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.

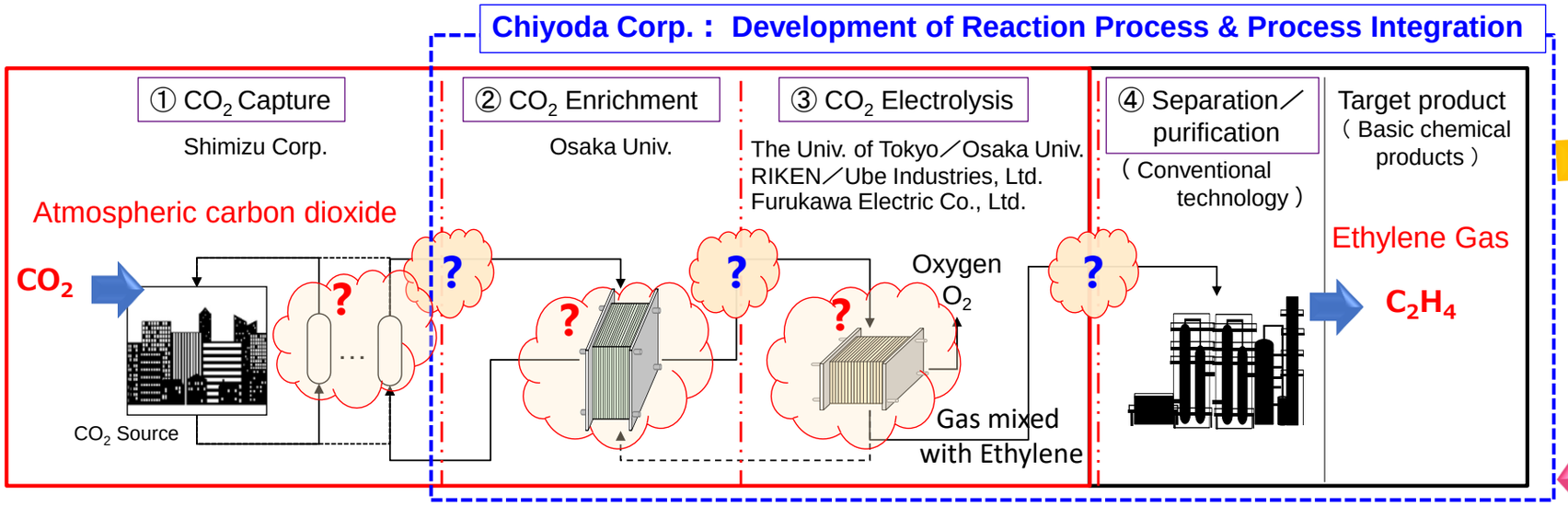
Chiyoda Corporation / Business description / Role in this PJ

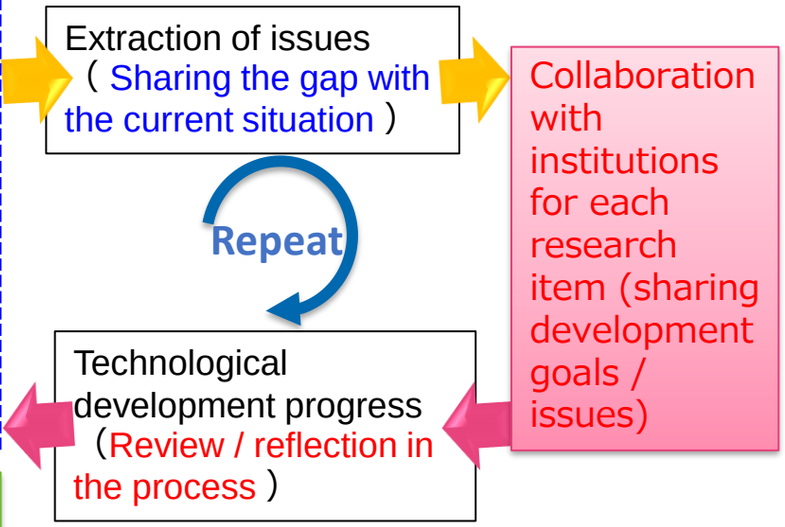
☐Business domain / strength

- Comprehensive engineering company
- Contributing to the development of a sustainable society with the aim of "harmony between energy and the environment“
- Implemented various plant designs and constructions / Abundant knowledge

- Renewable energy
- Environment
- Pharmaceutical
- Non-ferrous metal / Metal
- General industry
- Gas value chain
- Petroleum refining
- Petrochemical
- General Chemistry

☐Role in this PJ





- Chiyoda will carry out process development and evaluation with an awareness of actual equipment (plant operability, productivity, etc.) from the perspective of a private company
- Chiyoda will identify and share the gaps and issues between the overall system and the current situation as early as possible.
- Chiyoda will review / reflect the process as appropriate according to the progress of technological development.

R & D / efficiency improvement with an awareness of actual equipment

Project organization and goals

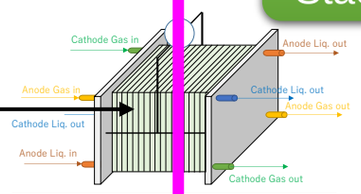
CO_2 electrolysis reactor

Osaka Univ.
Electrode

Catalyst / Electrode

CO_2 electrolysis reactor

Larger electrode area
Stacking of electrodes



Scale up/ stacking

System development

Furukawa Electric Co., Ltd.
Cu-based substrates

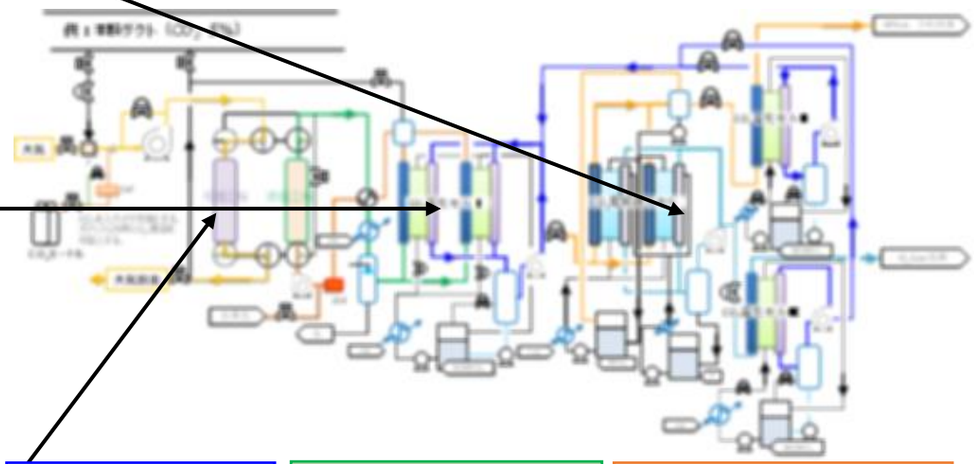
Ube Industries, Ltd.
Acid-tolerant catalysts

RIKEN
Reactor

The Univ. of Tokyo Chiyoda Corp.
Process integration

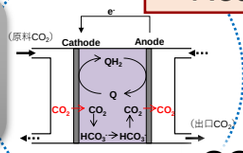
The Univ. of Tokyo・Chiyoda Corp.
Process integration / system control / characterization

The Univ. of Tokyo
LCA analysis



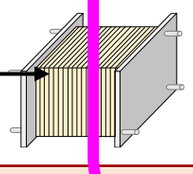
CO_2 enrichment reactor

Osaka Univ.
Reactor



CO_2 enrichment reactor

Electrochemical reaction system



Scale up/ stacking

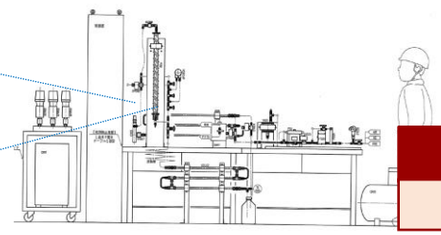
CO_2 Capture

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

Chiyoda's research item / Intermediate・Final goal

Research Item : Integrated process from CO_2 enrichment to CO_2 electrolytic reduction

Research Item Development of Reaction Process & Process Integration	FY 2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
a. CO_2 electrolysis system /evaluation/process development	●	▼			→					
b.CO_2 electrolysis catalyst evaluation / electrode development	●				→					
c.CO_2 enrichment system evaluation/process development	●						→			
d.System evaluation and process development from CO_2 enrichment to separation and purification				●			→			
e. Pilot test equipment Design and construction								●	→	
Demonstration									●	→

【 Intermediate target by the end of FY2024 】

- Completion of system verification from CO_2 enrichment to CO_2 reduction electrolysis on a laboratory scale.
  （Target continuous operation time of 1,000 hours, current density of 200 mA/cm^2, current utilization efficiency of 50%）

【 Intermediate target by the end of FY2027 】

- Verify current utilization efficiency of 80% and continuous operation for 5,000 hours on a laboratory scale .
  （current density of 200 mA/cm^2）
- Obtain necessary specifications for pilot design.

