

# Development of Global CO<sub>2</sub> Recycling Technology Towards “Beyond-Zero” Emissions

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**Kyushu Univ.**

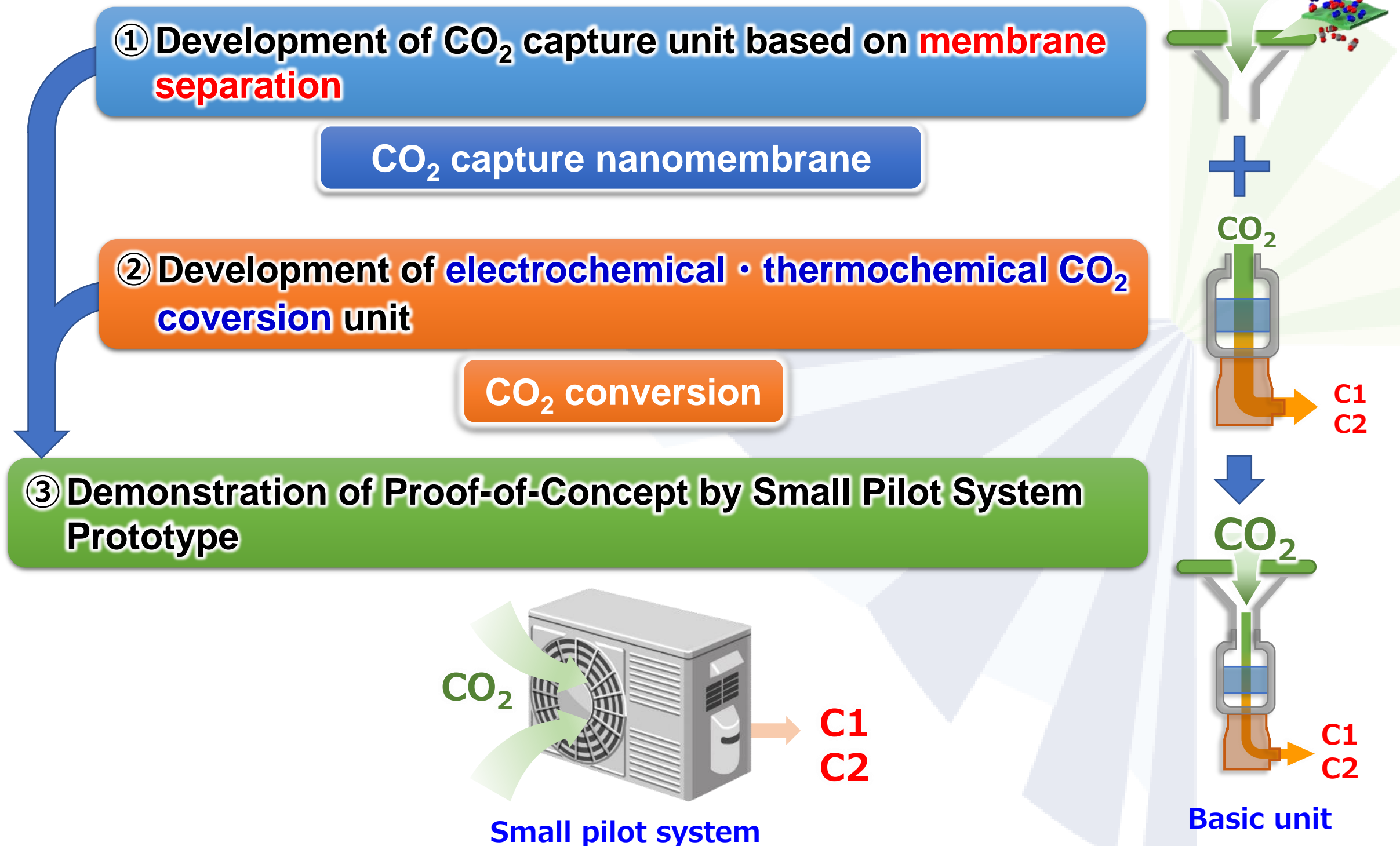
**International Institute for Carbon Neutral Energy Research**

**PJ Institutes:**

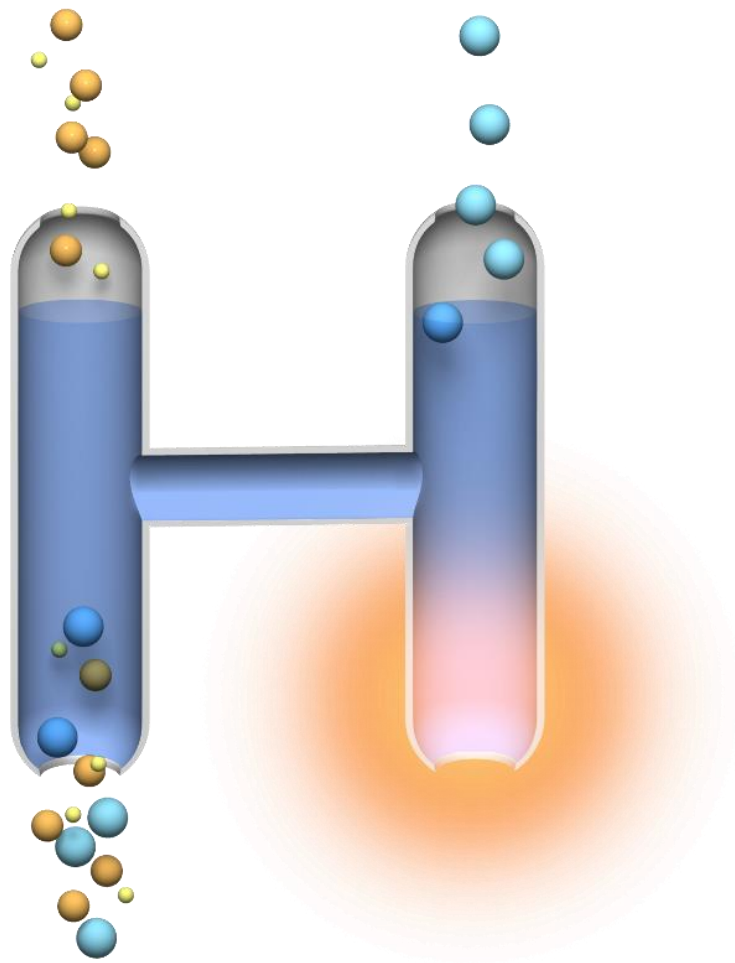
**Kyushu Univ., Kumamoto Univ., Hokkaido Univ., Kagoshima Univ., Univ. Tokyo,  
Osaka Inst. Tech., Univ. Illinois at Urbana Champaign, NanoMembrane Tech. Inc.**

## 【Our goal】

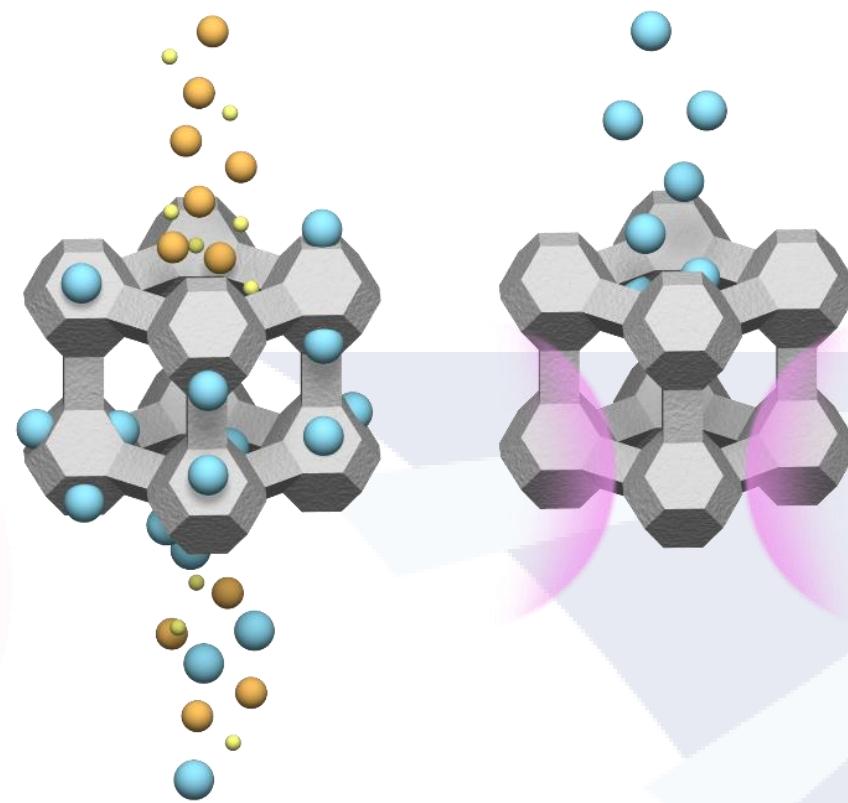
The **Direct Air Capture and Utilization (DAC-U) system**, which is compact, scalable, and decentralizable, continuously captures  $\text{CO}_2$  from the atmosphere and converts it into carbon resources.



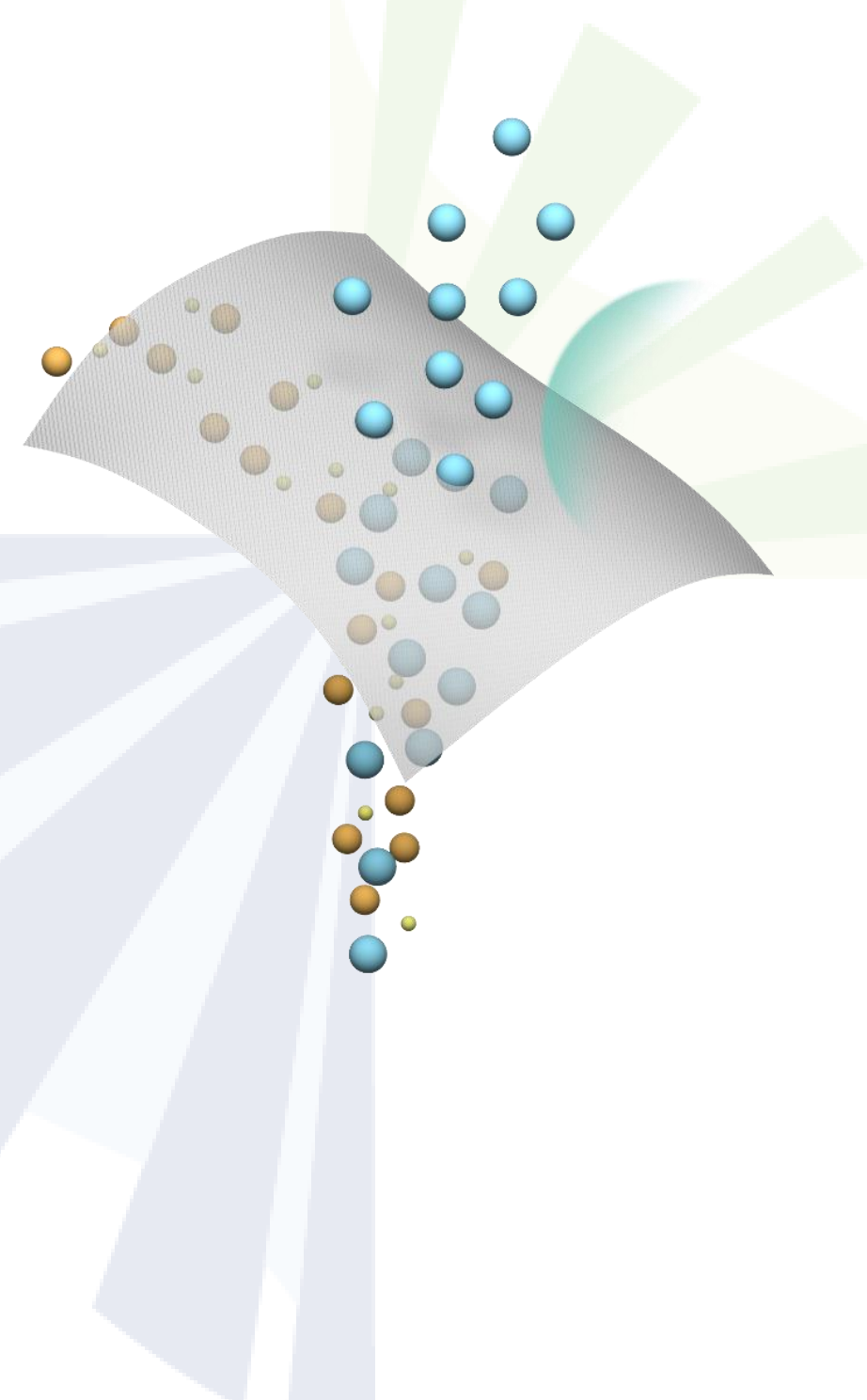
**absorption**

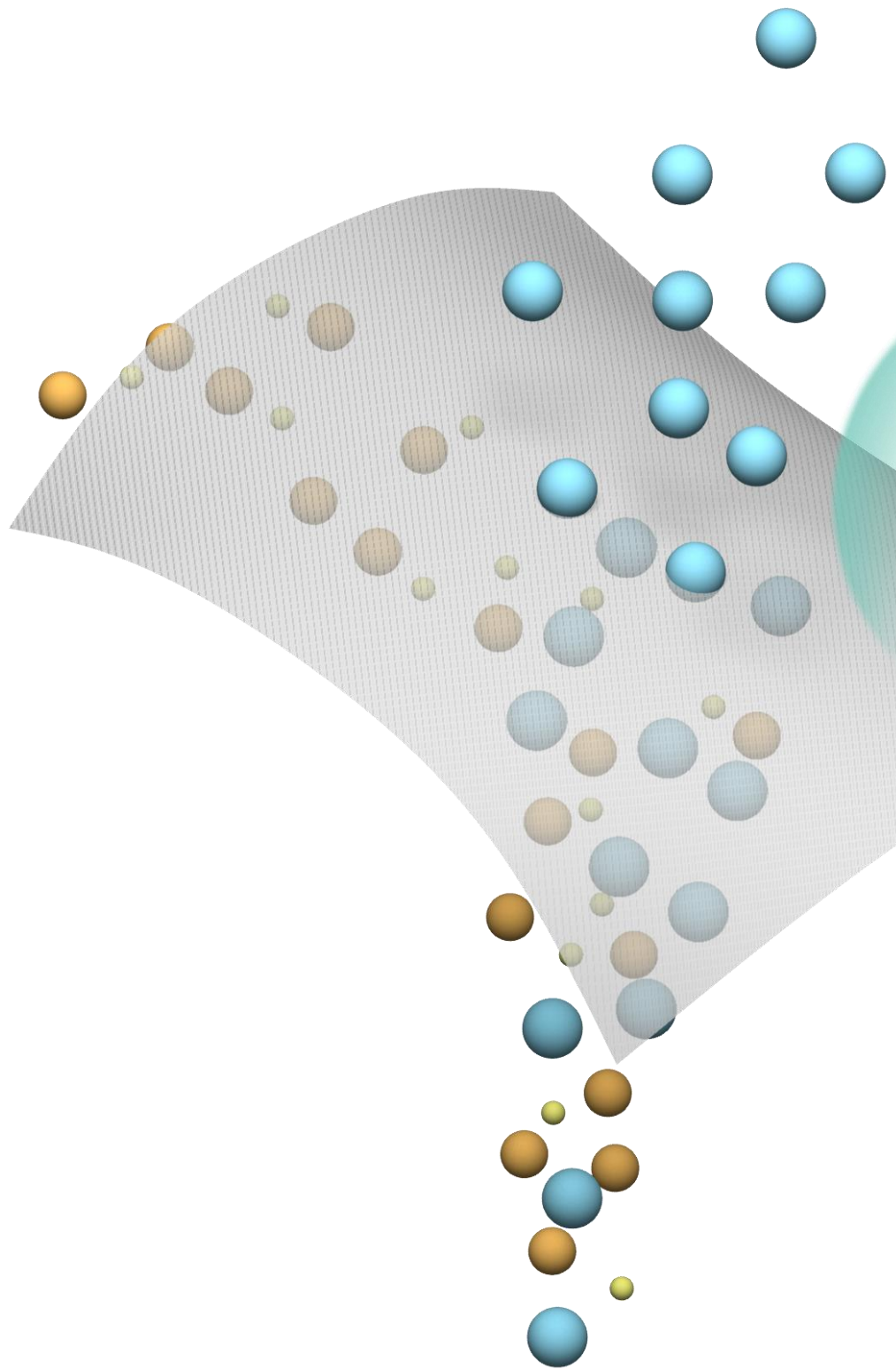


**adsorption**



**membrane**





- **Simple process**
- **Low cost • small foot print**
- **Size adjustable**
- **No hazardous chemicals**
- **Installation site free**

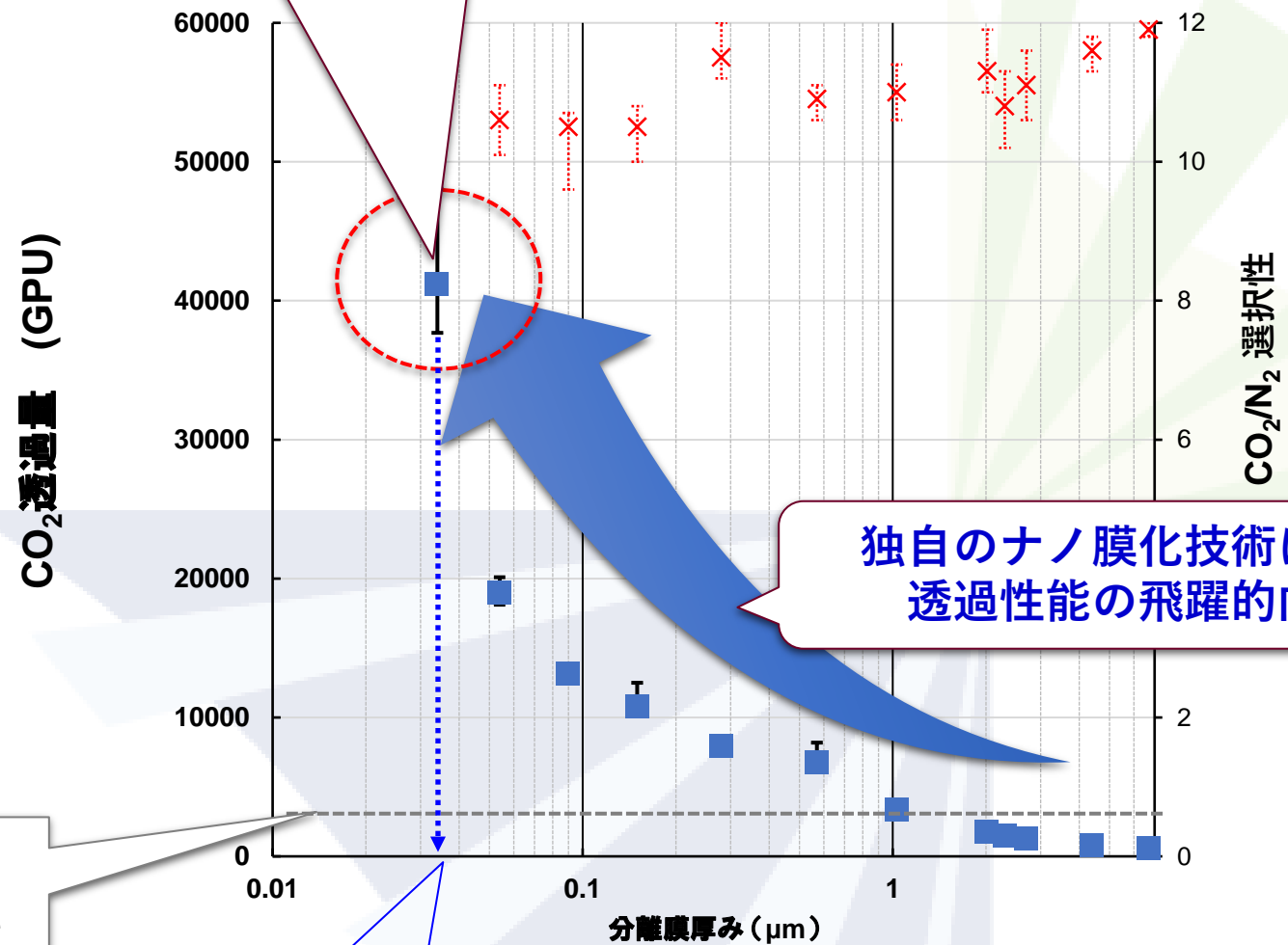


**CO<sub>2</sub> capture anywhere**

## Free-standing nanomembrane for CO<sub>2</sub> separation



World-high CO<sub>2</sub> permeance by nanomembrane

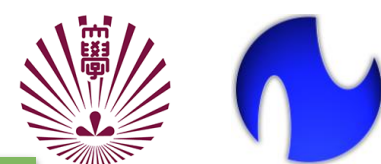


Conventional Performance in the past (2,000~3,000 GPU)

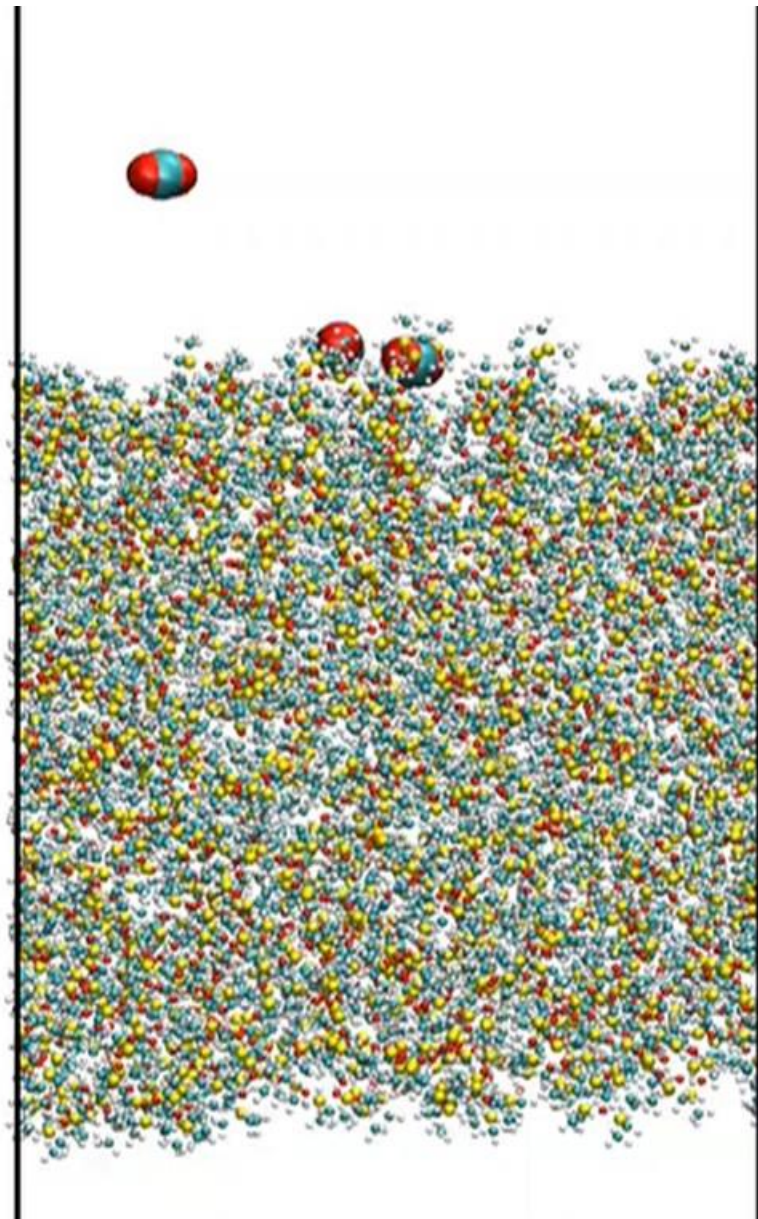
独自のナノ膜化技術による透過性能の飛躍的向上

Thickness: 34nm

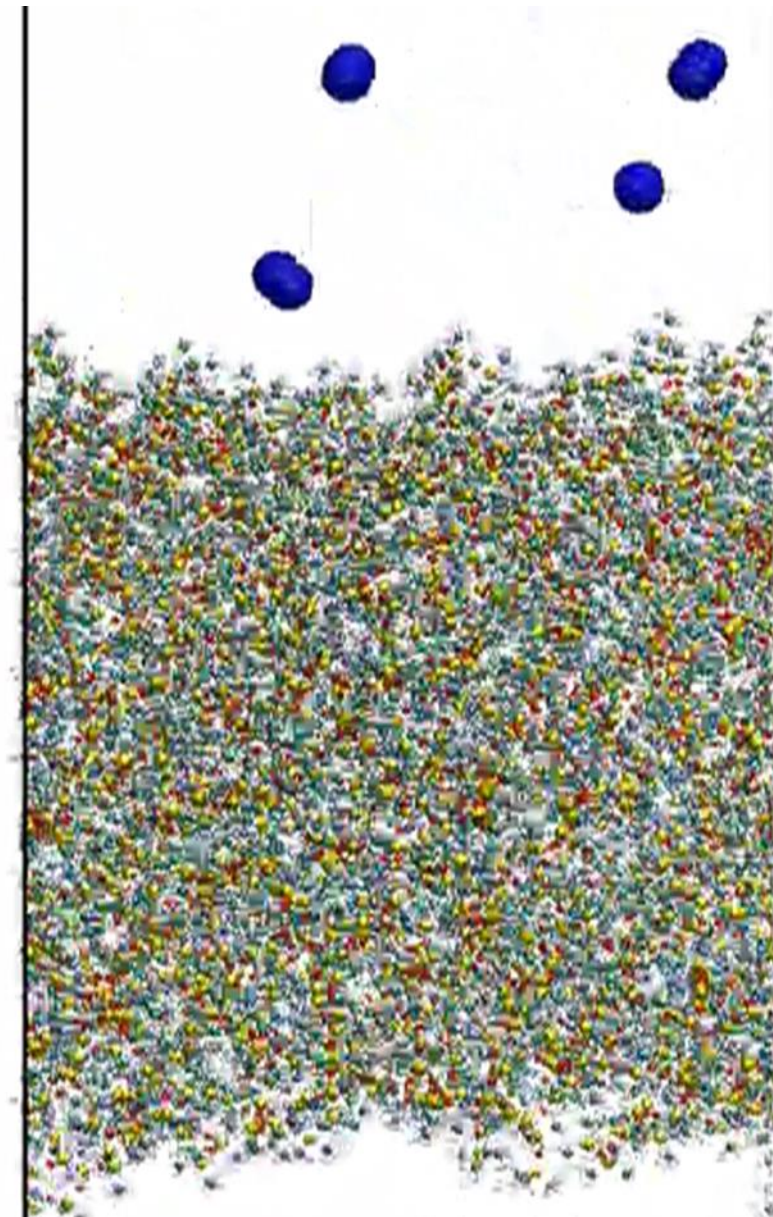
Realization of DAC using separation membrane, previously thought to be impossible



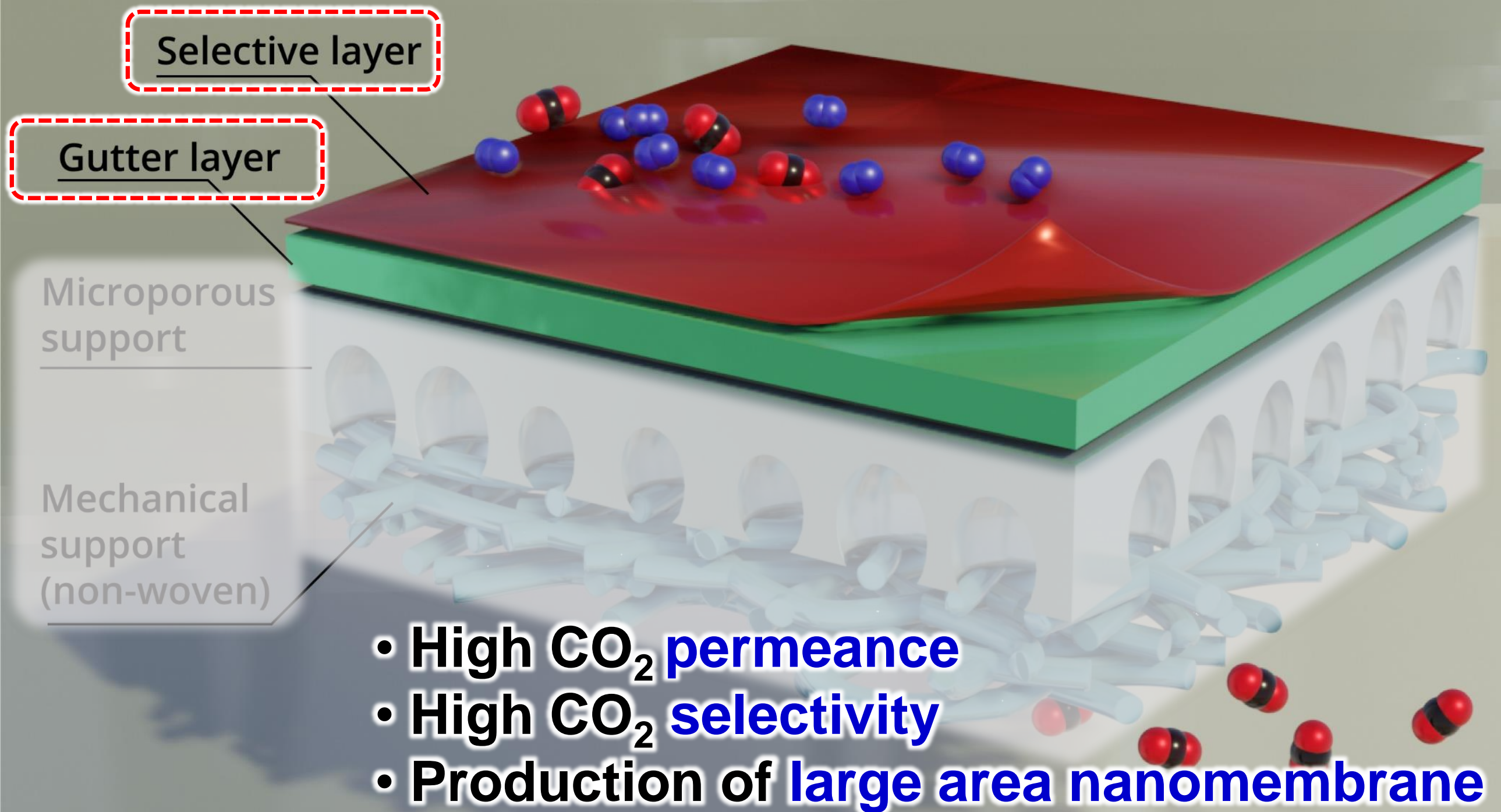
**CO<sub>2</sub>**



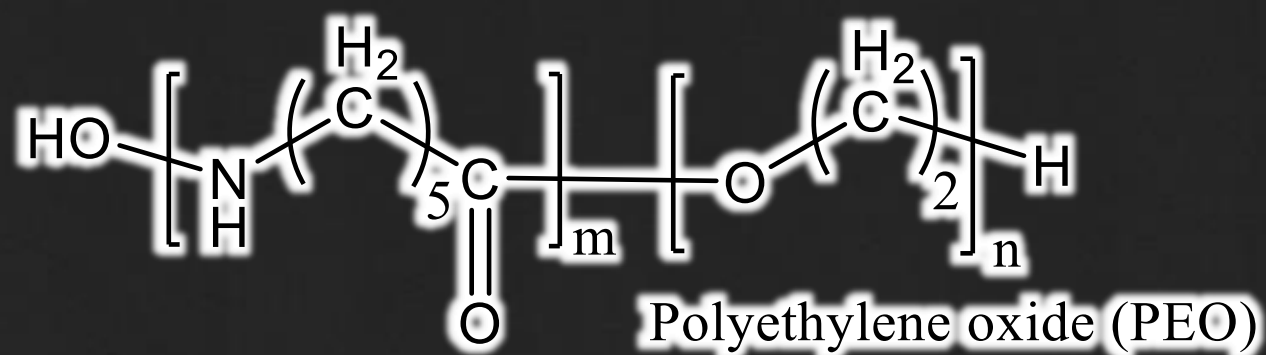
**N<sub>2</sub>**



**Prof. S. Okazaki, Dr. T. Nagai  
(Univ. Tokyo)**



## Selective layer (Pebax-1657)



~10 nm

~250 nm

gutter layer (PDMS)

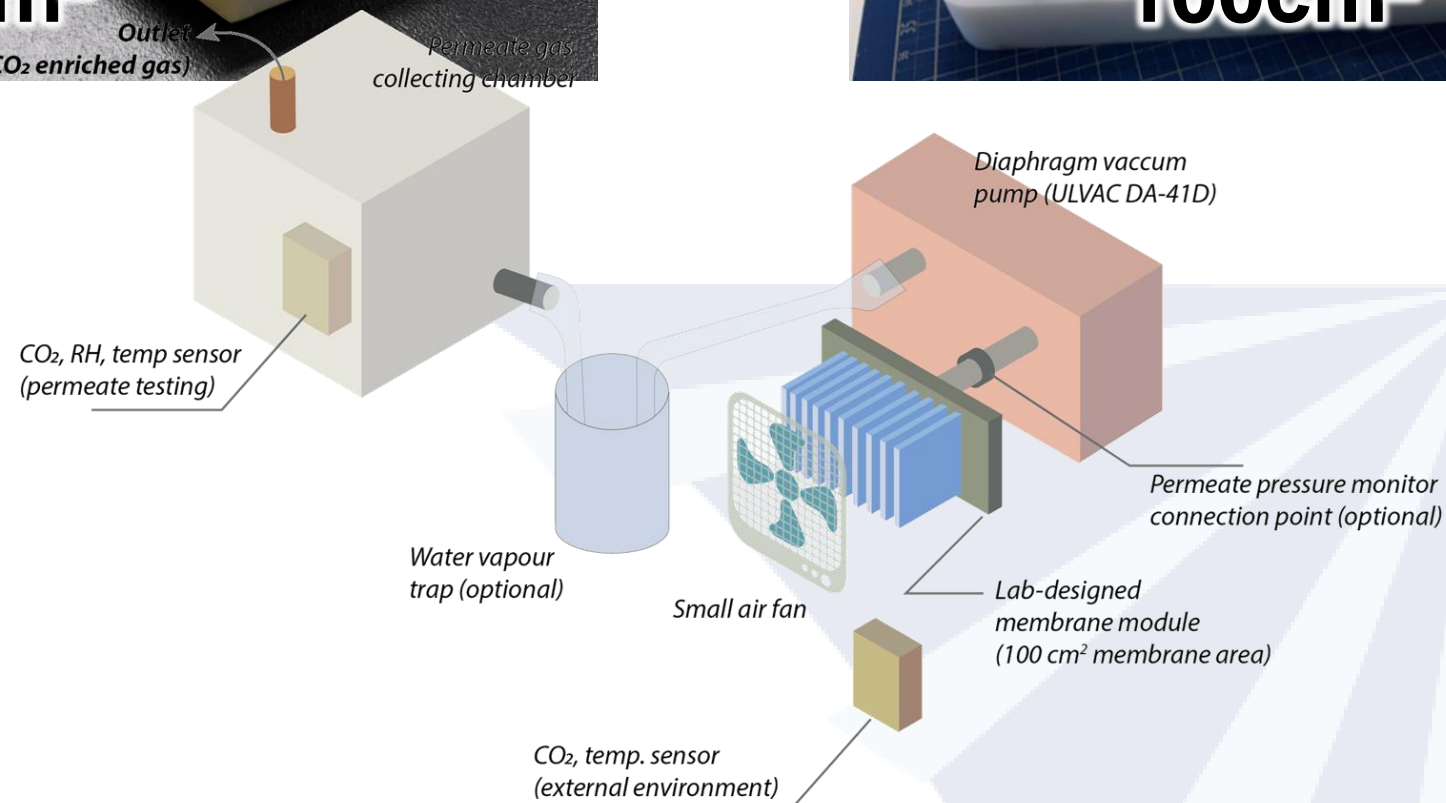
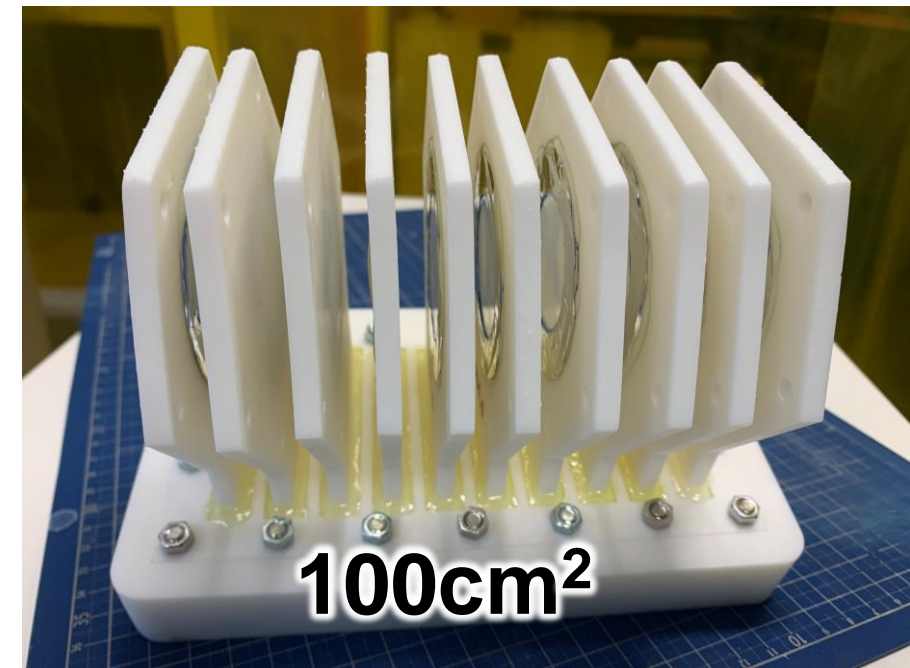
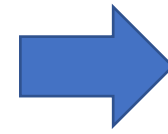
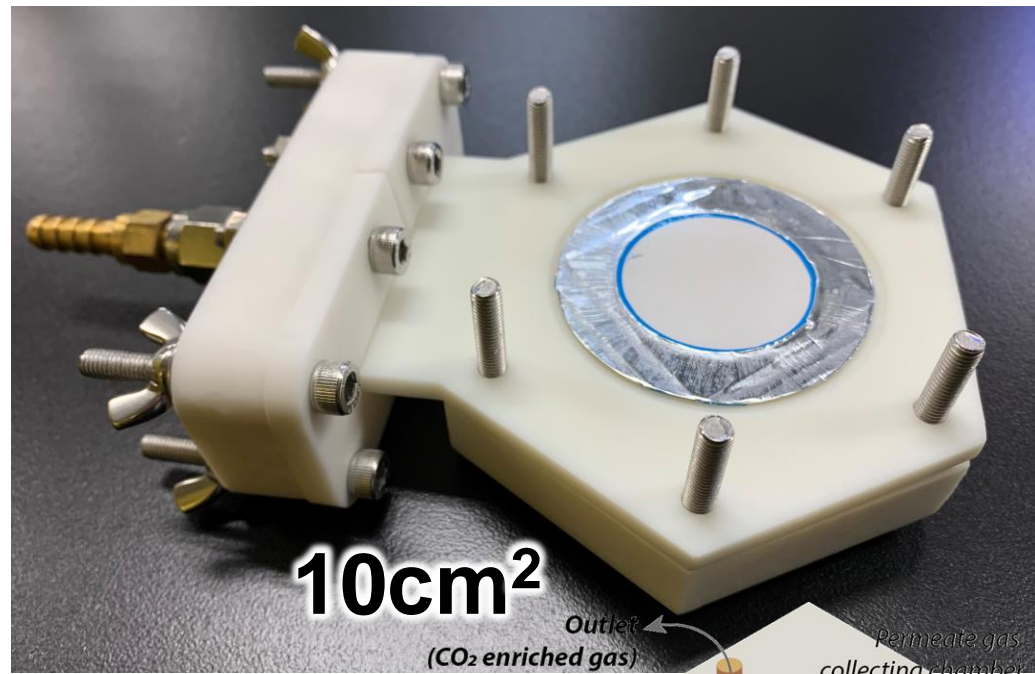
**CO<sub>2</sub>/N<sub>2</sub> selectivity : 23~72**

porous support layer (PAN)

200 nm



# Large-area and modularization of separation nanomembranes



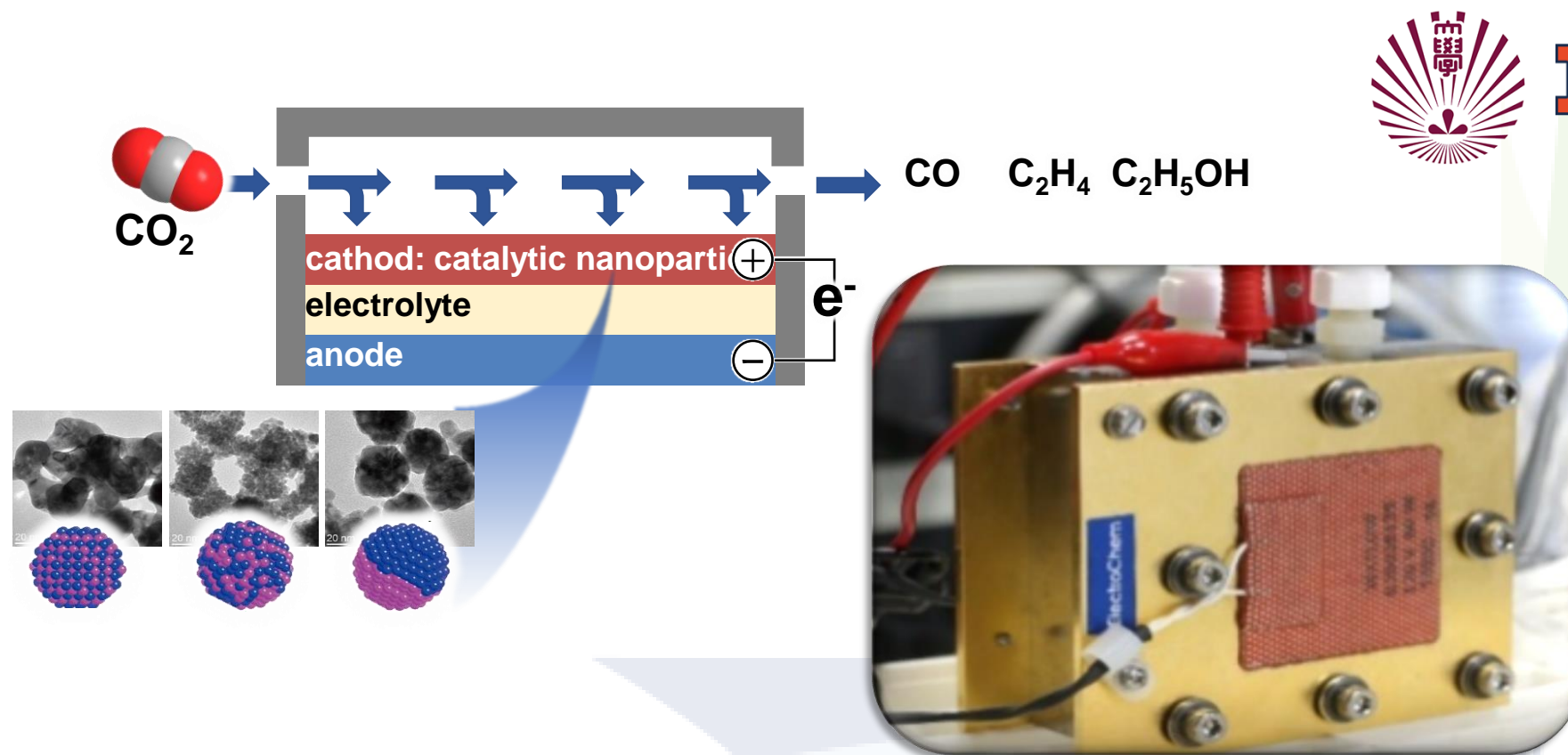
**Single step separation : 4.2 times concentration  
(Theoretical number : 5.2 times)**



**Multi-step separation**



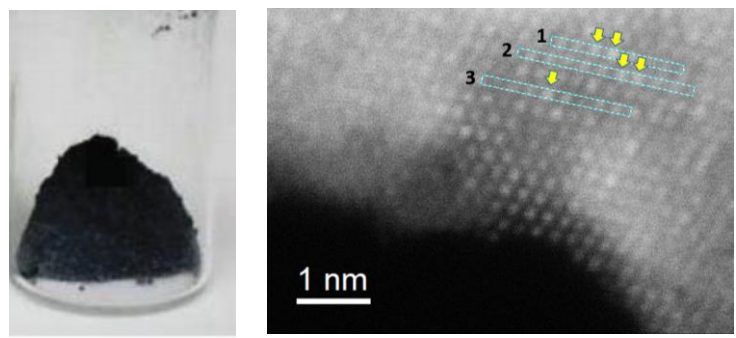
## Production of carbon resources from CO<sub>2</sub> mixed gas separated by nanomembranes



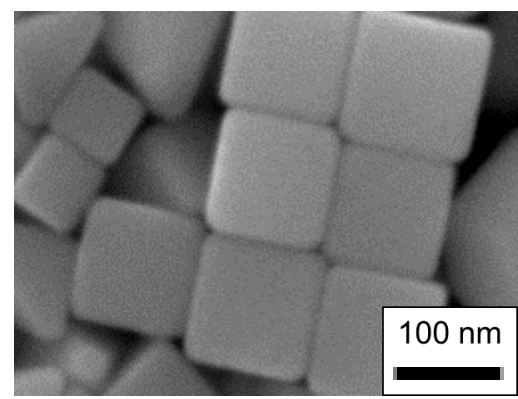
Appearance of the small CO<sub>2</sub> electrolyzer

- High performance catalyst to produce chemical raw materials and fuel from CO<sub>2</sub>
- Electrolysis system for producing fundamental chemicals from low-concentration CO<sub>2</sub> mixed gas containing oxygen

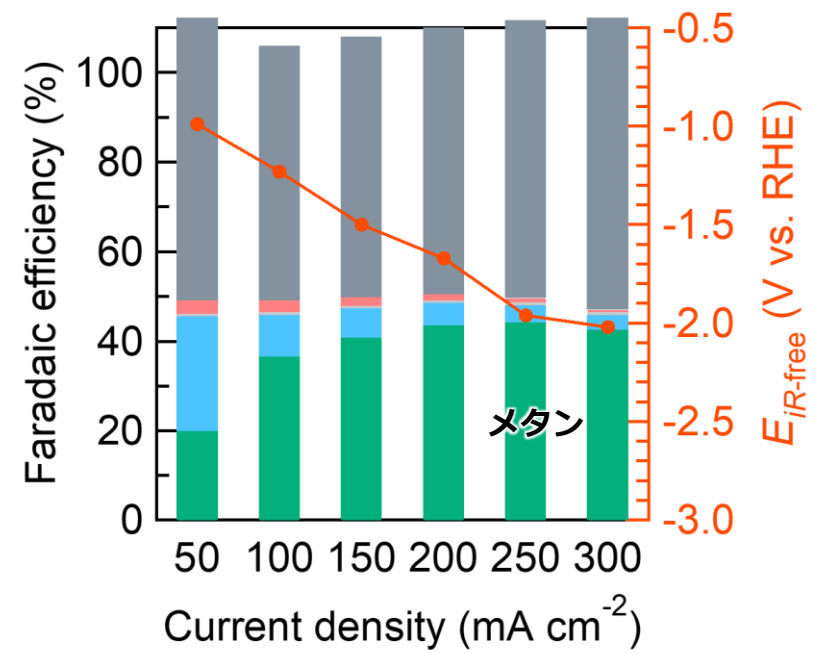
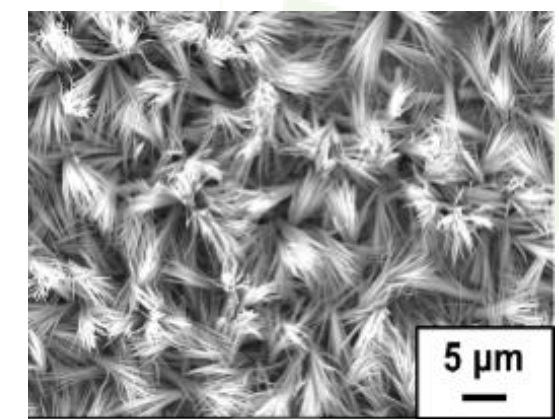
### Atomic-scale Cu composite catalysts



### Cubic Cu nanocatalysts

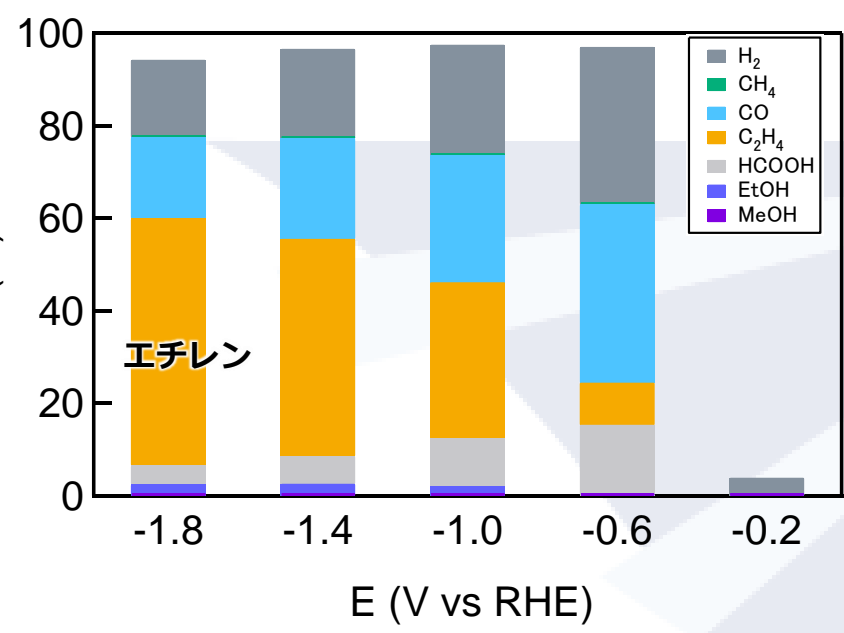


### Nanoneedle Cu catalysts



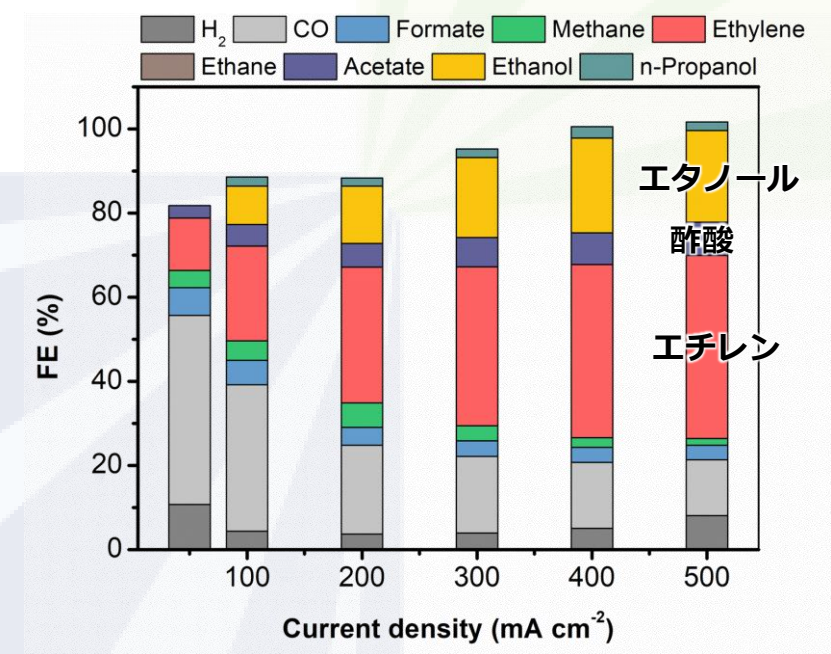
methane

Natural gas → fuel



ethylene

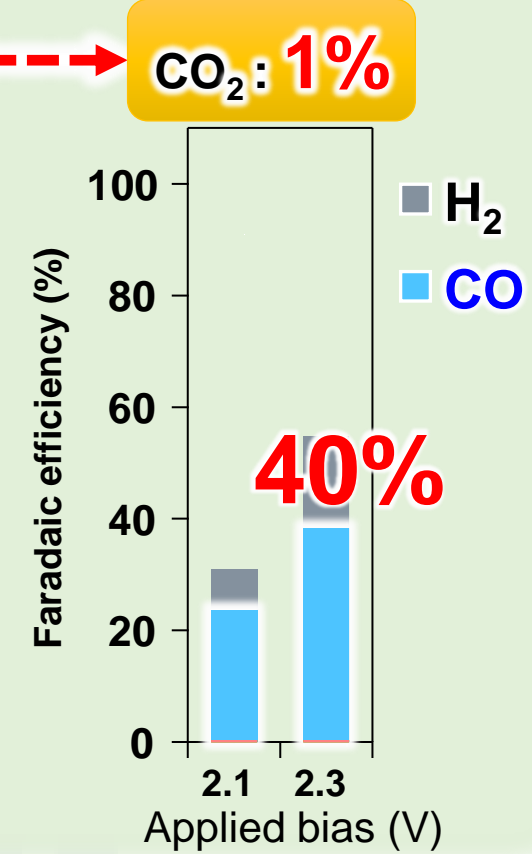
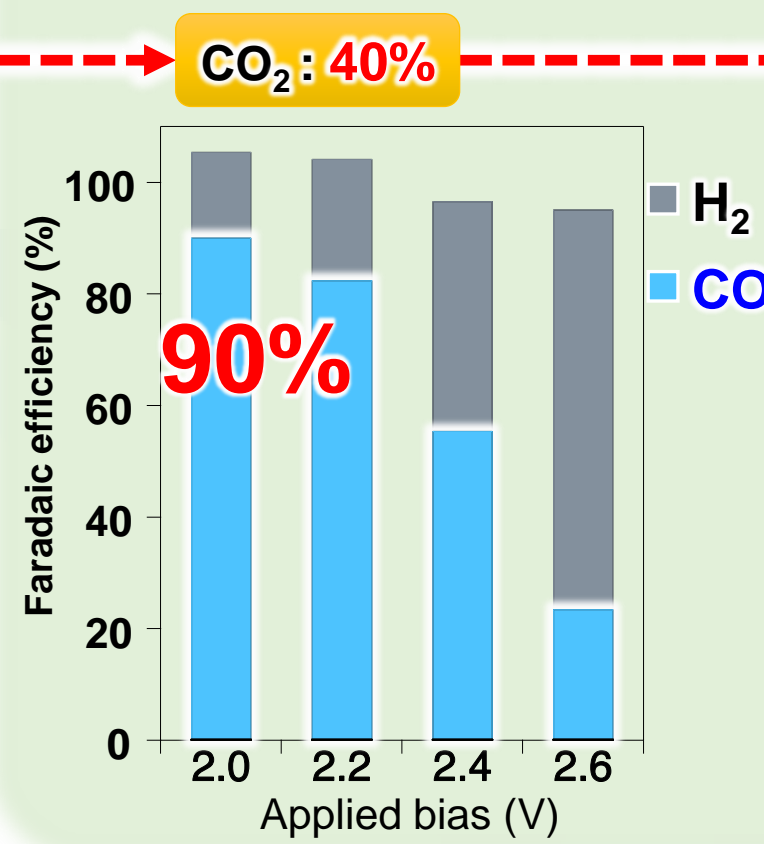
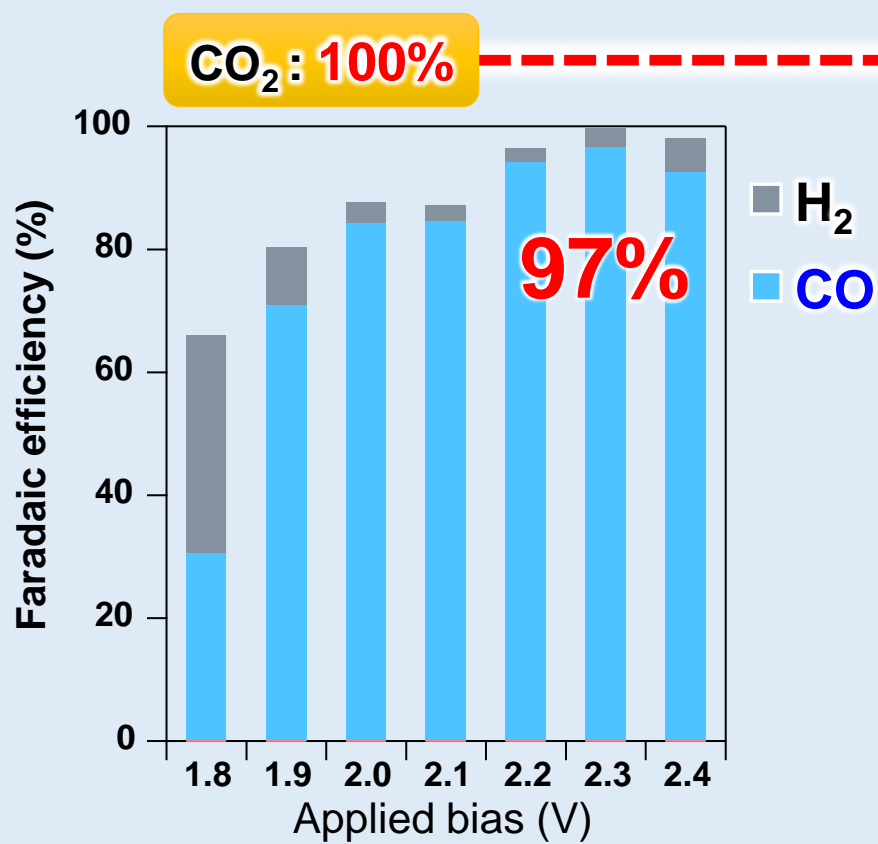
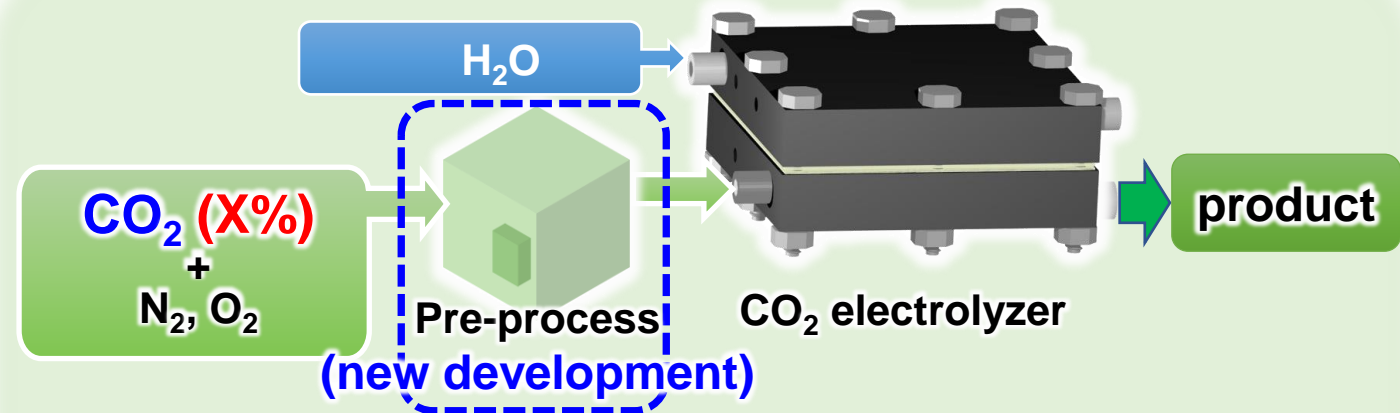
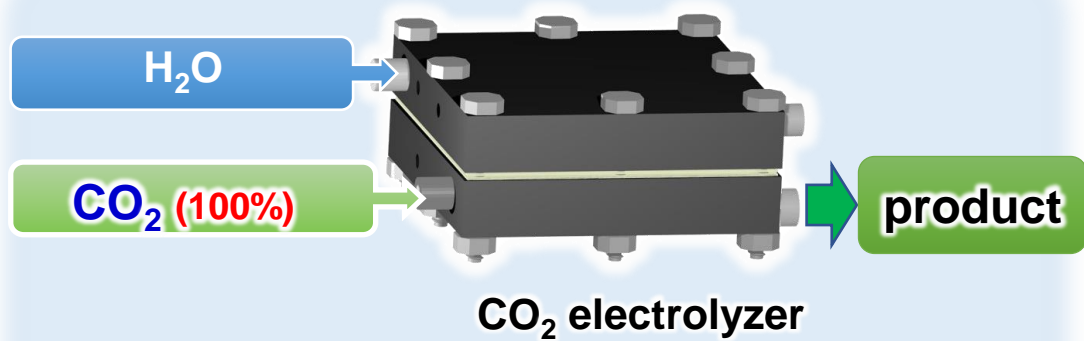
Plastic, additives



ethanol

Alcohol, fuel, sanitizer

# Development of a syngas (CO) production system from CO<sub>2</sub> mixed gas [12]



**World First!**

**Syngas production from 1% CO<sub>2</sub> mixed gas and water**

