Introduction of the Dalian Institute of Chemical Physics (DICP), CAS

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  - **Nano-Particle: Quantum size effects**
  - **Nano-pore: Confinement effects**

中国科学院大连化学物理研究所

Dalian Institute of Chemical Physics, CAS

About the Chinese Academy of Sciences

STRUCTURE:

- **Merit-based Academic Divisions:**

  Members: 700 inc.
  35 Foreign Members

- **Comprehensive National Research Institution:**

  90 Institutes,
  1 University
  1 Postgraduate School
  Total Staff : 50,000

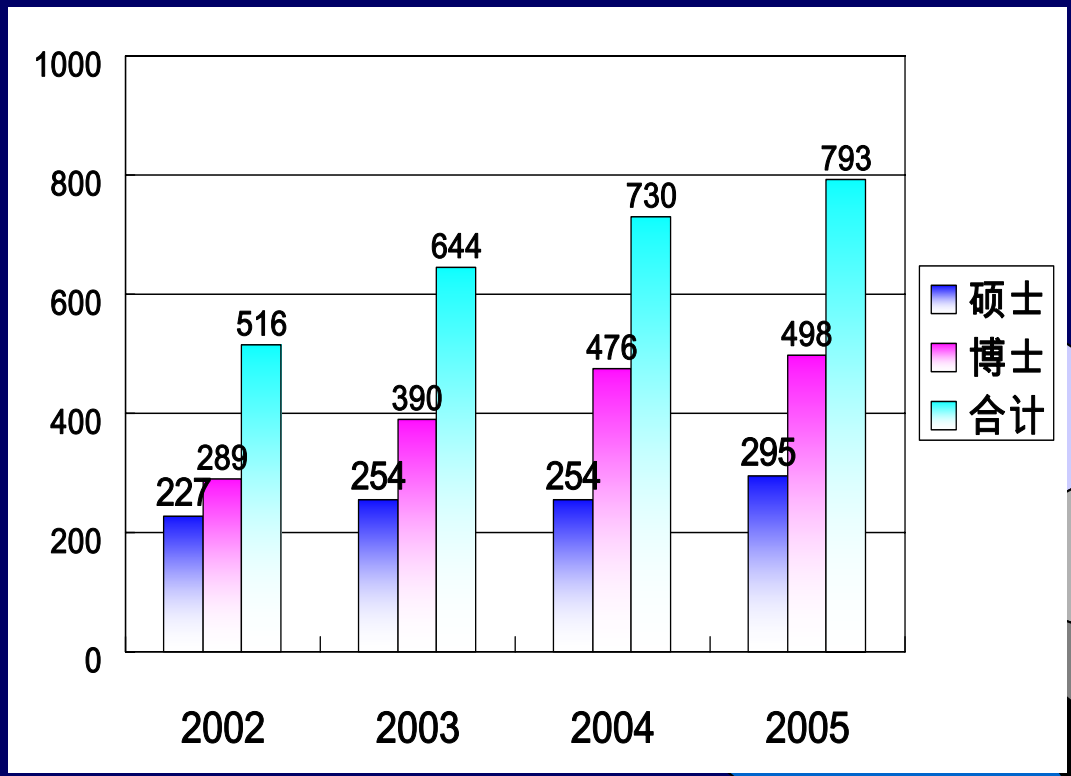
MISSIONS:

- Scientific Research
- High Technology Development
- Education and Training
- Think Tank of Science Policies

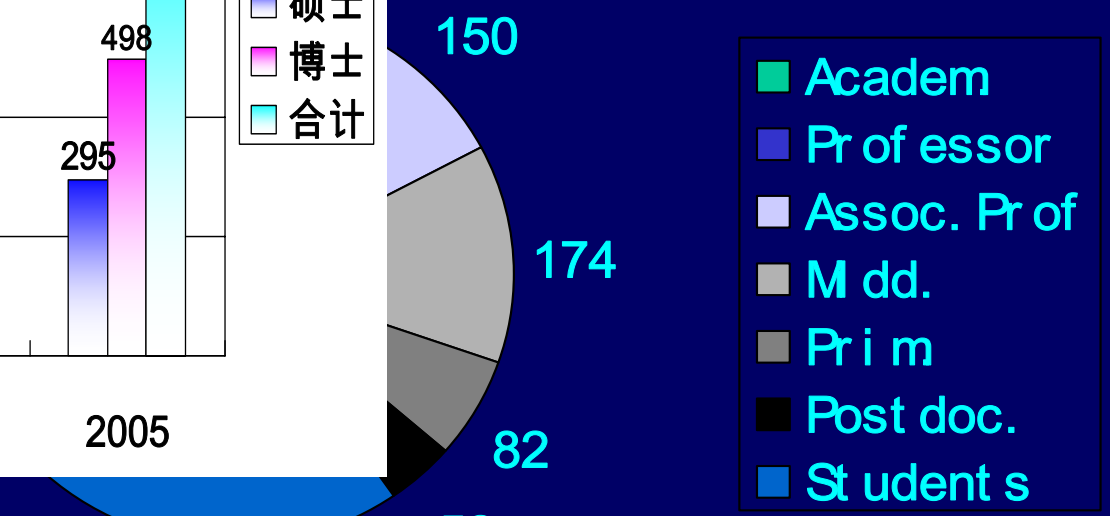
中国科学院大连化学物理研究所

Dalian Institute of Chemical Physics, CAS

Dimensions of Dalian Institute



Staff Members



Graduate Students

- 51 Research Groups and Teams
- 1500 Researchers

Research Organizations of DICP

Basic Research

- State Key Laboratory of Catalysis
- State Key Laboratory of Molecular Dynamics

National Key Projects

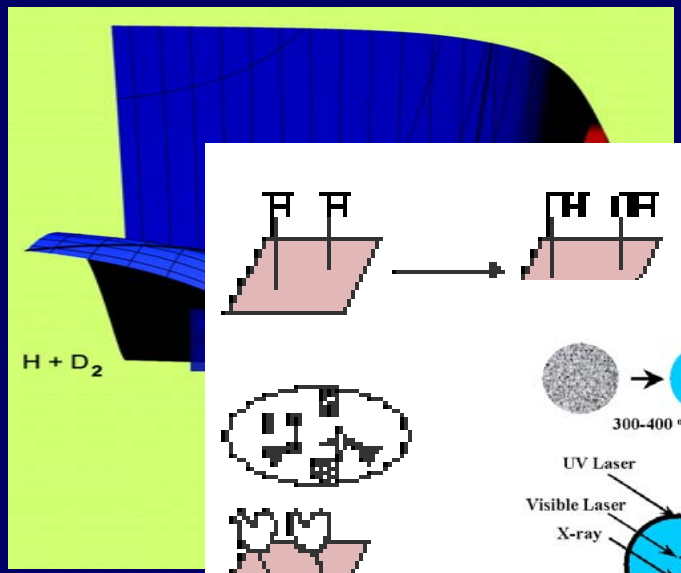
- Laboratory of Fuel Cell
- Laboratory of Chemical Lasers
- Laboratory of Materials

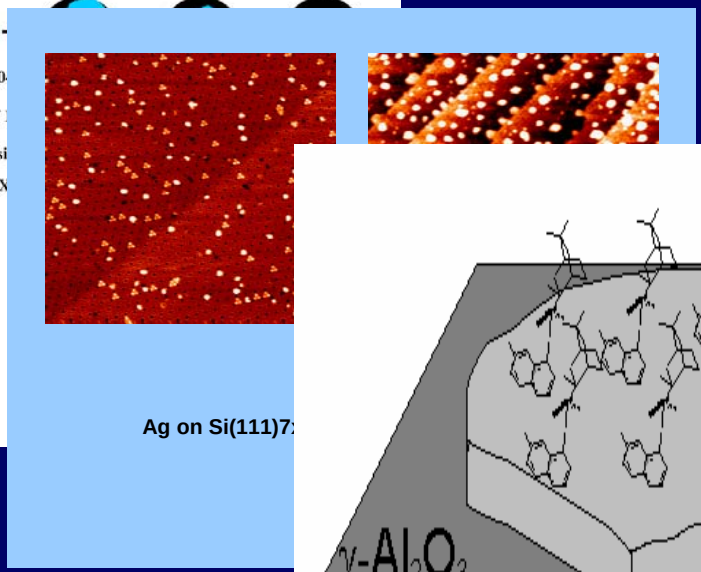
Applied Research

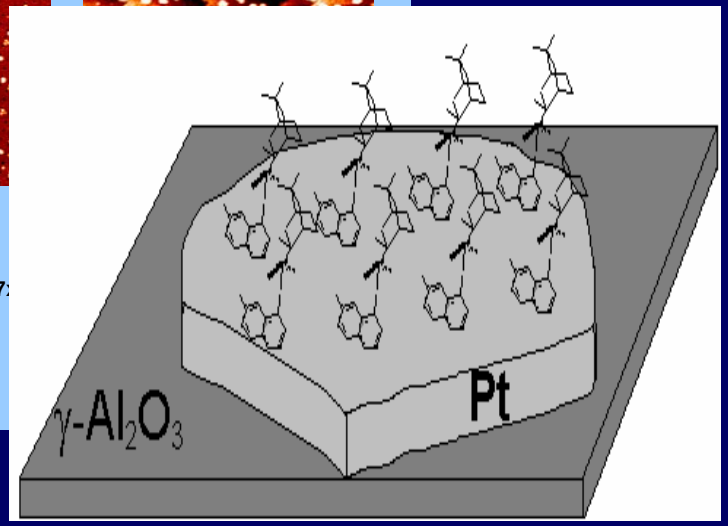
Spin-off Companies

- Pesticide Intermediates
- Membrane Technology
- Chromatographer
- Fuel Cell
- Catalyst

Fundamental Researches at DICP







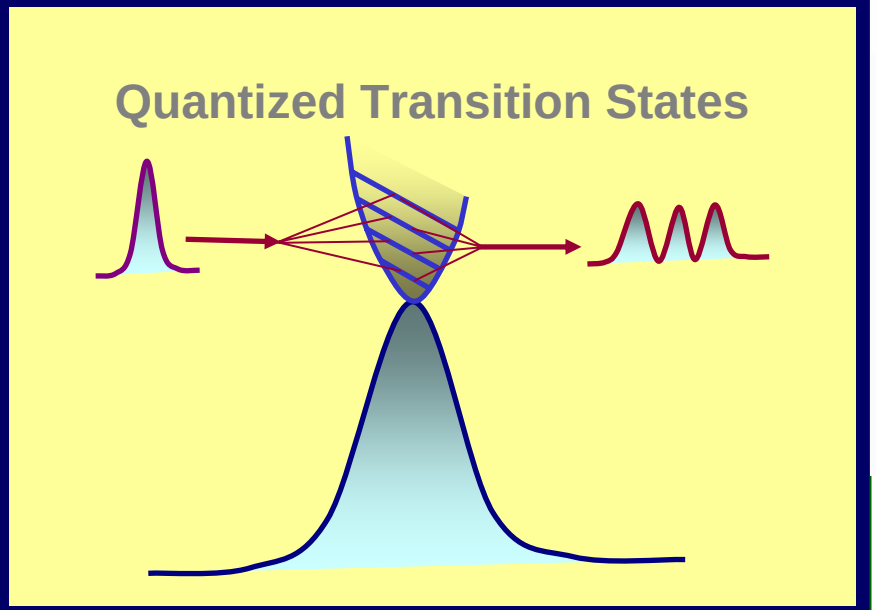
Science	2
Nature	1
Agew. Chem	7
JACS & PRL	11

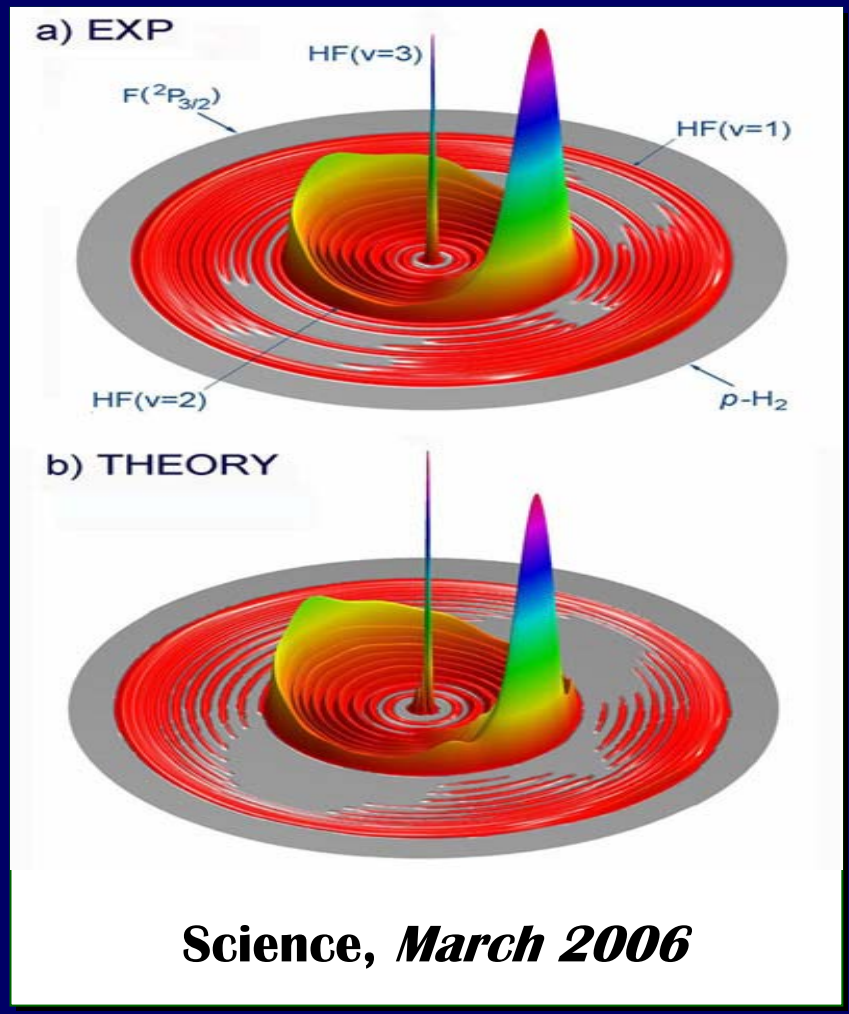
1 National Science Award

2 National Invention Award

Fundamental Researches in DICP

Nature (2002)
Science (2003)





Science, ***March 2006***

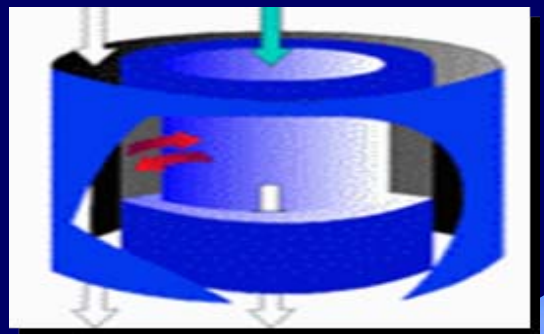
Applied Researches in DICP

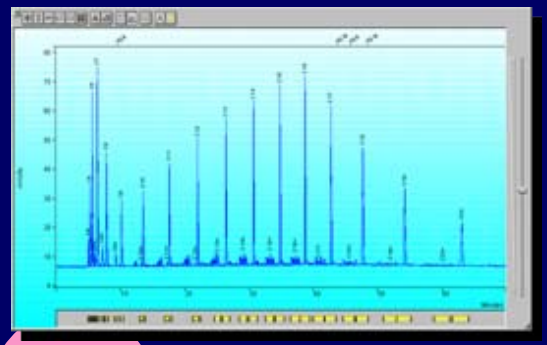
- Sustainable Energy
- Resources Optimal Utilization
- Bio-Technologies

Energy Researches in DICP

- **Optimal Utilization of Natural Gas**
  - Production of Syngas via Low-cost Process
  - Syngas Chemistry including FT and Oxygenate Synthesis
  - Direct conversion of Methane
- **Hydrogen Energy**
  - Hydrogen Production from Natural Gas, Lower Alkanes and Resid as well as Methanol
  - Hydrogen Production via Bio-technology
  - Separation of Hydrogen from Carbon Monoxide and Carbon Dioxide by membranes
- **Fuel Cell**
  - Proton-Exchange Membrane Fuel Cell (PEMFC)
  - Solid Oxide Fuel Cell (SOFC)
  - Direct Methanol Fuel Cell (DMFC)
  - Micro Fuel Cell and Micro Sensors

Key Techniques to Polygeneration





S resistant

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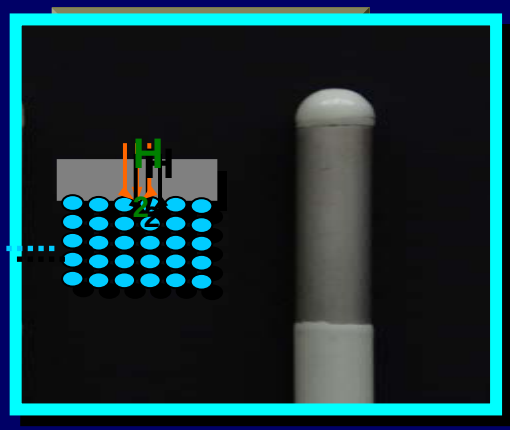
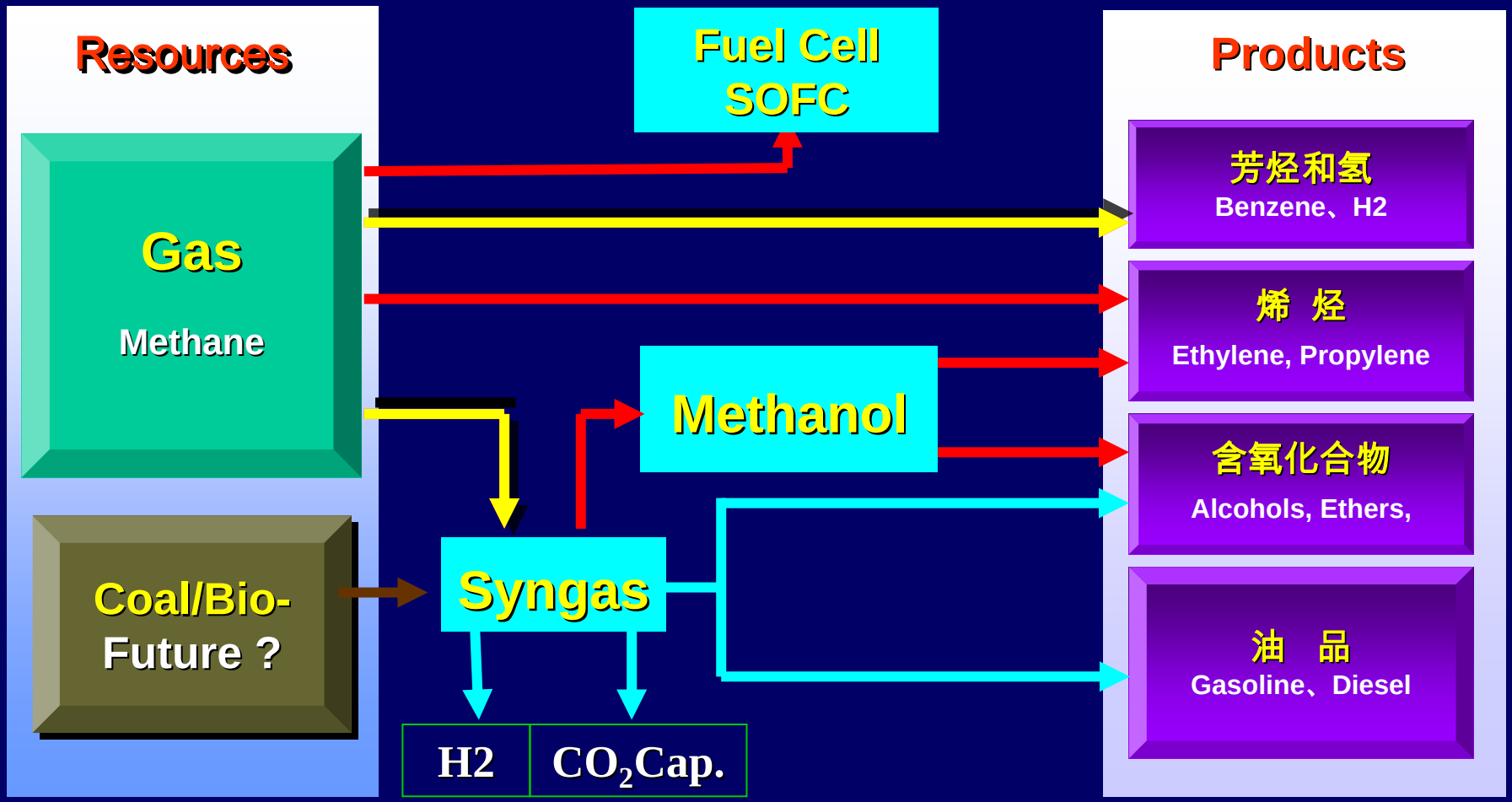
Chemical Synthesis

Genera
SOF



WGS

Utilization of Natural Gas & Coal



Gas to Liquid (GTL)

Syngas
Coal-based
→ Fe →
Gasoline、Diesel

- ICC。。。

Syngas
Gas-based
→ Co →
Diesel、Waxes

C2 Oxygenates from Syngas

Coal & Gas

$CO + H_2$

CO Conv. 56.4%

Selec. 73.5 wt%

C_2 Oxygenates

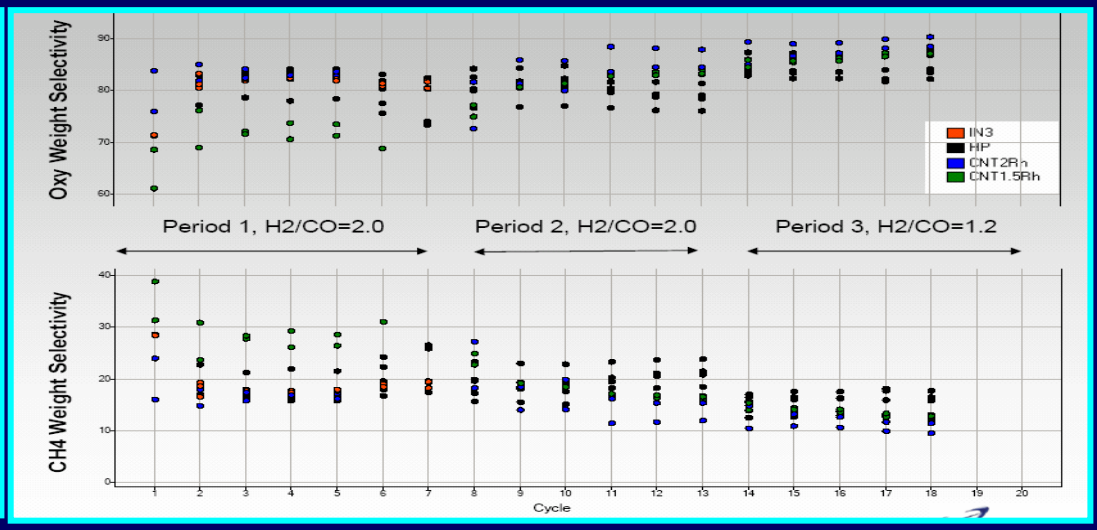
Hydrogenation → EtOH

Oxygenation → AcOOH

AcOOEt

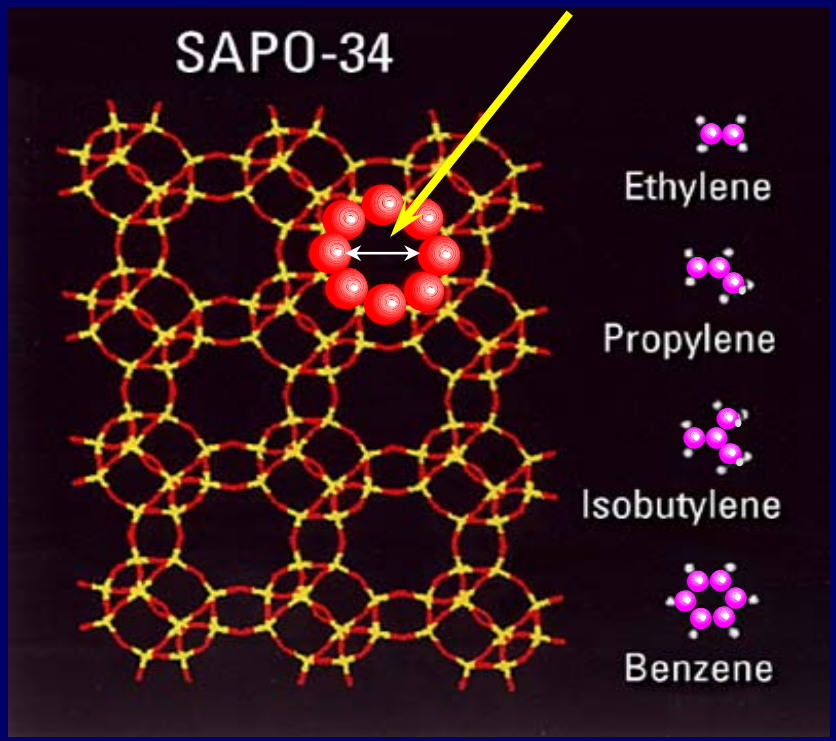
Economic. (BP) :

Present Tech. 2500 ~ 2800 RMB/ton Eth.

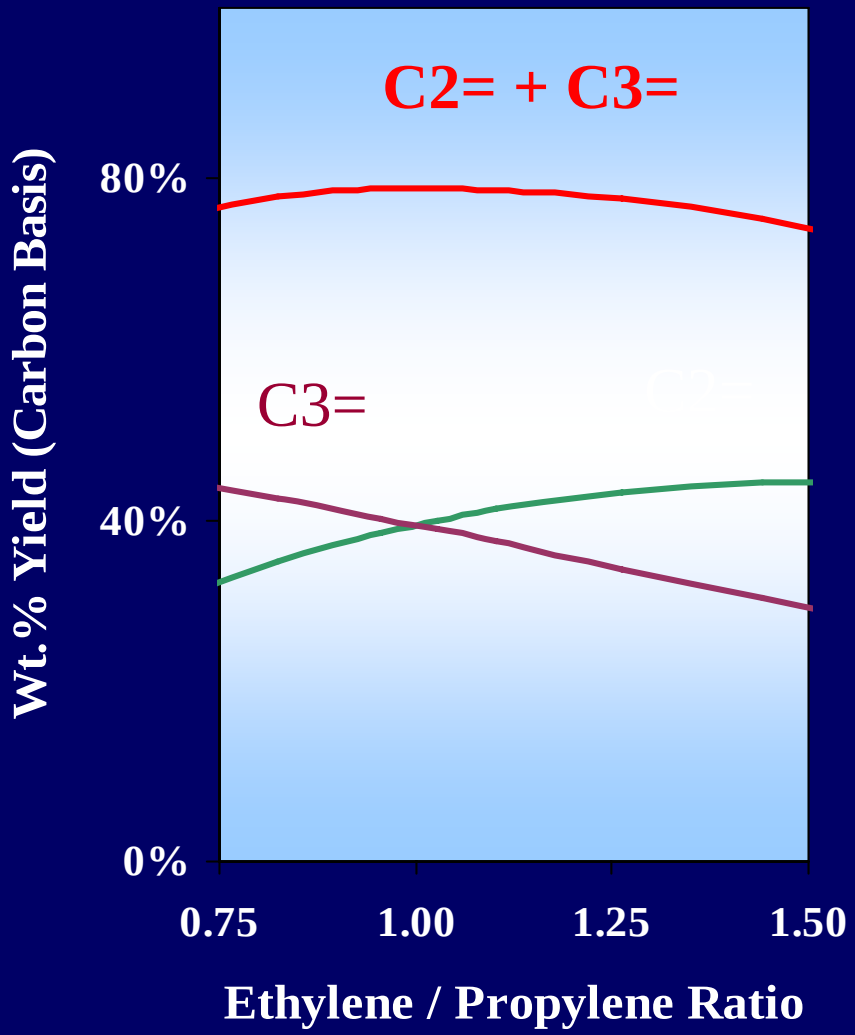


Methanol to Olefins (MTO)

3.8 Angstroms

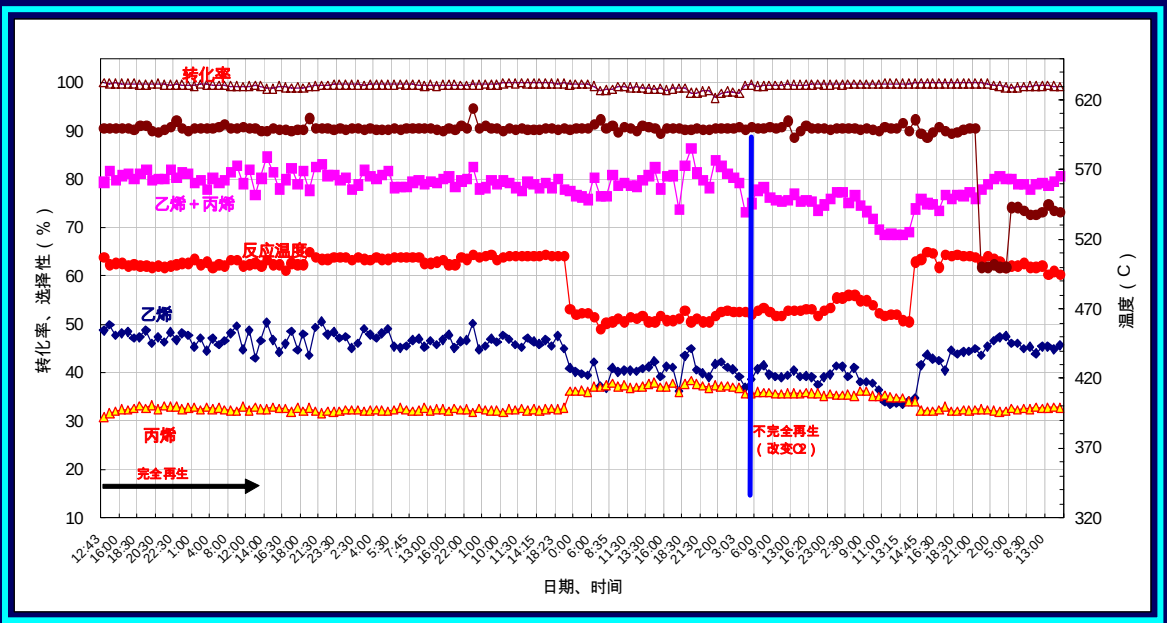


The unique pore size allows the selective conversion to olefins and excludes heavier compounds



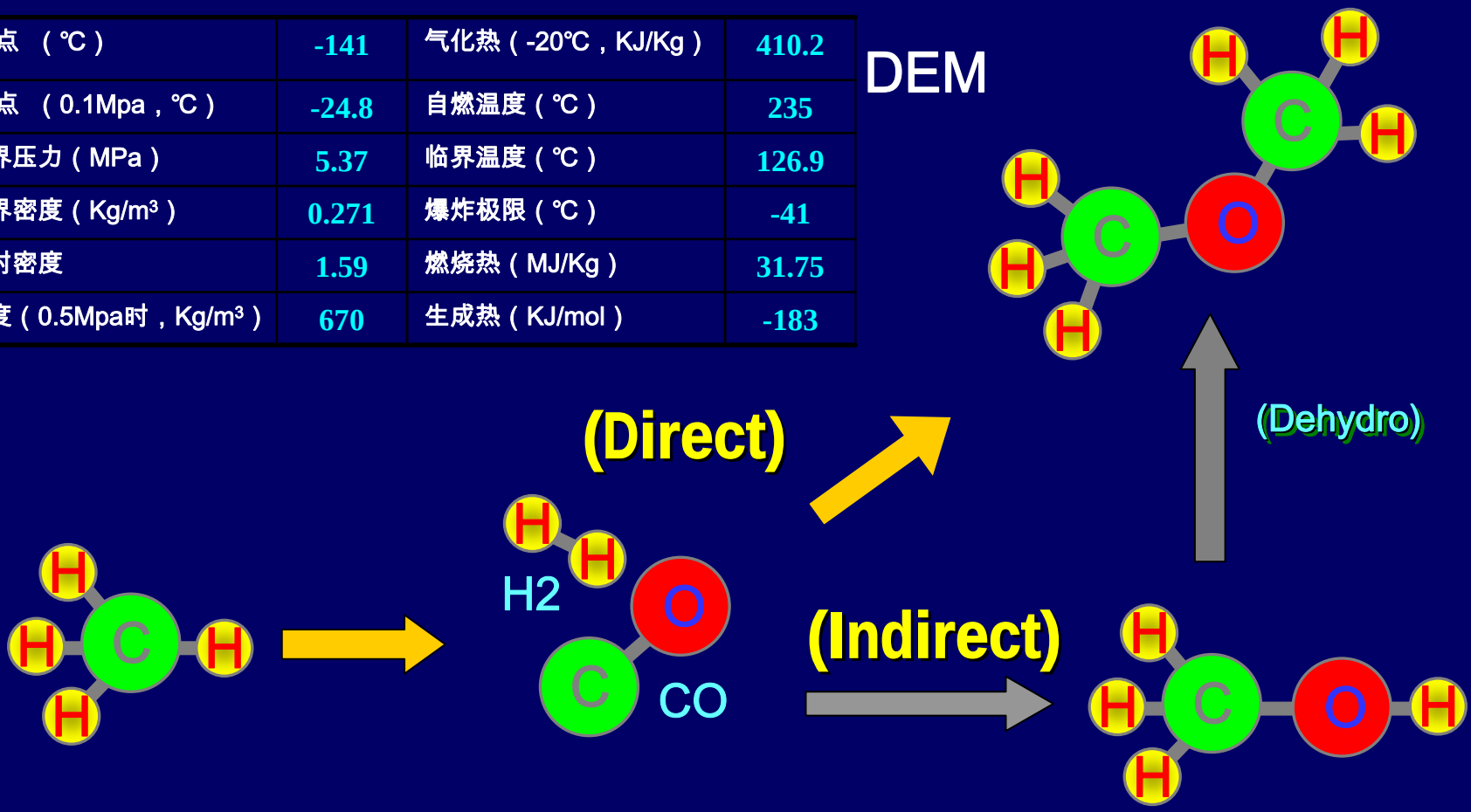
Pilot and Demo of the MTO process

- Shanxi Coal Company （ 86million RMB ）
- Sinopec Leyang Eng. Comp.（ Tech Design ）
- DICP （ Catalyst & Process ）



Dimethyl Ether (DME) and its Manufacture

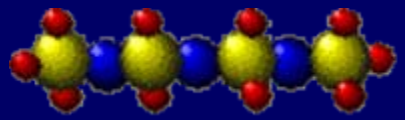
熔 点 （℃）	-141	气化热（-20℃，KJ/Kg）	410.2
沸 点 （0.1Mpa，℃）	-24.8	自燃温度（℃）	235
临界压力（MPa）	5.37	临界温度（℃）	126.9
临界密度（Kg/m³）	0.271	爆炸极限（℃）	-41
相对密度	1.59	燃烧热（MJ/Kg）	31.75
密度（0.5Mpa时，Kg/m³）	670	生成热（KJ/mol）	-183



"Poly-DME-DMM" _Diesel Substitution

DME

Dimethoxymethane (DMM)



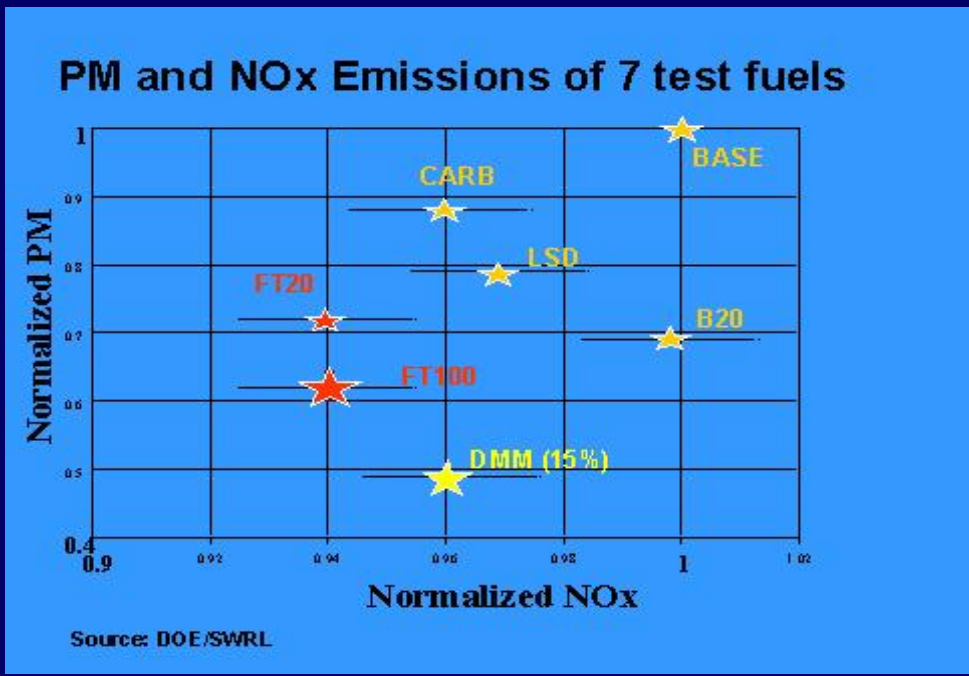
Dimethyldioxymethylene (DMM_2)

Poly-Dimethoxymethane (DMM_x)

	DMM	DMM_2	DMM_{3-8}
BP, ºF	42	105	152-315
Flash Pt., ºF	0	<24	65
Cetane No.	28	41	76

DMM_{3-8}

- Most suitable DME analog
- Can be blended with diesel without engine modifications
- Low emissions in engine testing
- Made from methanol, DME and formaldehyde via low temperature catalytic distillation reactor with acidic catalyst



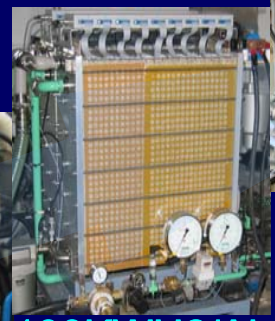
Development of PE Fuel Cell

FUEL CELL ENGINE

2004

150kwH2/Air

2003.12



100KWH2/Air

2003.10

100KWH2/Air

2003.8

90KWH2/Air

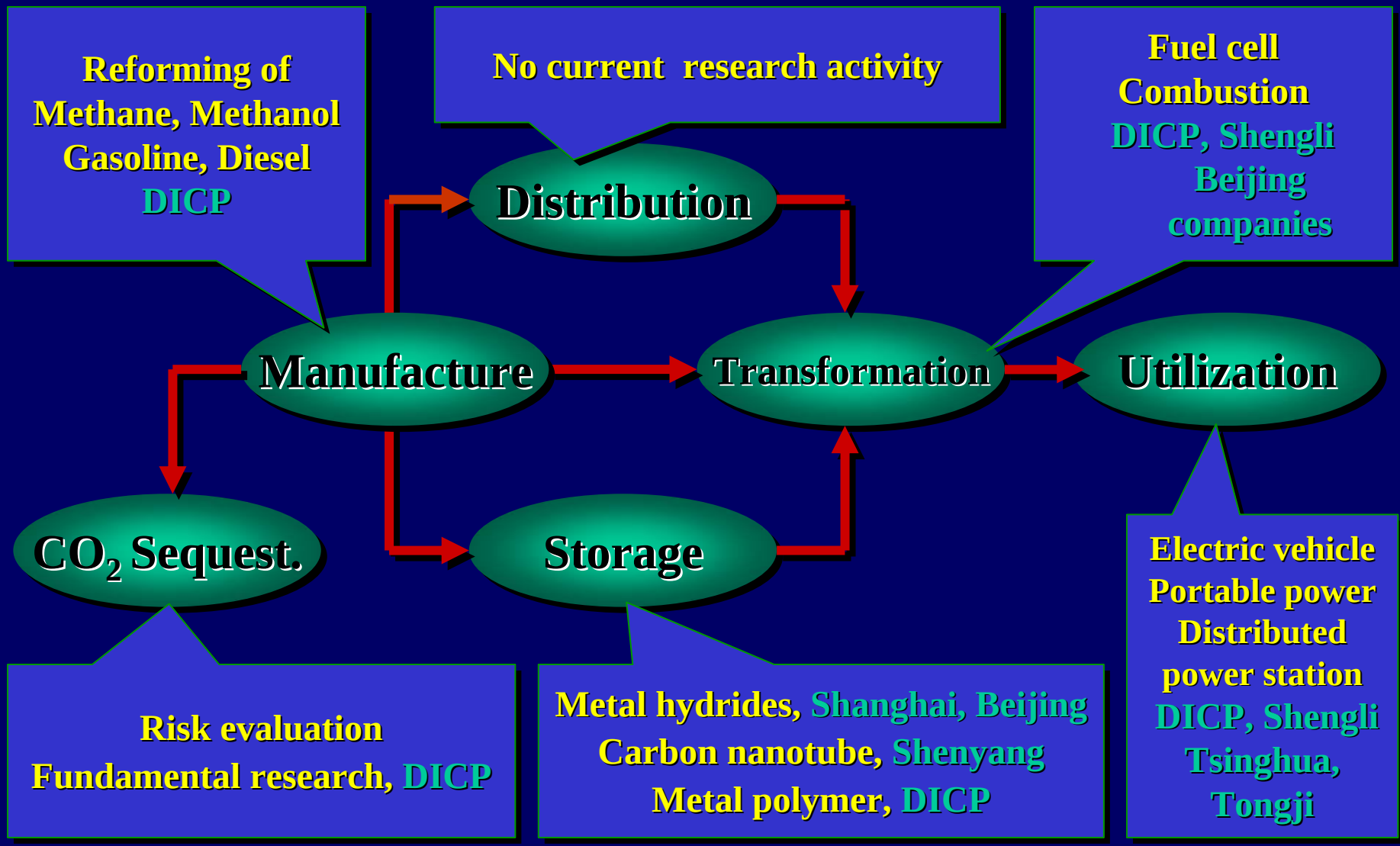
2002

75KWH2/Air

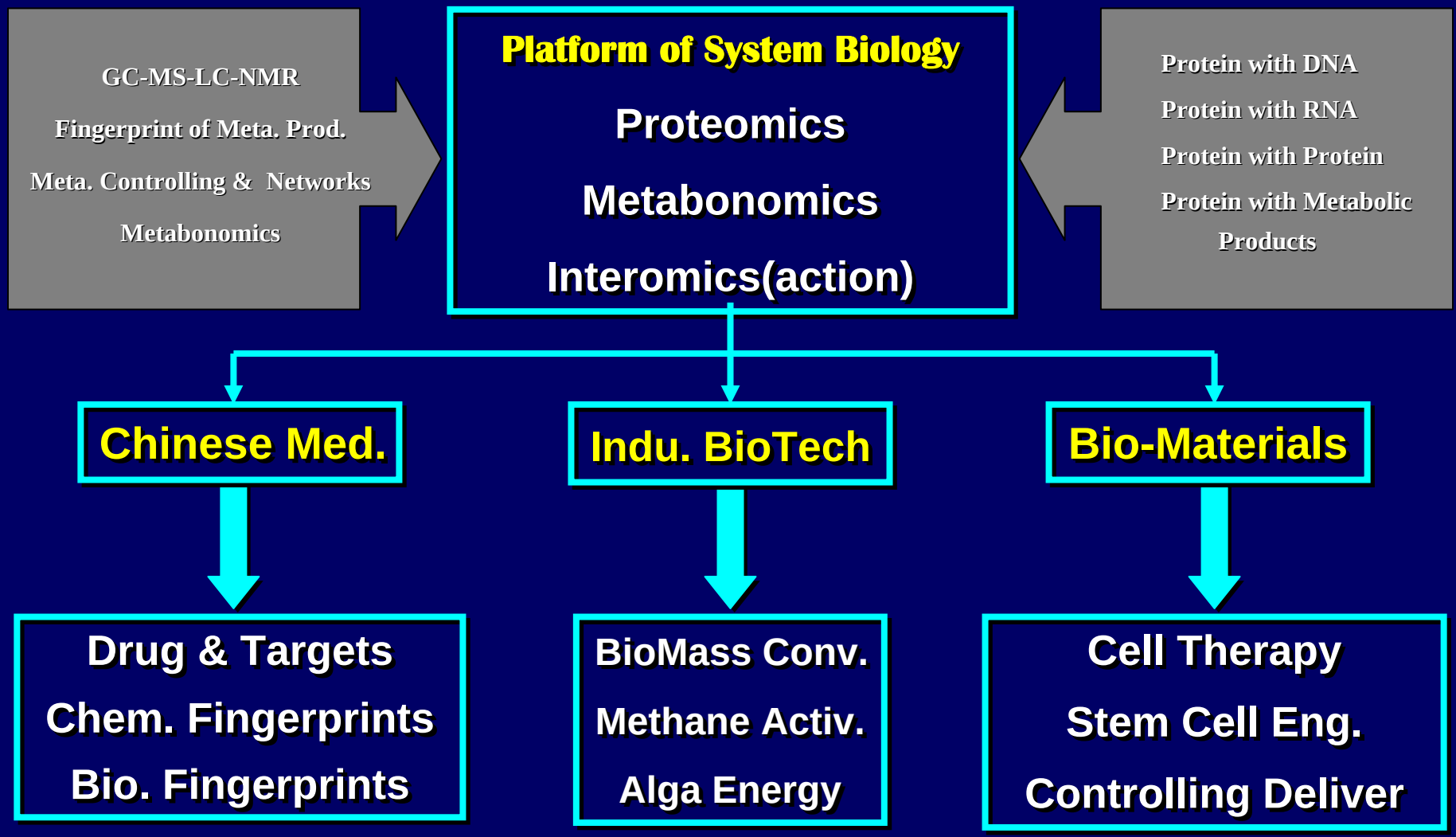
2000

30KWH2/O2

Hydrogen Related Researches in DICP



Strategy of Bio-Technology in DICP



Biomass Utilization at DICP

Biomass
- Residue Harvesting
- Energy Crops

Cat.

Sugar Platform
- Enzymatic Hydrolysis
- Lignin Products

Products
- Fuels, chemicals
- Materials
- Heat & Power

Thermochem. Platform
- Pyrolysis
- Gasification

Biorefineries

Biodiesel from CAS

1MW BGPG Power Plant from CAS

Dalian National Lab of Clean Energy

Oil & Gas Conver.

Fuel Cell & hydrogen

Bio-Energy

Solar Energy

Energy Environment

Energy Fundament

Strategic & evalu.

National Eng. Cent.

State Key Lab.

Research Cent of DICP

Sinopec

PetroChina

Gov. Program

Foundation

Enterprises

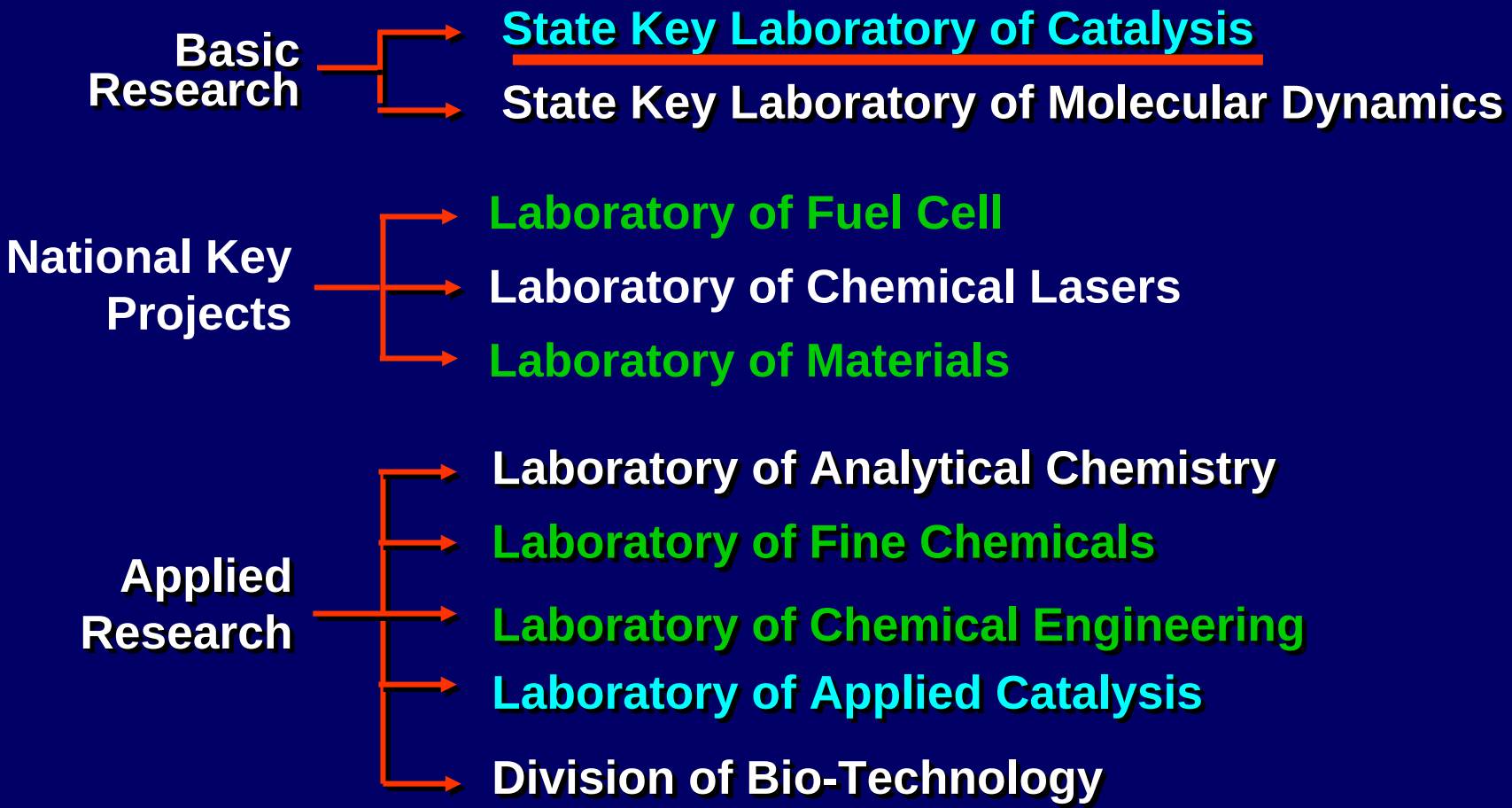
Energy Demo

SINOPEC、BP、Gov.

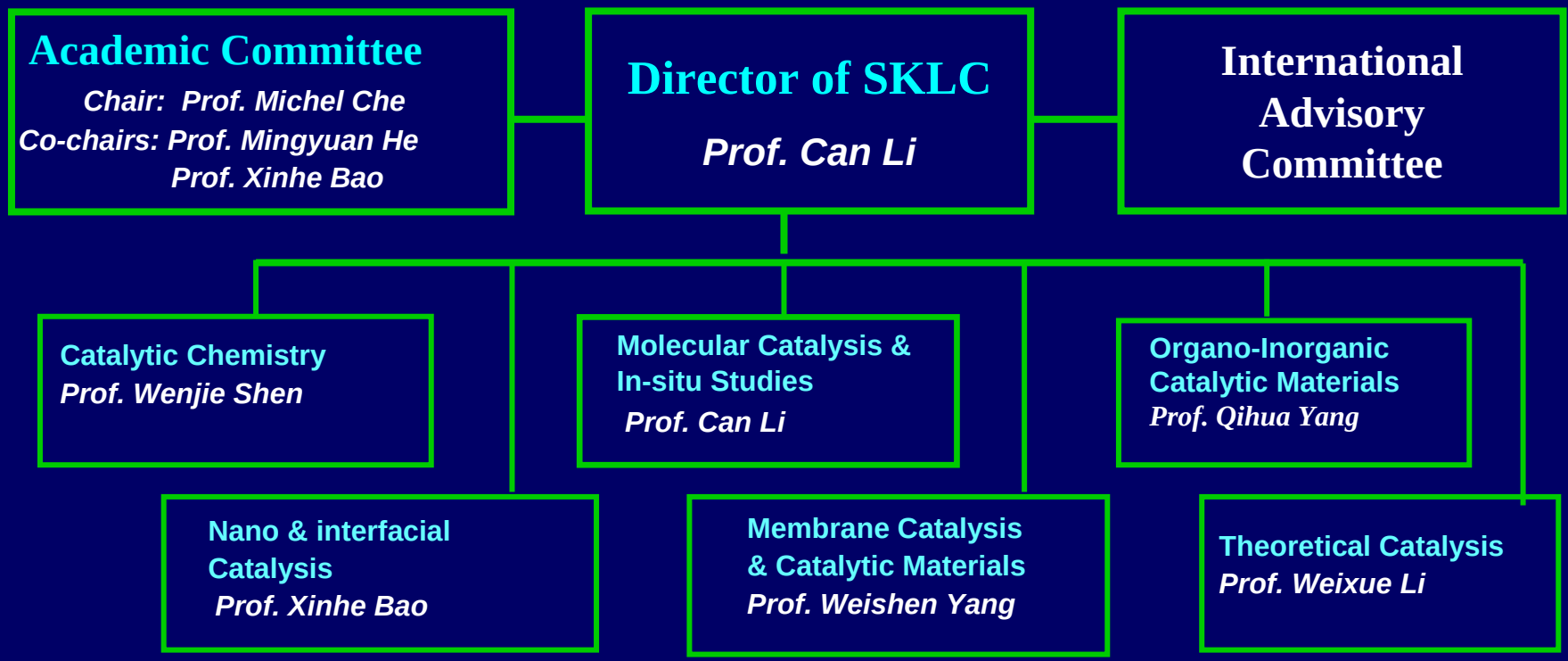
International Co.

BP、CNRS、BASF

Catalysis researches at DICP



the State Key Laboratory of Catalysis (SKLC)



Cooperated with applied research labs.

- Laboratory for Environmental Catalysis and Technology
- Laboratory for Applied Catalysis and Natural Gas Conversion
- Laboratory for Fine Chemicals
- National Center for Catalytic Technology Development

The present research Activities

- Energy Catalysis

  Fuel Cell, Hydrogen production, C1 Chemistry, Photocatalysis,
- Environmental Catalysis

  NOx redution, VOCs oxidation and

  ultra-deep desulfurization and denitrogenation
- Catalysis for Fine Chemicals and Chiral Products

  Asymmetric synthesis, selective oxidation and hydrogenation
- Nanocatalysis and Advanced Catalytic Materials

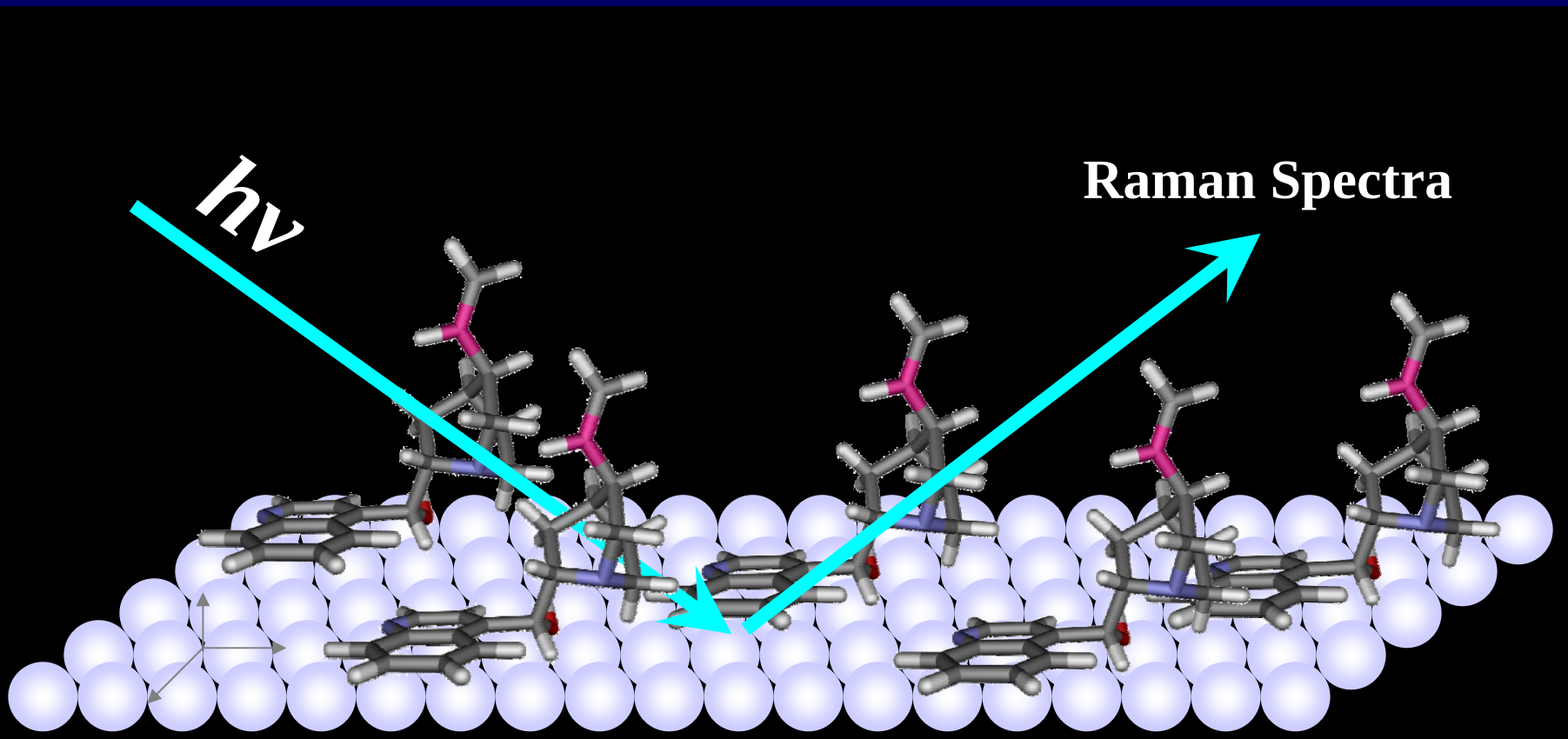
  Au, Ag and noble metals, CO oxidation
- In-situ, dynamic, time-resolved characterizations
- Theoretical catalysis

Catalyst Characterizations

- **In-situ characterization**
  FT-IR, NMR, UV Raman, Laser Raman, TPSR, TGA-DTA, ...
- **Dynamics and kinetics**
  PEEM, Time-resolved Spectroscopy, LISF, TPD-Mass,, ...
- **Structures of real catalysts**
  XRD, SEM, TEM, EDX, BET, ...
- **Atomic, molecular and nano scale**
  Multi Nano-Probe, HREELS, XPS, AES, LEED,

Achievements: Example 1

UV Resonance Raman Spectroscopic Studies on Catalysis

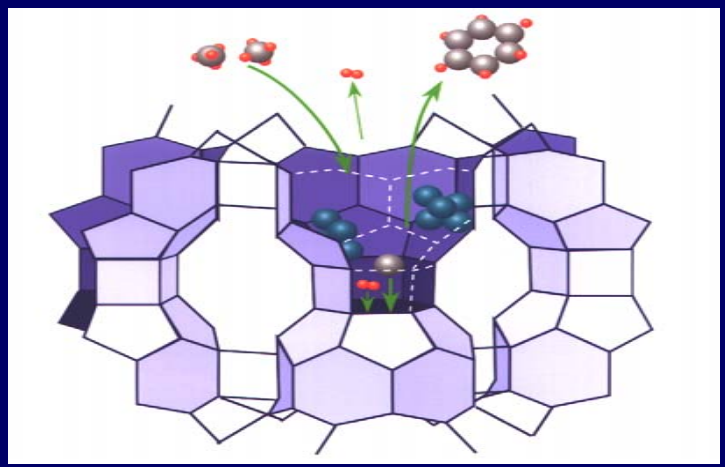


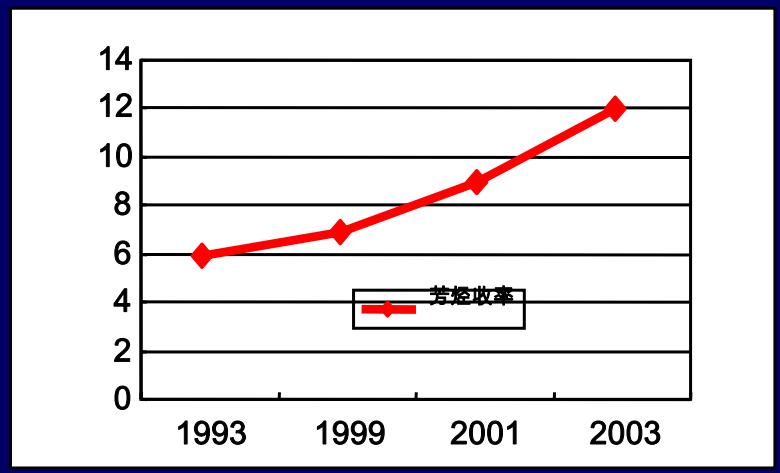
Non-oxidative Aromatization of Methane

$$6CH_4 \xrightarrow{Mo/ZSM\text{-}5} Ben + 9H_2$$

$9H_2$ → Eng.

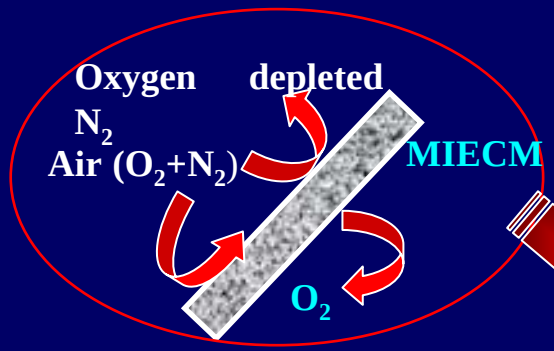
Ben → chemicals





Achievements: Example 3

Applications of Mixed Ion & Electron Conductivity Oxygen Permeable Membrane



Dense ceramic membrane with mixed oxygen ionic and electronic conductivity

- 制氧 Oxygen production
- 甲烷氧化耦联 Oxidative coupling of methane
- 烃类的部分氧化 Partial oxidation of hydrocarbons
- 烃类的选择氧化 Selective oxidation of hydrocarbons
- 烃类的氧化脱氢 Oxidative dehydrogenation of hydrocarbons

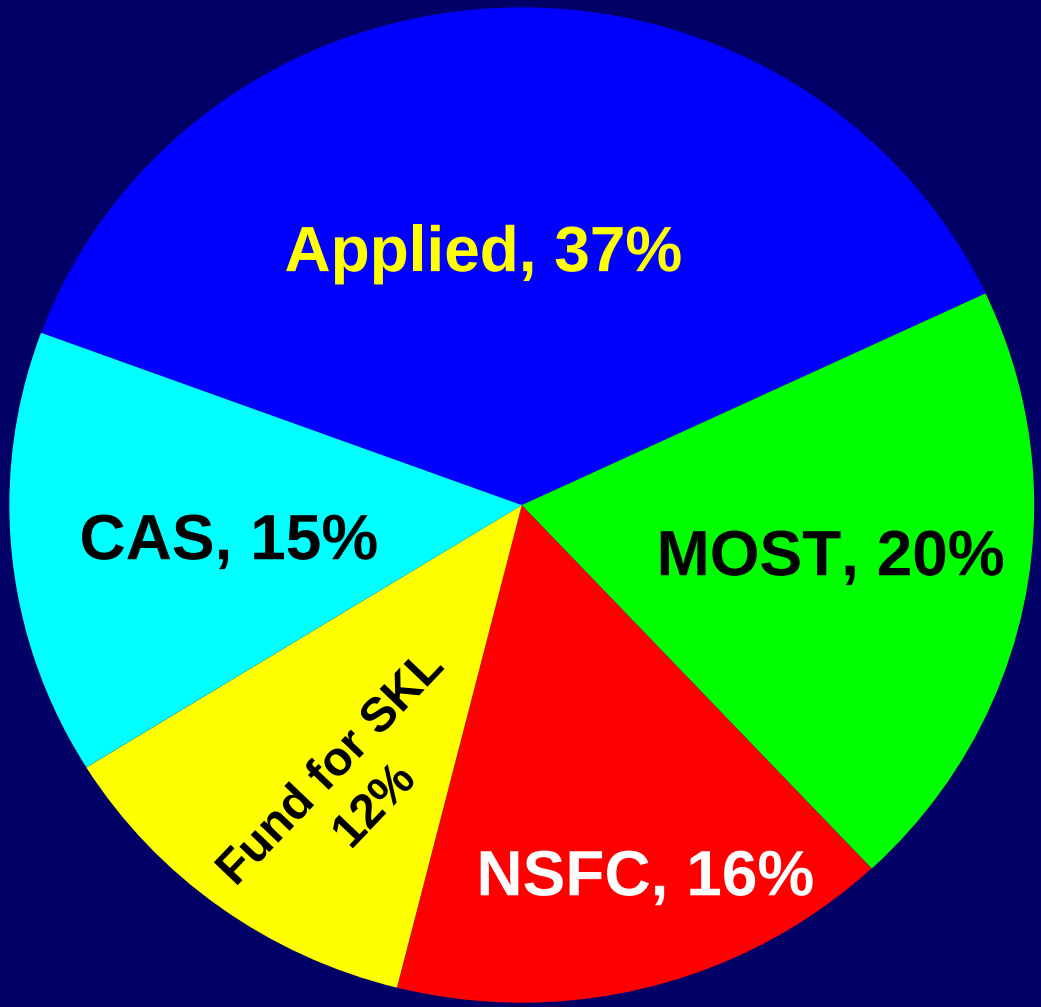
Oxygen Production:

- 100%oxygen permeation selectivity
- High oxygen permeation
- Continuous production of oxygen.

Membrane Reactor:

- Combining reaction and air separation into a reactor
- Increasing yield and selectivity by controlling oxygen species
- Being energy efficient and relatively safe to operate
- Avoiding formation of hot spots

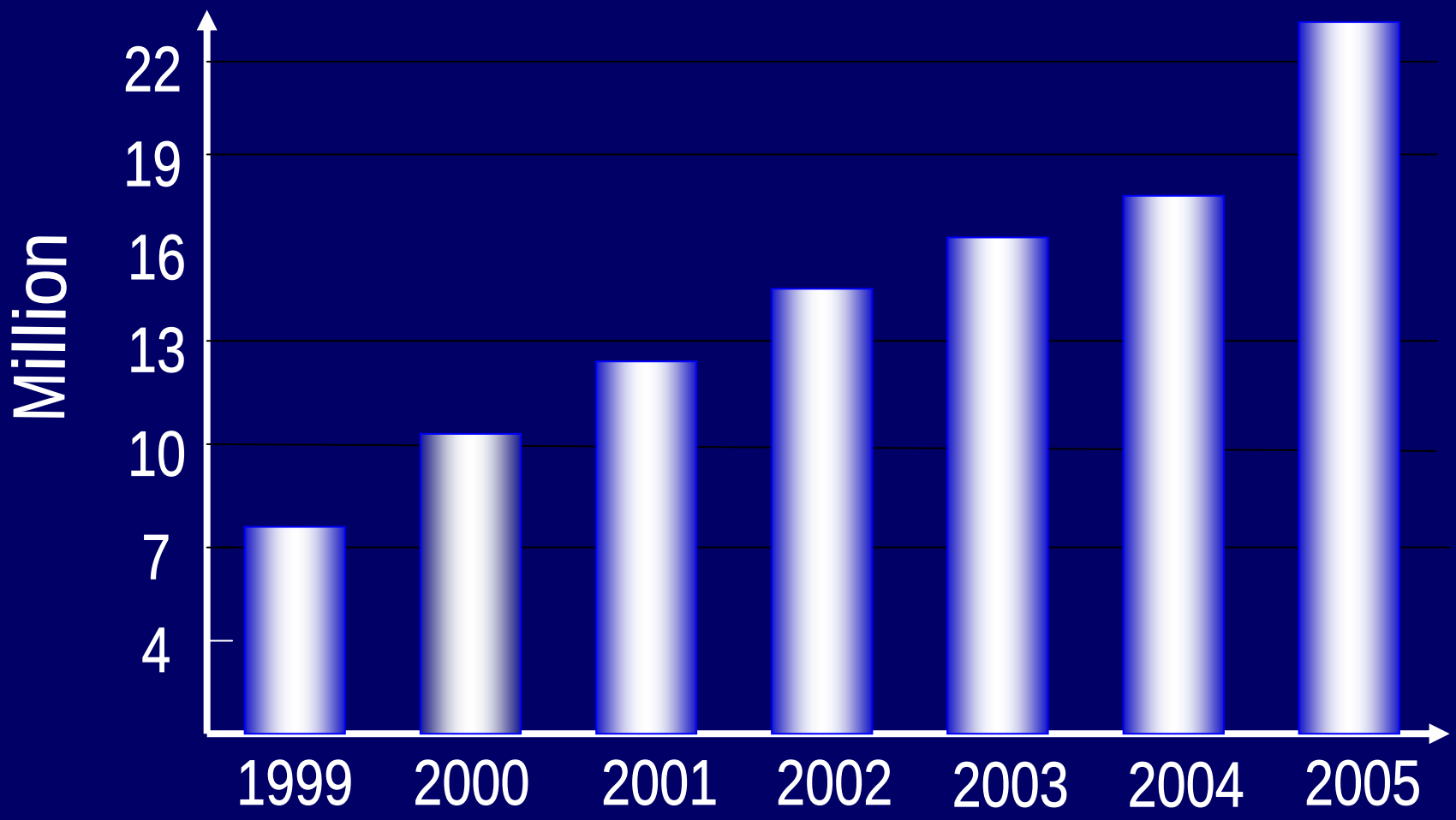
Composition of the Research Projects



Applied, 37%
Fundamental, ~ 63%

MOST: Ministry of Sci. & Tech.
CAS: Chinese Academy of Sciences

Budgets for Research in past years



Researches to be focused

- Scientific bases for renewable energy, environmental begin, human health and better life, and optimized utilization of resources
- Design and synthesis of more active and selective catalysts including based nano materials
- Essential correlation through heterogeneous, homogeneous and enzymatic catalysis. Biocatalysis may play more and more role in synthesis chemistry.
- In-situ, dynamic, spatial and time-resolved characterization together with theoretical calculation may eventually reveal the nature of catalysis and make catalysis a science
- Catalysts with desired functions could be designed and synthesized based on the fundamental understanding

DICP's Activities in International Collaboration

Research Collaboration in DICP

Dispatch and Acceptance of Researchers

Domestic and oversea Organizations

Joint Projects

Domestic and oversea Enterprises

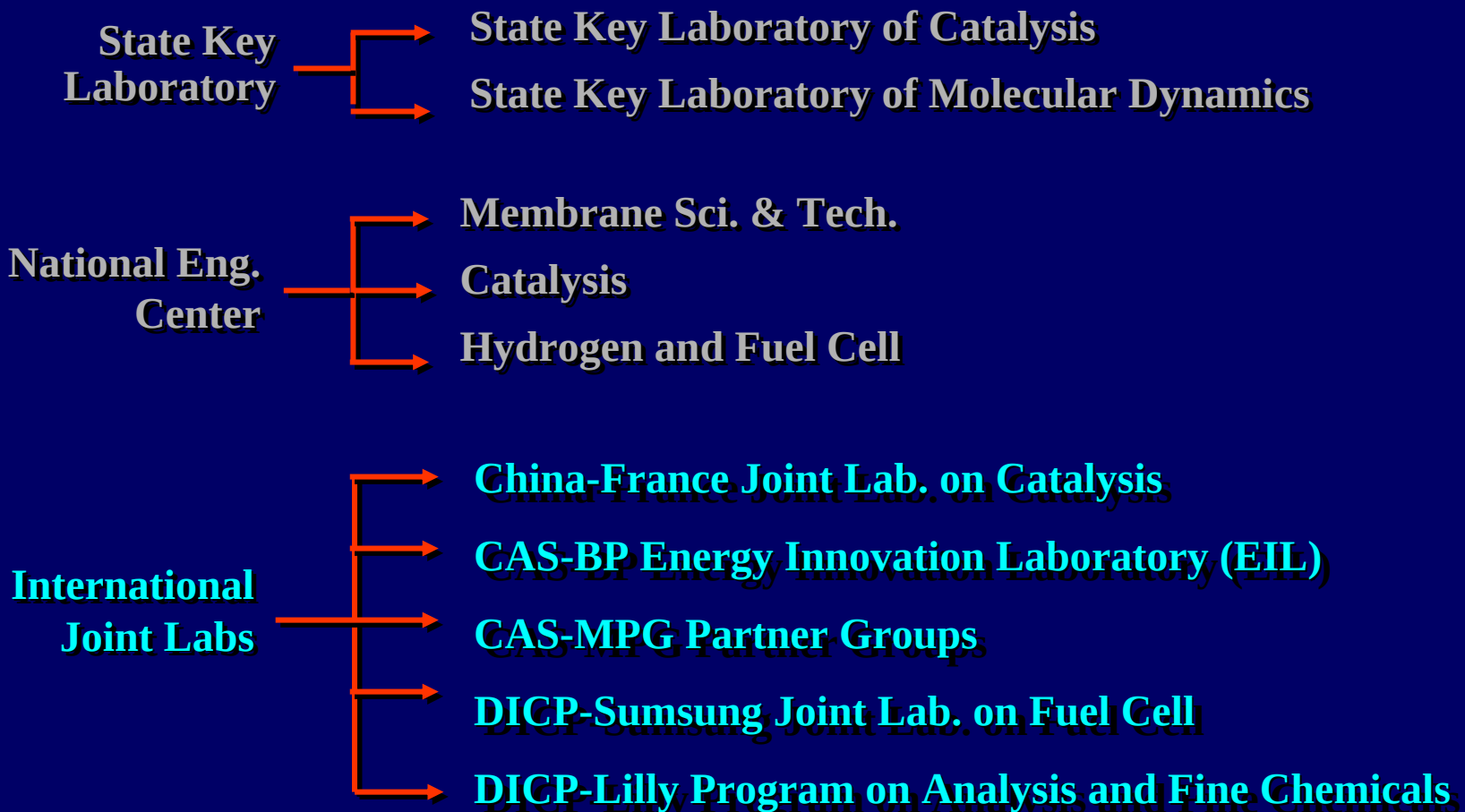
Contract Researches

Domestic and oversea Enterprises

Joint Research Centers

Universities and Enterprises
Government Organizations

International and National Research Organizations at DICP



Collaboration with the Organizations in Europe

- Fuel Cell Testing, Safety and Quality Assurance
- Carbon Dioxide Capture via Hydrogen Energy Technology
- SOFC Stack Technology for Operation at 600℃

- Gene Technique with Uni. of Aarhus
- Oligosaccharides with TCM-denmark

- PEM Fuel Cell with Lund Institute of Technology
- Sino-Swedish Workshop on FC

- CAS-BP Clean Energy Program
- DICP-Cambridge Training Project

- MPG-CAS Partner Group
- DFG-NSFC Fuel Cell Program
- DICP-BASF INCON project
- DICP-Bayer Project

- Metabolomics for Traditional Chinese Medicine
- Catalysis

- Joint Lab of Catalysis with CNRS

Cooperation Partner between UCSB and DICP Supported by NSF

THE PARTNERSHIP FOR INTERNATIONAL RESEARCH AND EDUCATION AT THE UNIVERSITY OF CALIFORNIA

ELECTRON CHEMISTRY AND CATALYSIS AT INTERFACES

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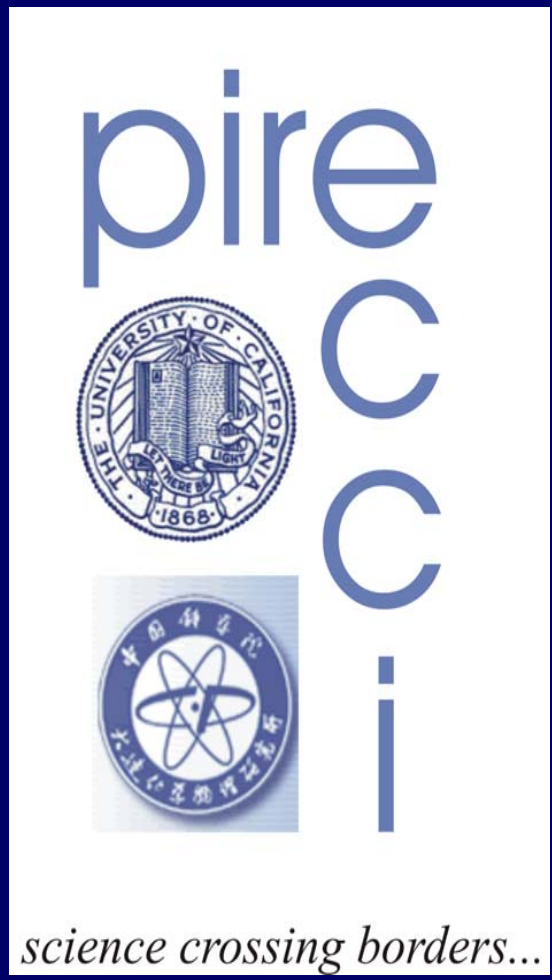


To Enhance Comprehensive Cooperation at DICP

- Special funds for international cooperation and exchange

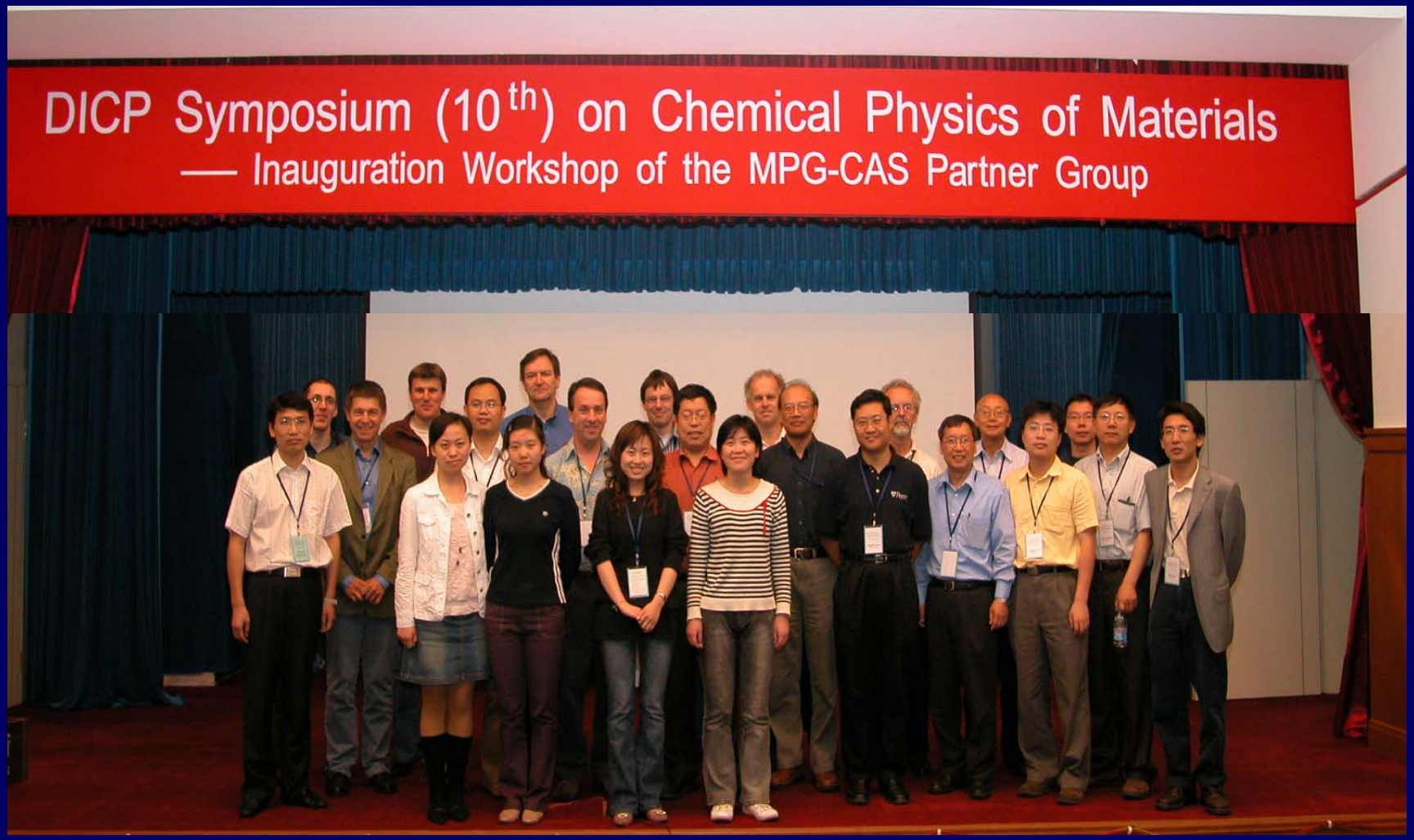
  (1 million RMB per year for travel and accommodation, i.e. student, postdoctoral researcher)

- Special funds for scientific symposia in DICP

  (1 million RMB per year for scientific program & costs)

- Open grants and projects for joint research

DICP Symposium



Thank for Attention

Welcome to DICP