【 Final goal at the end of FY2029 】

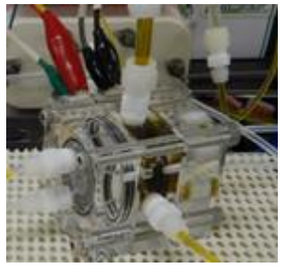
- Building a Pilot Plant for Atmospheric CO_2
- Obtain engineering data from pilot plant tests
- Comprehensive evaluation and construction for commercial plant

（achievement）→ Achieve the ultimate goal of the overall project

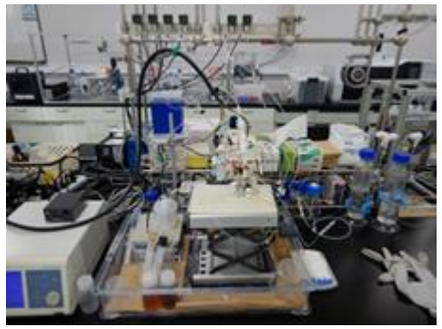
Major results /status at this point (1/2)

Results 1: Collaborate with each development agency in CO_2 enrichment development and CO_2 electrolytic reduction development.

- Design and manufacture of a new CO_2 enrichment system and CO_2 electrolytic reduction system capable of continuous operation
- Confirmed CO_2 separation characteristics using CO_2 source enrichment equipment and started data acquisition and evaluation necessary for actual equipment design, etc.
- Confirmation of stable operation for 200 hours of ethylene production using a CO_2 electrolytic reduction system (Ethylene selectivity of 30% or higher)



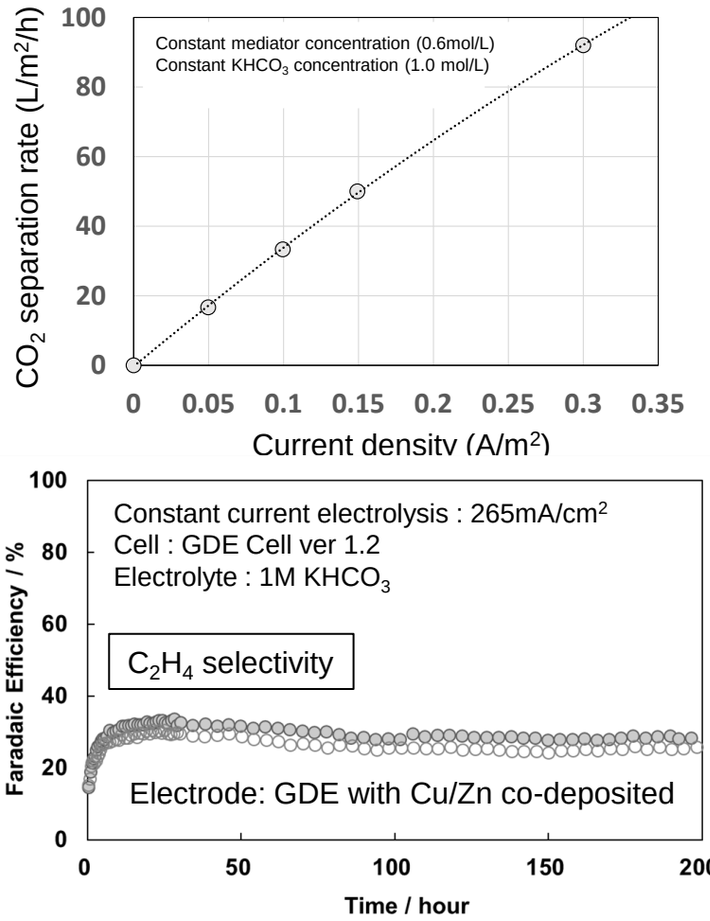
CO_2 Enrichment Cell



Lab. Continuous Evaluation Test Equipment for CO_2 enrichment

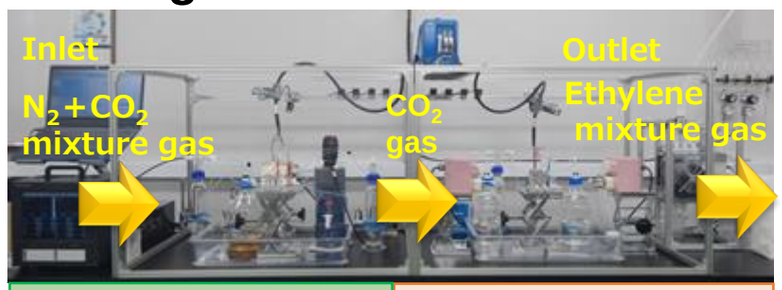
CO_2 Electrolytic Reduction Cell

Lab. Continuous Evaluation Test Equipment for CO_2 Electrochemical Reduction



Results 2: Based on Outcome 1 above, the study of system integration was started.

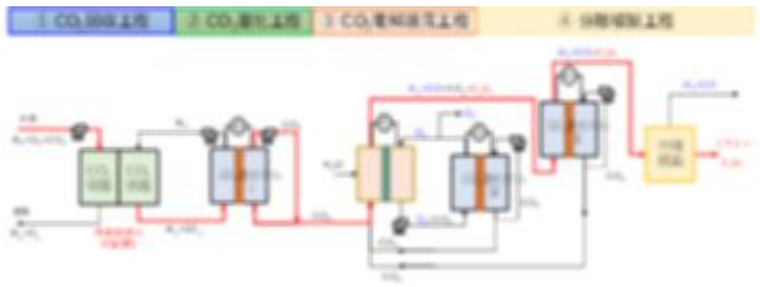
- Newly designed and fabricated evaluation test equipment for system integration study of "CO_2 Enrichment + CO_2 Electrolytic Reduction Process" that can be operated continuously, and started integrated evaluation.



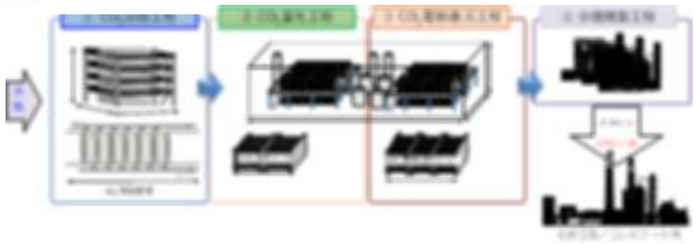
Major results /status at this point (2/2)

Results 3: Collaborate with each development agency in CO_2 enrichment development, CO_2 electrolytic reduction development and system control development.

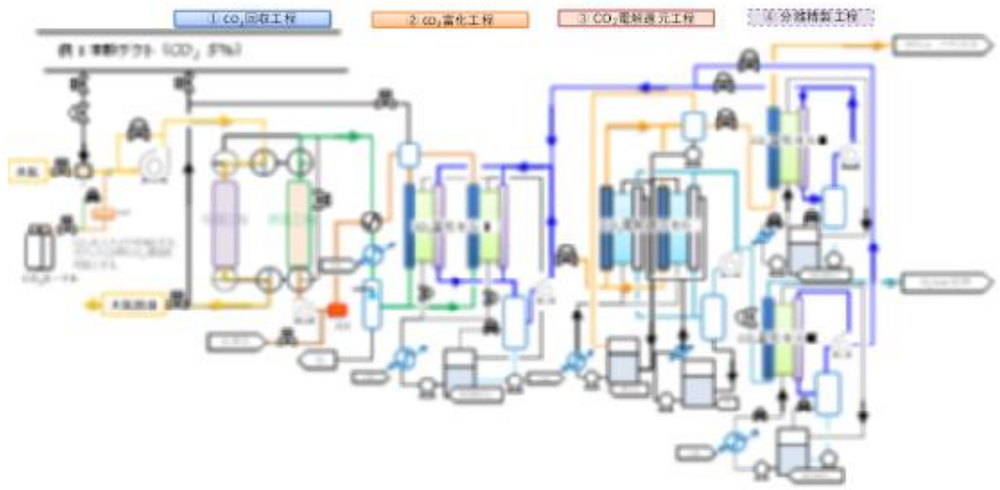
- The outline process for the actual equipment in the future was examined, and the equipment size per unit was examined.
- The conceptual process flow of the pilot test equipment assuming CO_2 capture from the atmosphere was examined.



Outline process review



Concept of Ethylene Production System (10,000 tons/year per unit)



Pilot Test Equipment Conceptual Flow

Results 4: Three cases of intellectual property creation

- System patent for CO_2 enrichment equipment (jointly filed with Osaka Univ.)
- System patent for CO_2-free tire material (butadiene) production (jointly filed by Ube Industries)
- Patent on catalyst for cathode electrode (jointly filed by the Univ. of Tokyo and Furukawa Electric)

Results 5: External PR activities (8 cases)

- Conducted press releases (4 cases:The Nikkan Kogyo Shimbun, etc.)
- Participation in exhibitions, etc. (4 cases:Hydrogen Fuel Cell Expo, etc.)

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM