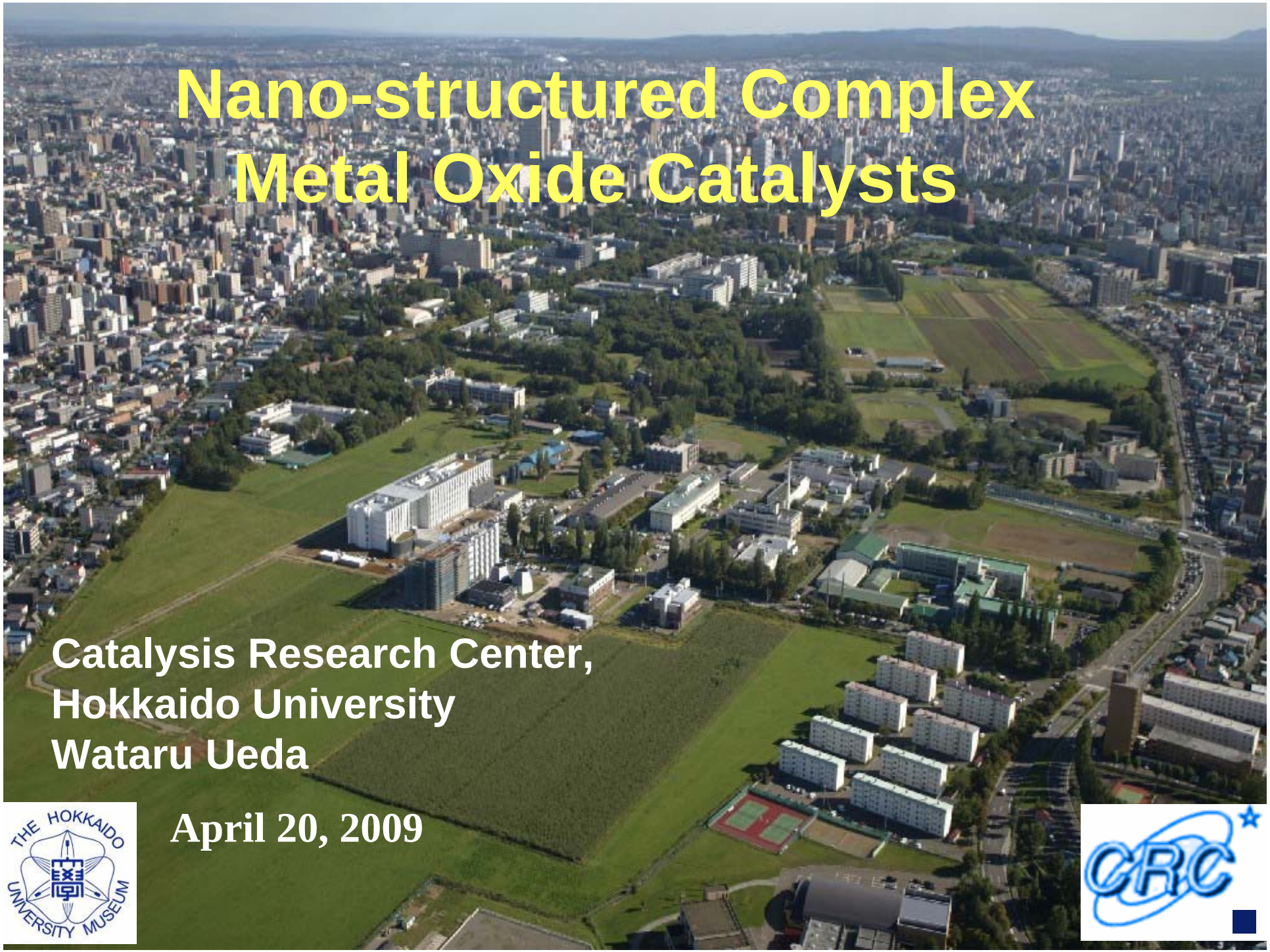


Nano-structured Complex Metal Oxide Catalysts

Catalysis Research Center,
Hokkaido University
Wataru Ueda

April 20, 2009


Hokkaido University
Catalysis Research Center
The national collaborating institution
in the field of catalysis in Japan

Catalysis Research Center (CRC) originated from the Institute of Catalysis which was founded in 1943 in Hokkaido University for fundamental studies on catalysis, and started as a national collaborating institution in 1988, followed by scale-up reorganization in 1998 and by a organization renewal in 2007 for playing a leading role in catalysis studies and a bridging role among interdisciplinary scientific researches.

Multifunctional activity

CRC

7 professors
7 associate professors
6 assistant professors
29 research fellows
5 visiting professors
19 collaborative researchers
58 students
13 tentative stuffs
8 technical stuffs
20 Administrative stuffs
172 Total

Fundamental CRC researches supported by government, JSPS, JST, etc.
Only one research, Challenging research, New field research

Collaborative research projects organized by CRC with researchers in Japan

Research projects with companies, NEDO, etc.

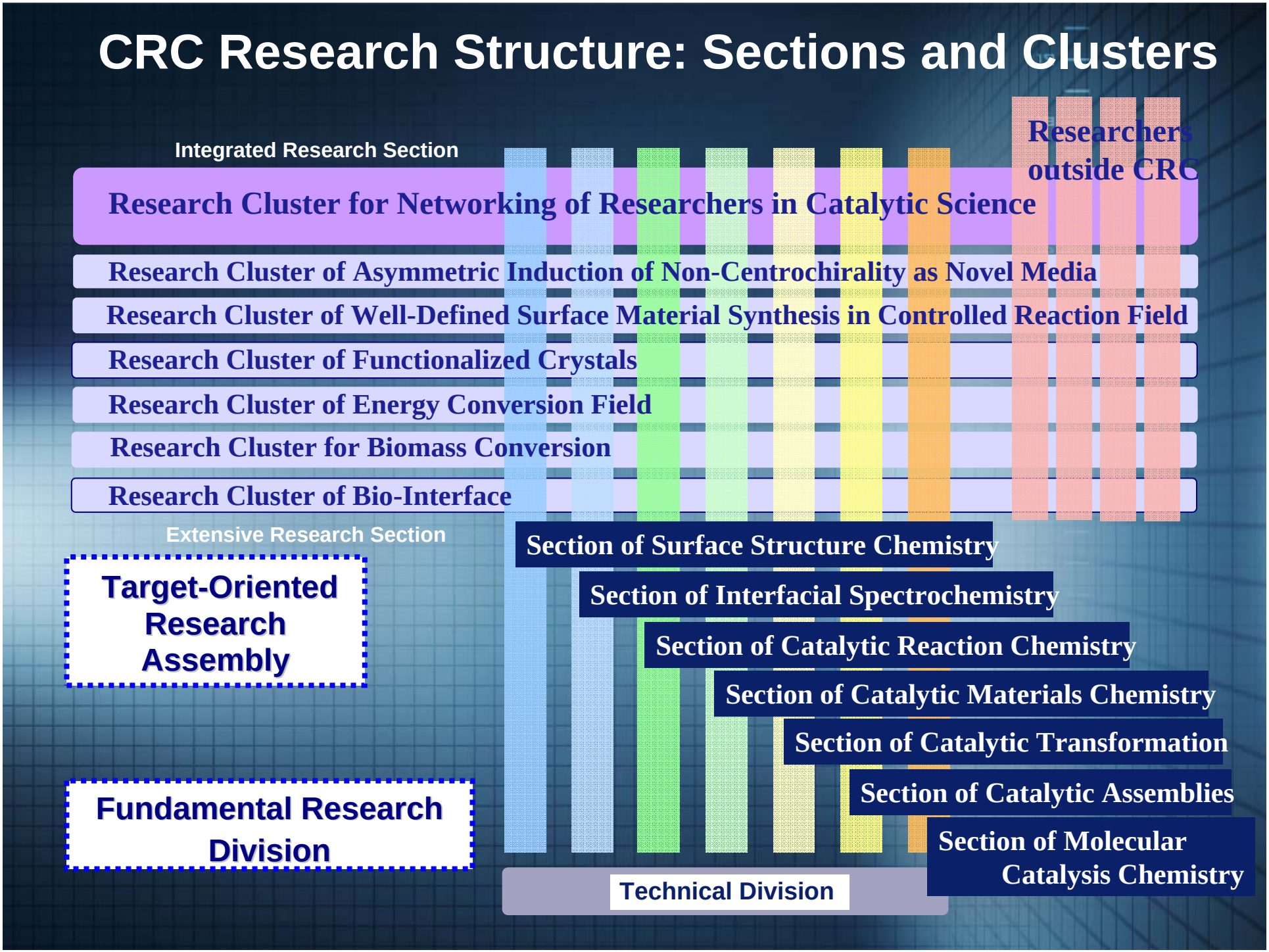
Research networking
Catalysis Summit
Various scientific open facilities

International collaborations
International symposium
Joint laboratories in China
International research exchange program

Domestic activity for catalysis community
Various scientific symposium, seminar

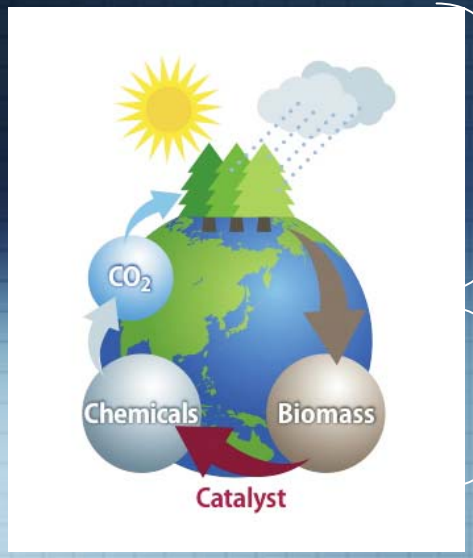
Educational activities
Global COE program
Students from various faculties of Hokkaido Univ.
Educational program for researchers

CRC Research Structure: Sections and Clusters



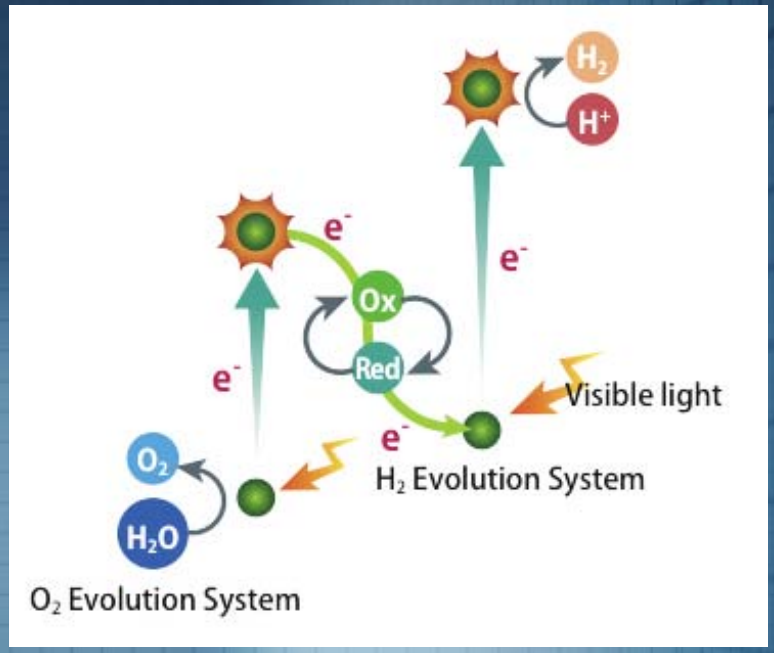
Recent topics

Collaboration between Catalysis and Nature for the Realization of Sustainable Development



Nature step
(Photosynthesis)

Artificial
Catalytic step

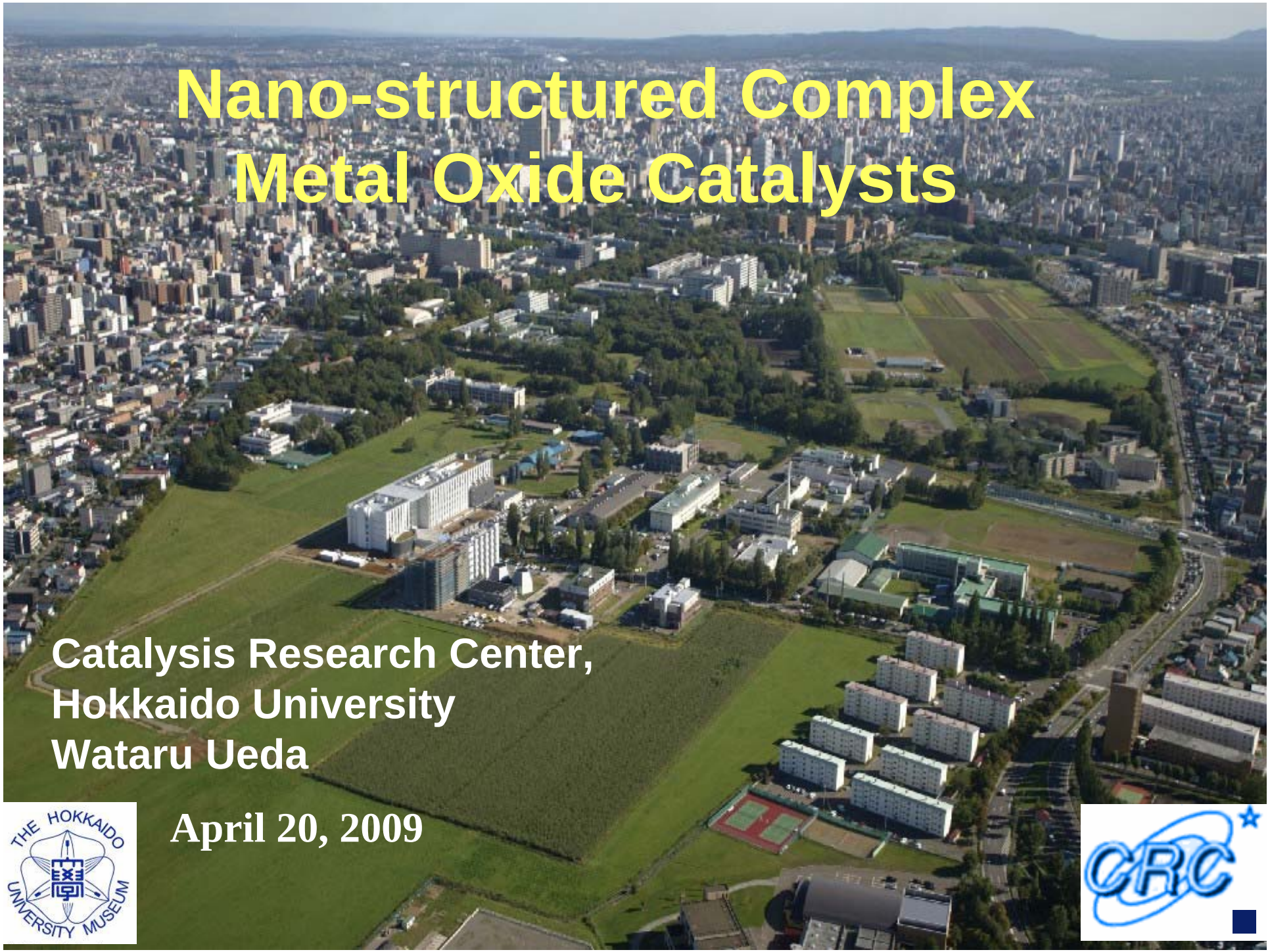


Supported Pt or Ru catalysts can convert cellulose into sugar alcohols such as sorbitol and mannitol by an environmentally benign process. The process provides new opportunities for the utilization of abundant and inexpensive cellulose as a chemical feedstock.

Fukuoka, *Angew. Chem. Int. Ed.*, 2006

A new photocatalytic water splitting system was developed to mimic natural photosynthesis, in which two photoexcitation steps were combined. The process allows visible light to be utilized efficiently and a wide spectrum of visible light.

Abe, *Chem. Phys. Lett.* 2008



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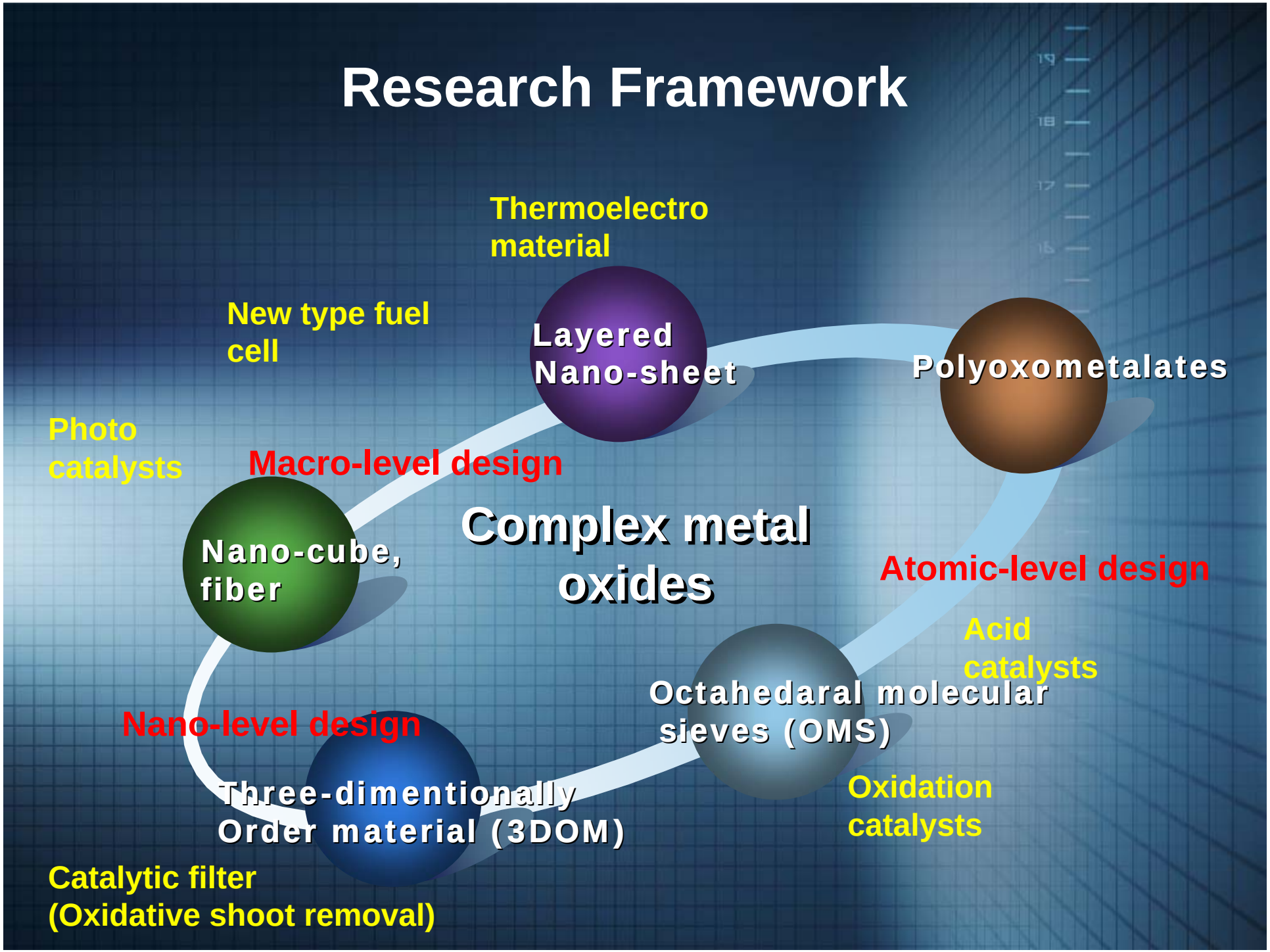
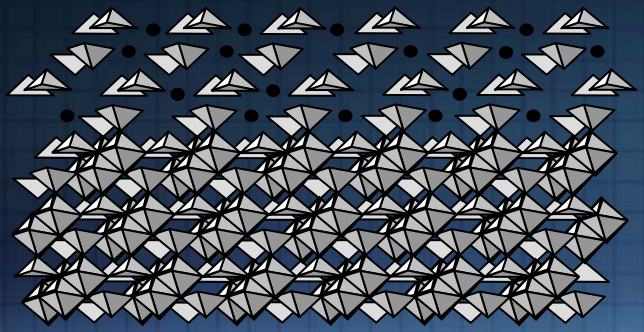
Research Framework

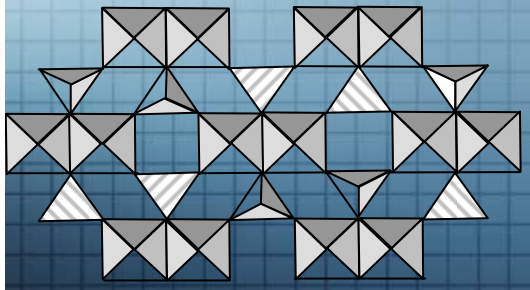


Multifunctional Complex Metal Oxide

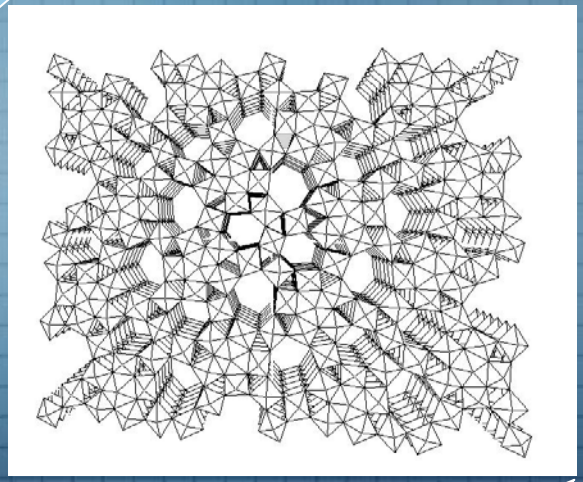


Multicomponent
Bi-Fe-Mo-O
Olefin oxidation

Three dimensional
Redox

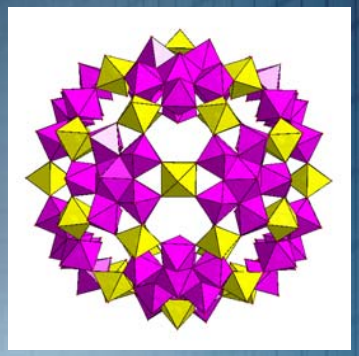


V-P-O
Alkane oxidation

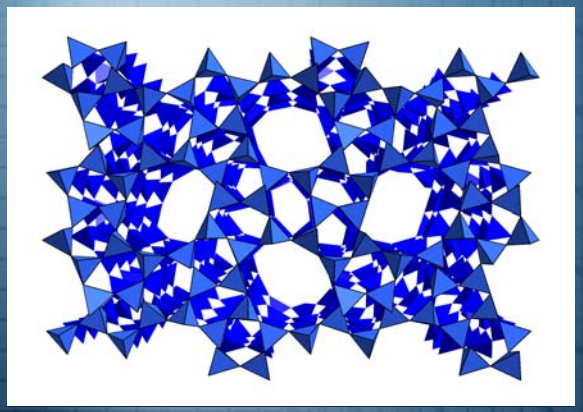


Porous property

Moleculariry



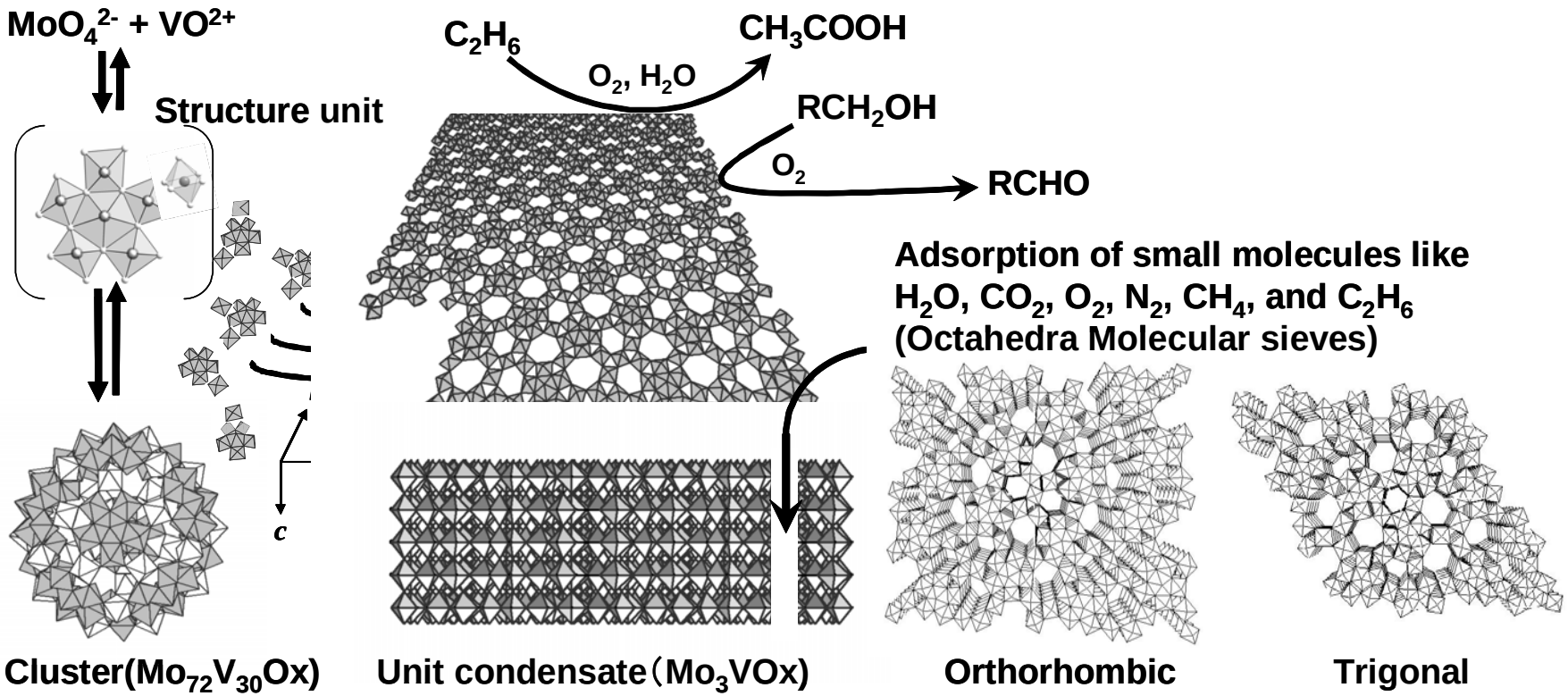
Heteropoly compounds
H_2O_2 oxidation
Gas-phase oxidation



Zeolite
Titanosilicate
H_2O_2 oxidation

Mo_3VOx Complex Metal Oxide Crystals

1. Crystal formation mechanism
2. Microporocity
3. Catalytic reactions



Catalyst preparation-Hydrothermal synthesis-

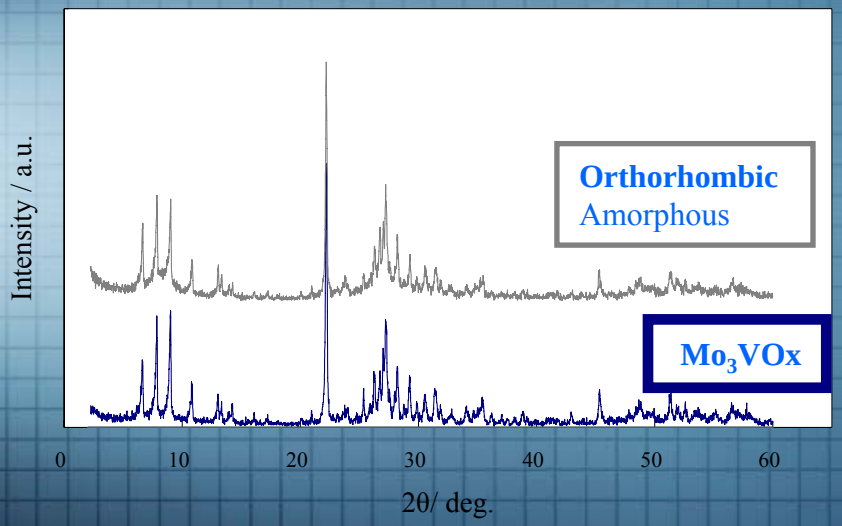
$(NH_4)_6Mo_7O_{24}\cdot 4H_2O$ (aqueous solution) ＋ $VOSO_4\cdot nH_2O$ (Mo:V = 4 : 1)

Hydrothermal synthesis in autoclave (Teflon inner tube)

175 ºC 48 h

Filtration, Washing, and Drying at 80 ºC

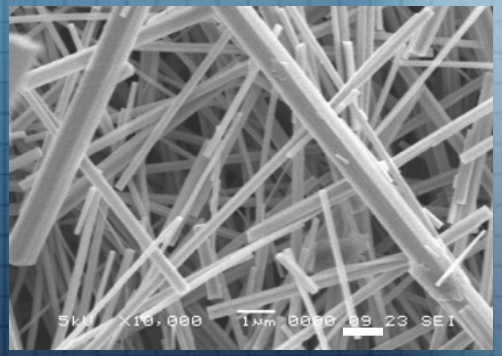
Crystal + Amorphous



Purification

Aqueous solution of oxalic acid 0.4 mol /l **pH 0.69**

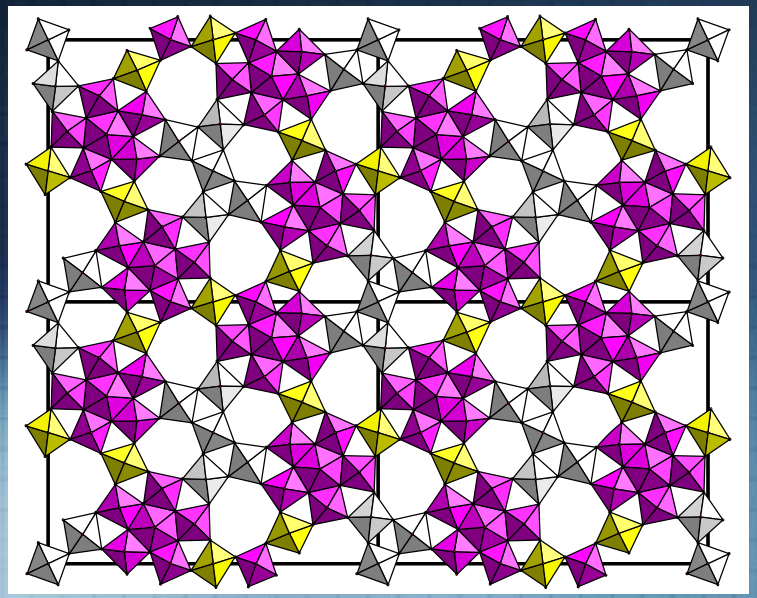
Stirring at 60 ºC



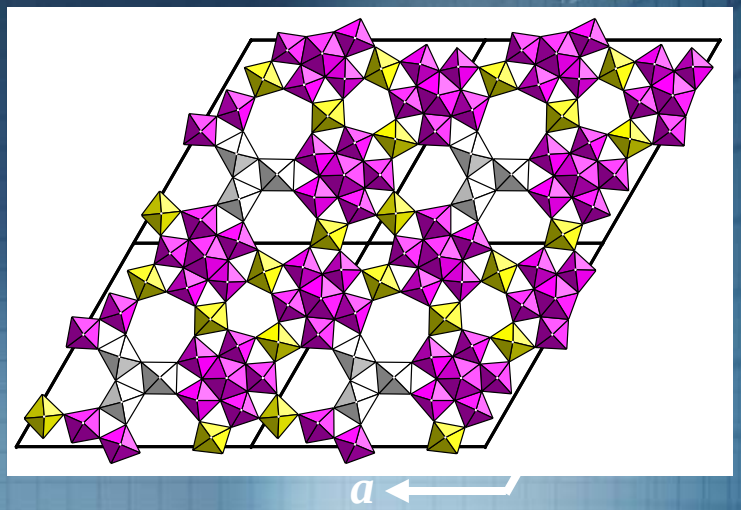
Filtration, Washing, and Drying at 80 ºC

crystalline Mo_3VOx

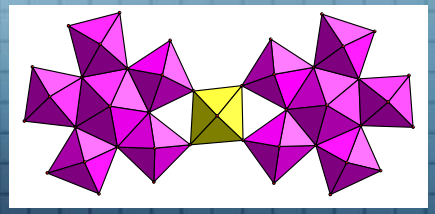
Structure comparison



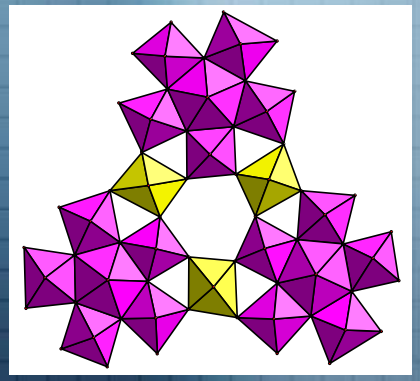
Orthorhombic phase



Trigonal phase



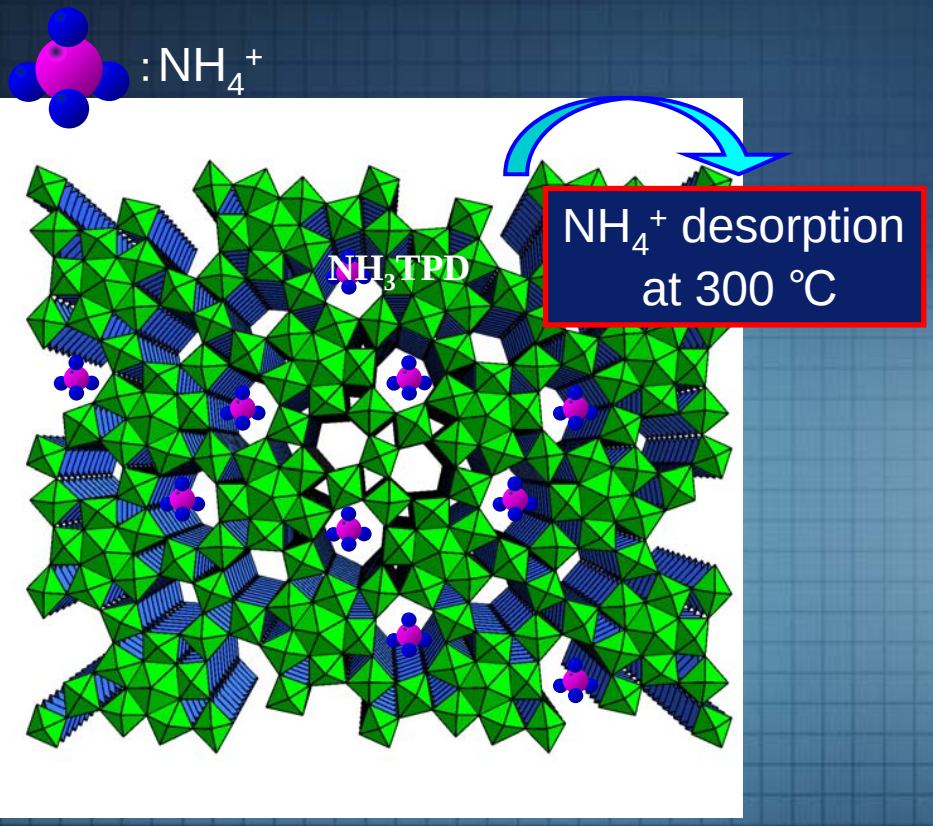
Assembly of $[Mo_6O_{21}]^{6-}$, as the structural unit



Octahedral coordination chemistry

Sadakane, Ueda, Angew. Chem. Int. Ed. (2007)

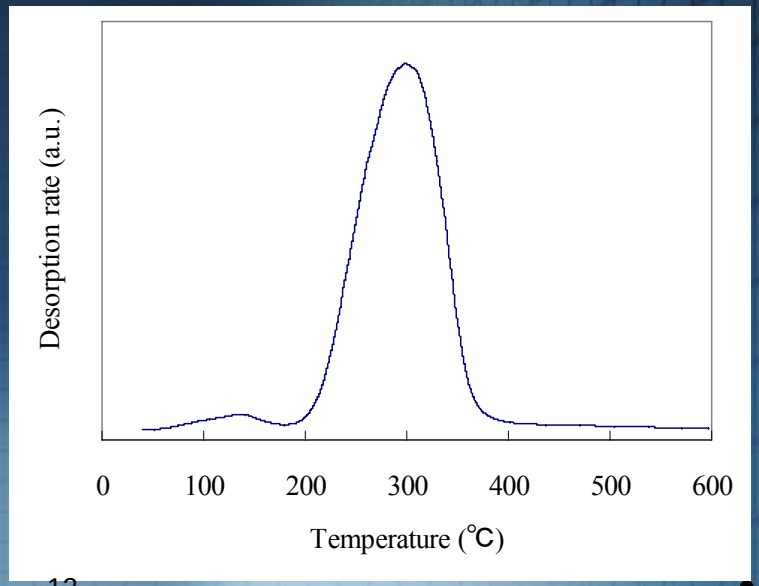
Effect of calcination on adsorption capacity

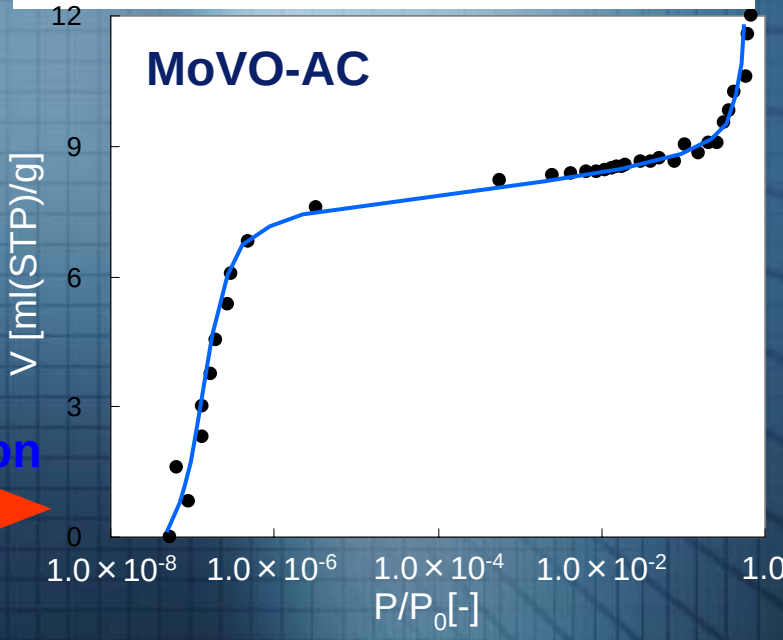


NH_4^+ type orthorhombic Mo_3VO_x

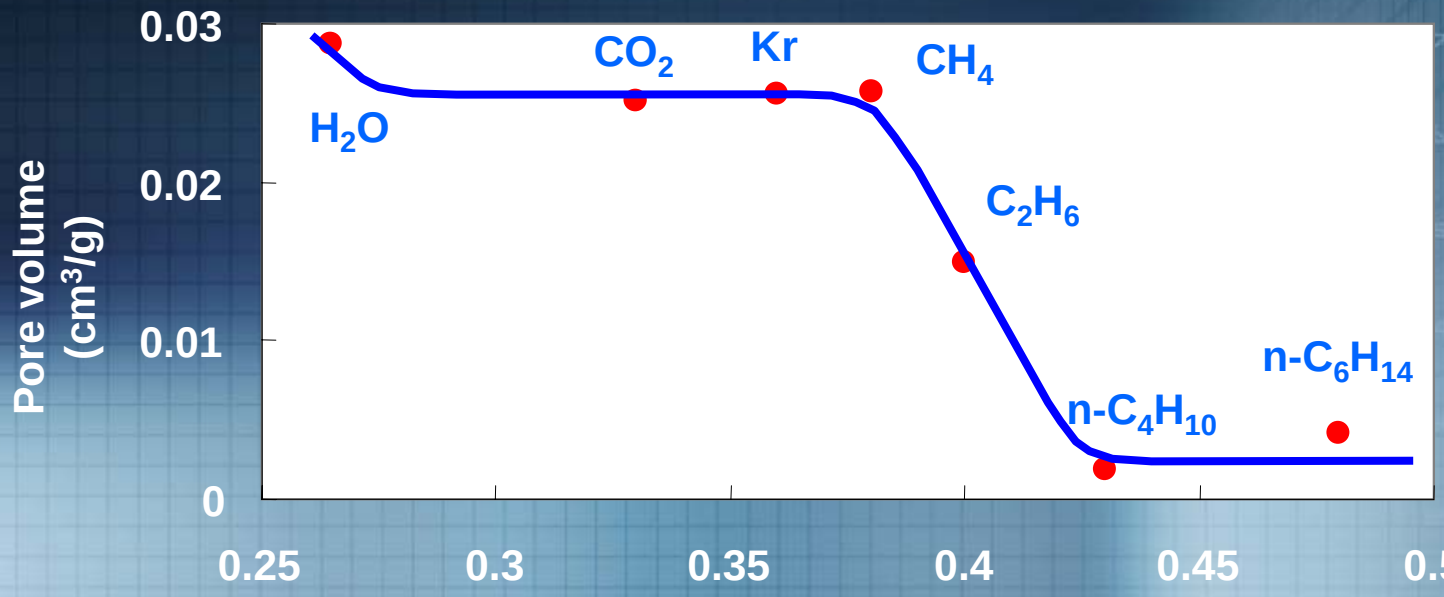
Air calcination 400 ℃

N_2 adsorption



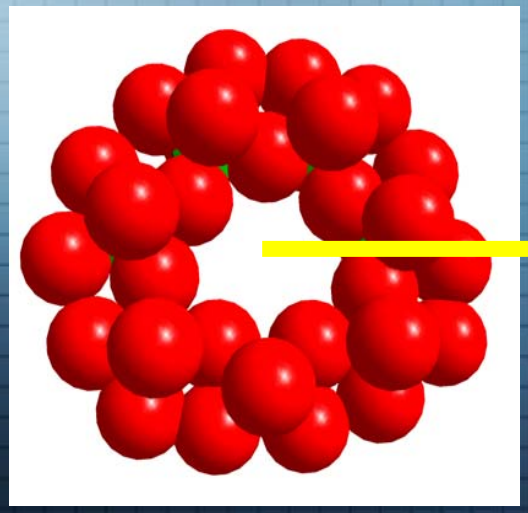


Adsorption of various small molecules



DA method was used,

0.4 nm



0.39 nm diameter

The heptagonal ring

0.0234 cm³/g

Sadakane, Ueda, Angew. Chem. Int. Ed. (2008)

Nano-structured Complex Metal Oxide Catalysts

Summary

- Crystal formation mechanism---**Cluster unit to solid**

2. Microporocity---

New octahedra molecular sieve with redox property

3. Catalytic reactions---**High performance and active pore site**