Integrated Electrochemical Systems for Scalable CO_2 Conversion to Chemical Feedstocks

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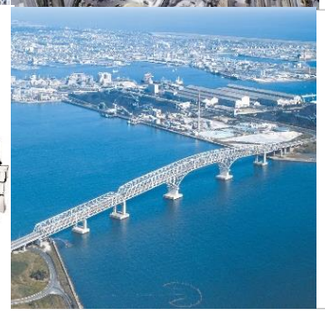
Implementing organizations : The University of Tokyo, Osaka University, Institute of Physical and Chemical Research (RIKEN), Ube Industries, Ltd., Shimizu Corporation, Chiyoda Corporation, Furukawa Electric Co., Ltd.

UBE Industries, Ltd. / Business description / Role in this PJ

☐Business domain / strength

Development of chemical manufacturing business originating from coal mining
Possessing unique synthesis technologies based on catalytic chemistry and organic synthesis

Chemicals 42% of net sales ¥ 259.3 billion			• Nylon raw materials and resin • Synthetic rubber • Industrial chemicals • Specialty products • Battery materials • Fine chemicals • Drug discovery and co-development • Contract manufacturing
Cement & Construction Materials 46% of net sales ¥282.8billion			• Cement, ready-mixed concrete • Building materials • Calcia, magnesia • Coal storage/sales • IPP/Power business
Machinery 12% of net sales ¥78.7 billion			• Molding machines (Injection molding machines, die-casting machines) • Industrial machinery • Bridge

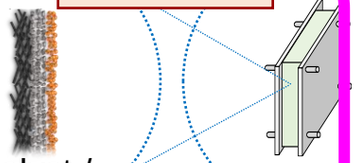
☐Role in this PJ

- ➢ Development of high-performance electrode catalyst based on synthesis technologies.
- ➢ Scale-up for catalyst manufacturing.

Project organization and goals

CO_2 electrolysis reactor

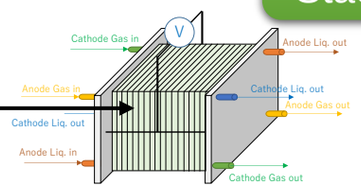
Osaka Univ.
Electrode



Catalyst / Electrode

CO_2 electrolysis reactor

Larger electrode area
Stacking of electrodes

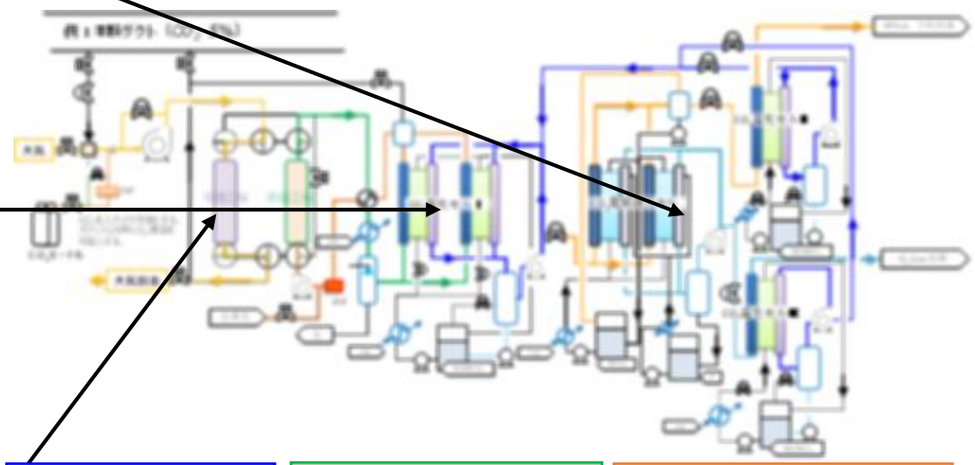


Scale up/ stacking

System development

The Univ. of Tokyo・Chiyoda Corp.
Process integration / system control / characterization

The Univ. of Tokyo
LCA analysis



Furukawa Electric Co., Ltd.
Cu-based substrates

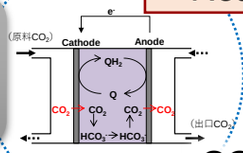
Ube Industries, Ltd.
Acid-tolerant catalysts

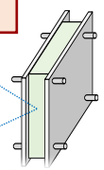
RIKEN
Reactor

The Univ. of Tokyo Chiyoda Corp.
Process integration

CO_2 enrichment reactor

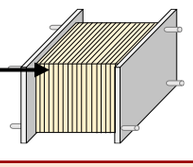
Osaka Univ.
Reactor





CO_2 enrichment reactor

Electrochemical reaction system



Scale up/ stacking

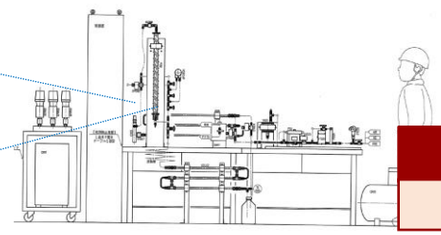
CO_2 Capture

CO_2 Enrichment

CO_2 Electrolysis

Physical CO_2 capture

Adsorption / desorption material



Adsorption / Desorption system

Shimizu Corp.
Prototyping

Shimizu Corp.
Process concept

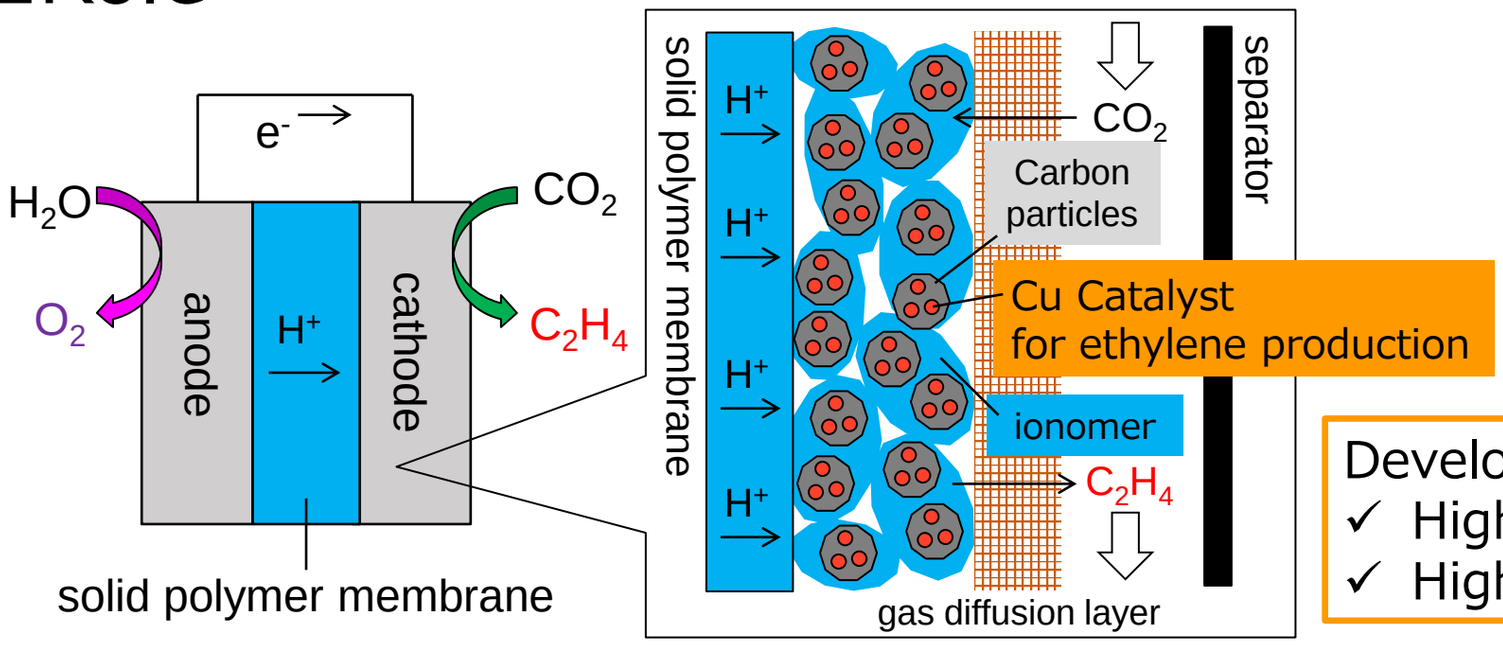
Ube Industries, Ltd.
Provisional pilot field /
Social implementation scenario

Goals

- Development of an integrated system that electrochemically converts CO_2 captured from an atmospheric air to valuable chemical substances
- Conducting a life cycle assessment on a pilot-scale plant to evaluate the effectiveness as a measure against global warming

Role / Research Subject

☐Role



Development of High-Performance Catalyst
- ✓ High Selectivity & Productivity of C_2H_4
- ✓ High Acid Resistance

☐Research Subject

① Selectivity & Productivity of C_2H_4

High faraday efficiency and High current density for ethylene (C_2H_4) production should be achieved.

Products possbily produced by CO_2 electrolysis

C_2H_4 H_2 CO CH_4
CH_3OH C_2H_5OH etc.

② Catalyst Lifetime (Acid Resistance)

It is necessary to suppress the elution of Cu catalyst by acid.

e.g.

Cu cat. $\xrightarrow{\text{HX[acid]}}$ CuX (elution)

Goals for FY2024 & FY2027

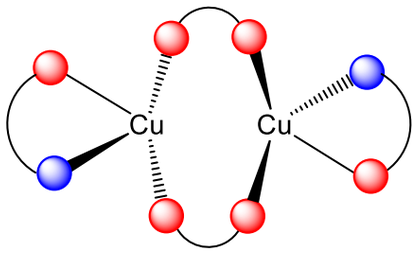
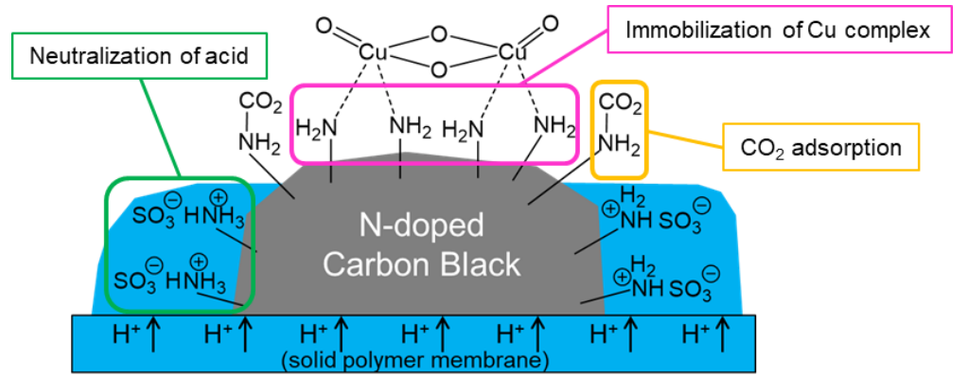
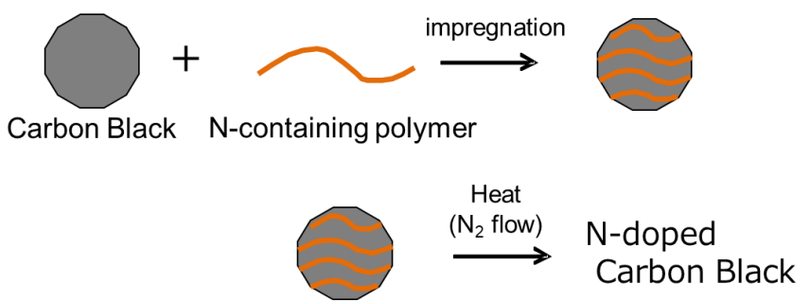
☐FY2024

- ●Selectivity (Faraday Efficiency): >50%
- ●Productivity (Current Density): >200 mA/cm^2
- ●Catalyst Lifetime：>1,000 hours

☐FY2027

- ●Selectivity (Faraday Efficiency): >80%
- ●Productivity (Current Density): >200 mA/cm^2
- ●Catalyst Lifetime：>5,000 hours

Achievement

	Plan ①	Plan ②
Catalyst Design	 Cu: soft acid, CO_2: hard acid ●: soft base, ●: hard base Binuclear Cu complex containing both soft and hard base was designed.	 Introducing Nitrogen to catalyst support (carbon black)
Expected Effects	① Improvement of acid resistance - Stabilization of Cu complex with soft base ② Enhancement of CO_2 reduction activity - CO_2 adsorption to hard base point ③ Improvement of ethylene selectivity - Binuclear Cu structure promotes C-C bond formation	① Immobilization of Cu complex - Nitrogen atom coordination to Cu complex ② Promotion of CO_2 reduction - CO_2 adsorption to nitrogen atom ③ Suppression of acid contact to Cu complex - Local neutralization of acid
Progress Results	• Several Cu complexes based on the catalyst design were synthesized and characterized. • CO_2 electrolysis performance of synthesized Cu complex is under investigation.	 • CO_2 electrolysis performance using N-doped carbon black is under investigation.

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM