle on ceramic supports
- Membrane preparation using mesoporous silica particle itself

Summary

- Organic/inorganic hybrid membranes
  - Ceramic support : alumina, silica, zirconia
  - Organic skin layer : silane groups
    → various functionality
    → good reaction to ceramic surfaces

- Mesoporous materials
  - Up to now : concentration to catalysts, adsorbents
  - Now : increase of interests to membrane applications
    gas separation, catalytic membrane, etc.