TNChE Asia 2026

Process development of lower olefins synthesis using carbon dioxide

June 11th, 2026

IHI Corporation

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Background — The Need for Carbon Recycling

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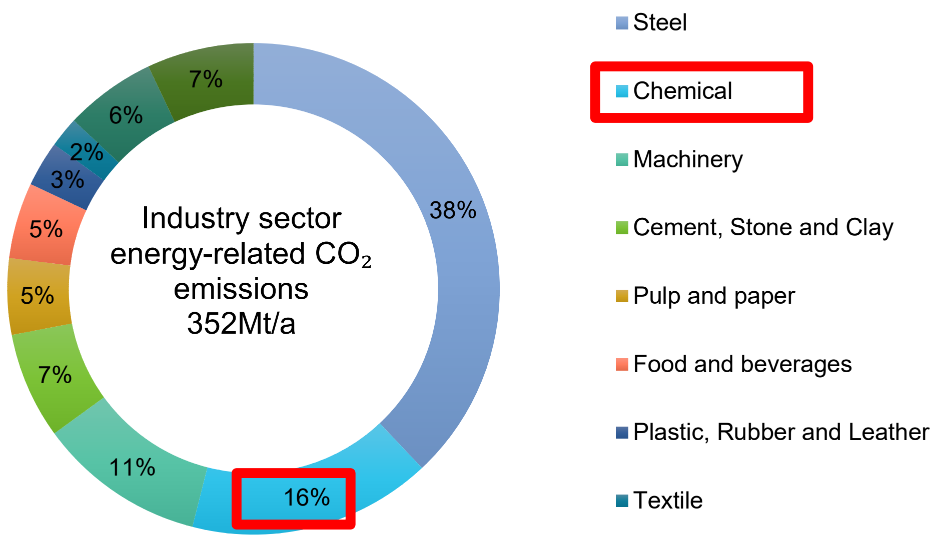
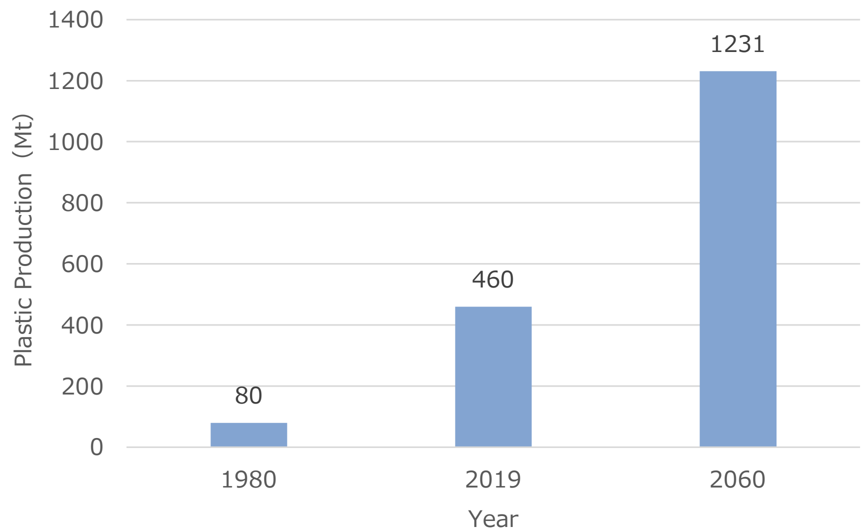
CO_2 emission in Japan



Ministry of Environment, Japan
https://www.env.go.jp/content/000234474.pdf

- ✓ Chemical industry is the 2nd largest contribution of CO_2 emission in industry sector in Japan.
- ✓ Plastic production is expected to grow more than double by 2060.

Forecast of Plastic production



OECD Global Plastic Outlook https://www.oecd.org › oecd › reports ›
Prepared by data of 2022/06.

- ✓ **Strong demand to decarbonize the chemical industry, particularly plastic production, is desired.**

Our Motivation

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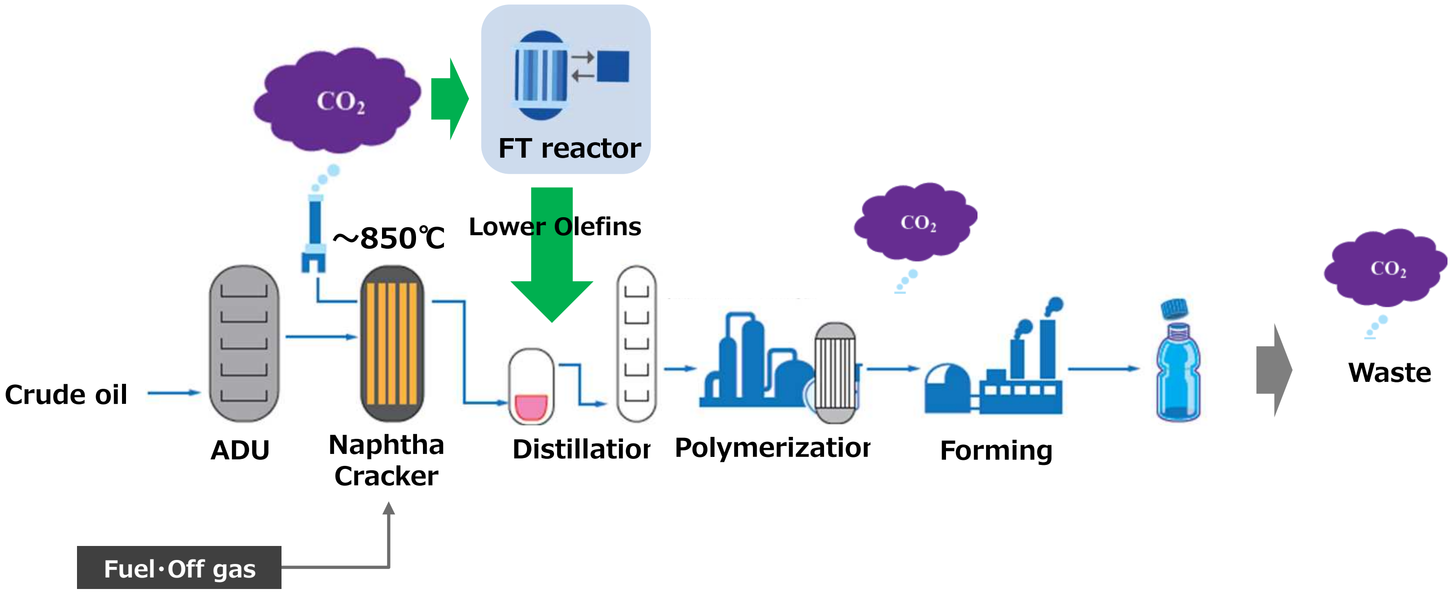
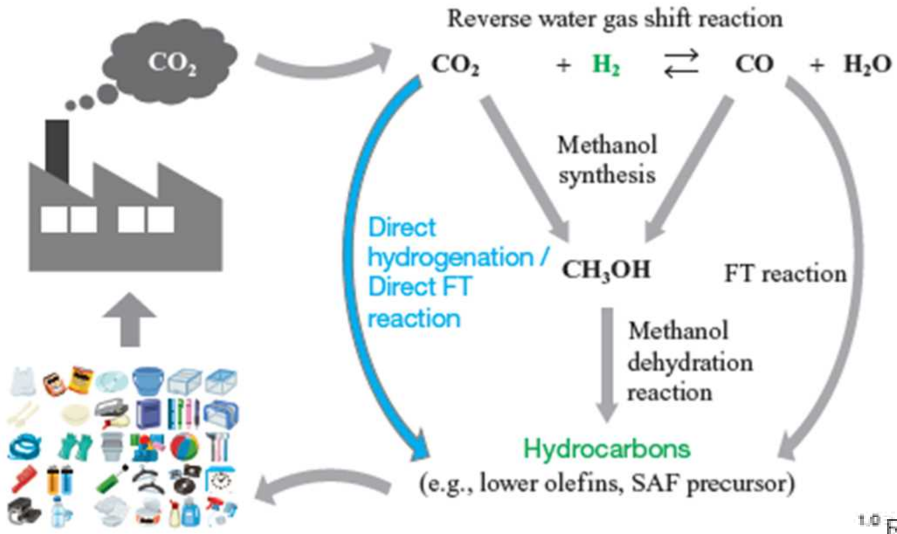
Lower Olefins Production Today

- ✓ Today, lower olefins are produced by thermally decomposing naphtha or natural gas.
- ✓ CO_2 is emitted from major steps of the plastic production.
- ✓ CO_2 from naphtha cracking process contributes most during life cycle of plastic products.



- ✓ **Converting CO_2 from naphtha cracker into lower olefins should be a promising option to reduce CO_2 footprint for plastic industry.**

Principle of Lower Olefins Synthesis from CO_2 and H_2



- ✓ Modified FT reaction may have advantage over other indirect process because of simpler process configuration.

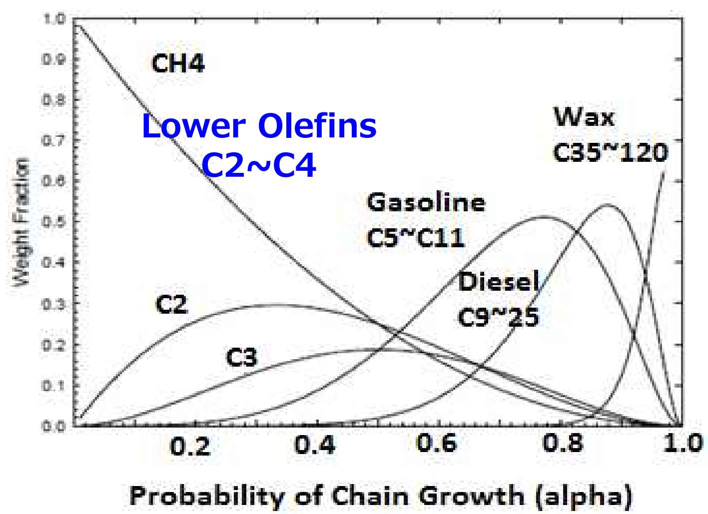
Modified FT reaction

- ✓ $nCO_2 + 3nH_2 \rightarrow (CH_2)_n + 2nH_2O$

  $\Delta H^0_{298} = -128$ kJ/mol exothermic

Main challenges for catalyst development

1) Higher CO_2 conversion
2) Higher selectivity to lower olefins
3) Catalyst stability



Roadmap to Deployment

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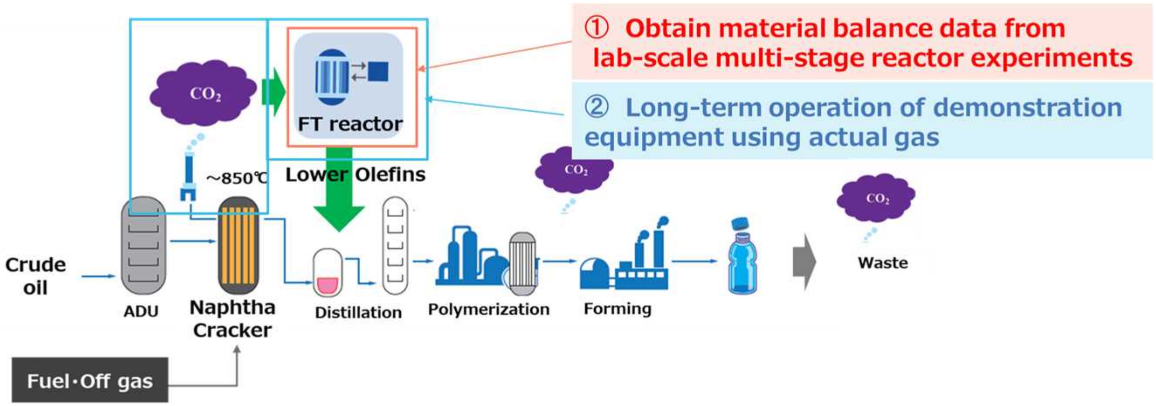
Phase 1	Phase 2	Phase 3	Commercial
- 2020	2021 - Present	2030	- 2040
Laboratory test	0.1 t-CO_2/d	100 t−CO_2/day	1000 t-CO_2/day

Phase 1
- ✓ Catalyst development
  - Basic recipe -
- ✓ Laboratory test
- ✓ Collaboration with ISCE2(ASTAR)

Phase 2
- ✓ Catalyst Synthesis More industry relevant process
- ✓ Larger Reactor test
- ✓ Test with flue gas from commercial Ethylene plant (naphtha cracker)

Phase 3 / Commercial
- ✓ Further scale-up
- ✓ Consolidate with Ethylene plant (naphtha cracker)
- ✓ Integration of CO_2 capture and FT reactor



Scale-Up of Catalyst Technology

From Laboratory to Industry-Relevant Process

Catalyst Synthesis in Large Scale

gram scale

10kg scale

Shaped Catalyst

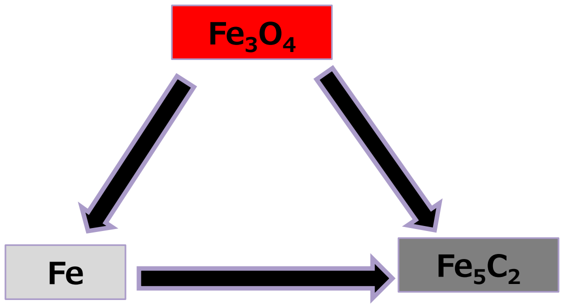
Shaped catalyst is required for the reactor scale performance test

Catalyst powder

Extrusion etc.

Activation of Shaped Catalyst

Dedicated activation conditions for shaped catalysts to achieve good balance of Fe_3O_4 and Fe_5C_2



Performance Test of Shaped Catalyst

Mid-sized reactor to evaluate the performance of shaped catalysts

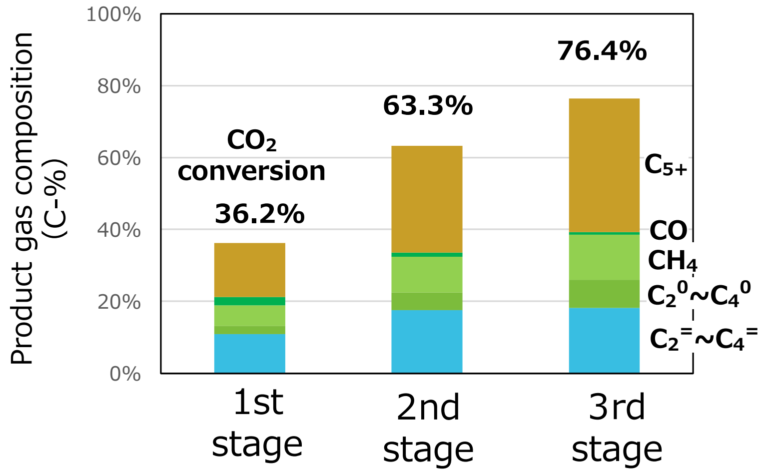
- ✓ Reaction heat was controlled by shell and multi-tube type
- ✓ 3 staged reactor

Multi-stage Reactor with Shaped Catalyst

- ✓ Concept of multi-staged reaction system was also verified for the shaped catalyst in larger scale.

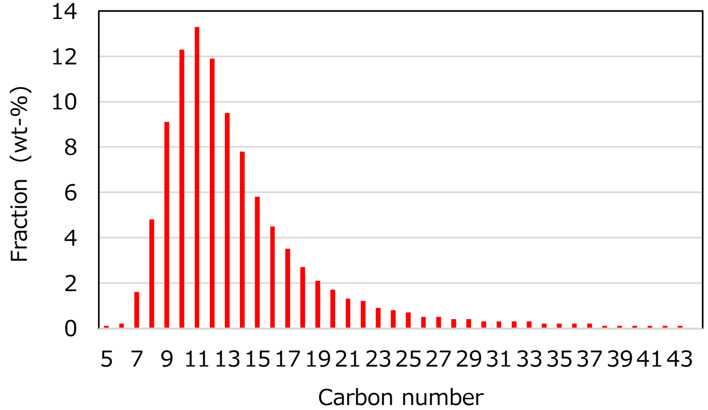
CO_2 Feed 8 kg/d

Product gas



- ✓ Collected oil consists of mainly more than C_8 hydrocarbons which can be used as precursor for SAF.

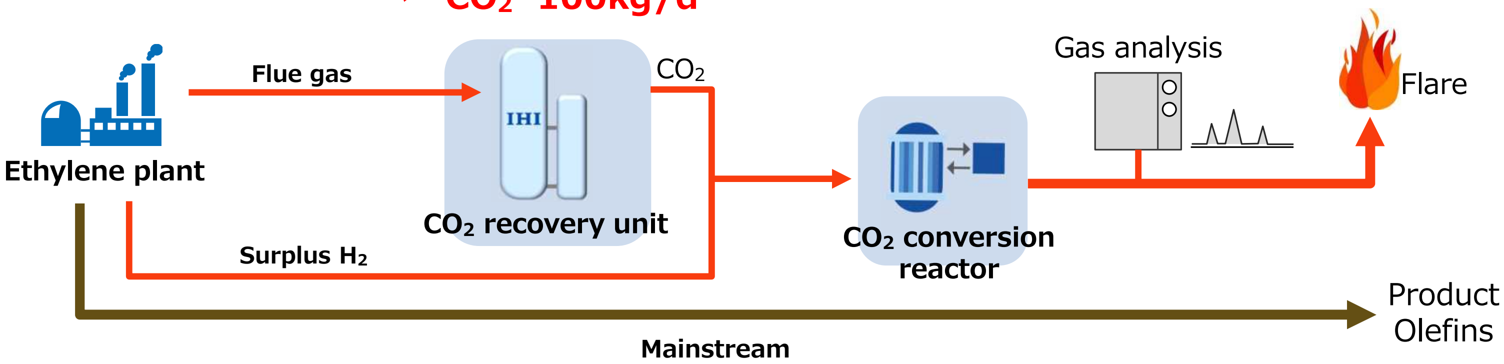
Liquid product



Test with Flue Gas from Commercial Ethylene Plant

✓ CO_2 from ethylene plant (SCG Chemicals) has been used as feedstock.
✓ Both CO_2 recovery unit and CO_2 conversion reactor unit have been installed.

✓ **CO_2 100kg/d**



Specification of the pilot plant

Item			unit
Flue gas flow rate		42.3	kg/h
Feed rate	H_2	6.7 (0.6)	Nm^3/h (kg/h)
	CO_2	100 (4.2)	Kg/d (kg/h)

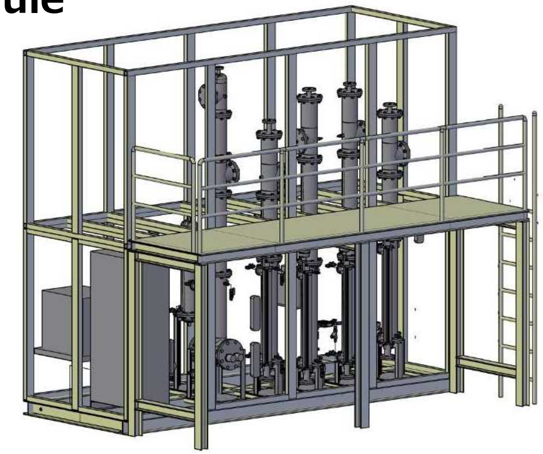
Lower Olefins Synthesis Pilot Plant

Achievements in 2025

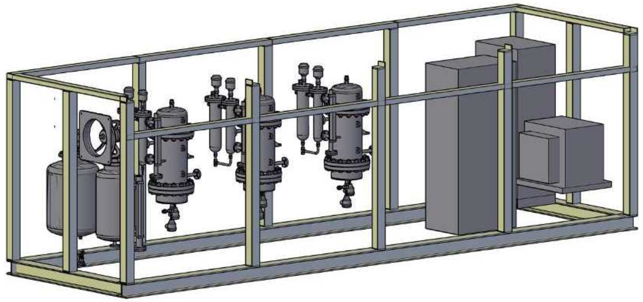
April	**Test-rig installed**	Completed
May	**Commissioning**	Completed
July	**1st Campaign completed**	1000hr operation completed
Nov.	**2nd Campaign planned**	>800hr operation completed

Main Modules of Pilot Plant

CO2 Capture Module

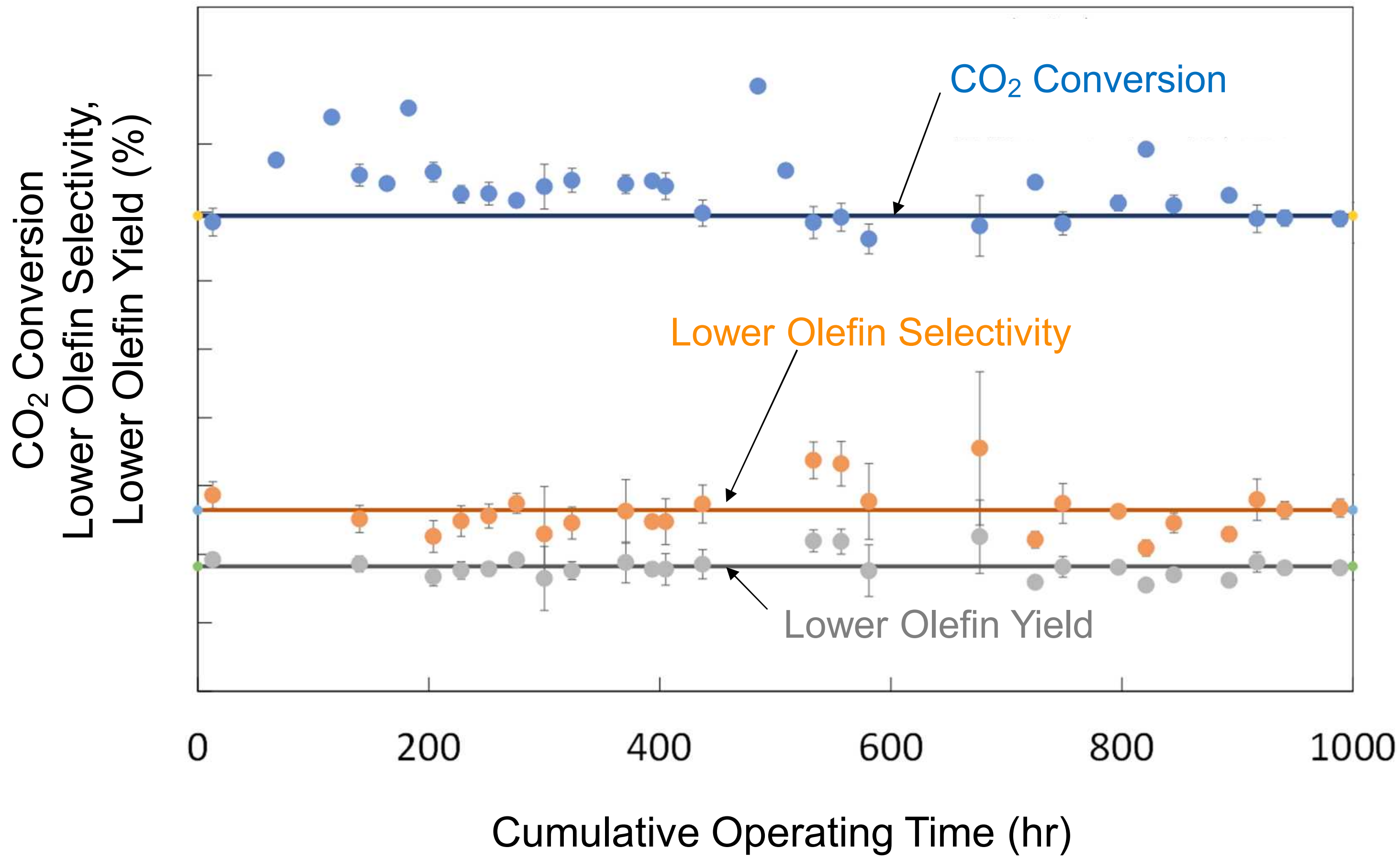


Olefin Reactor Module

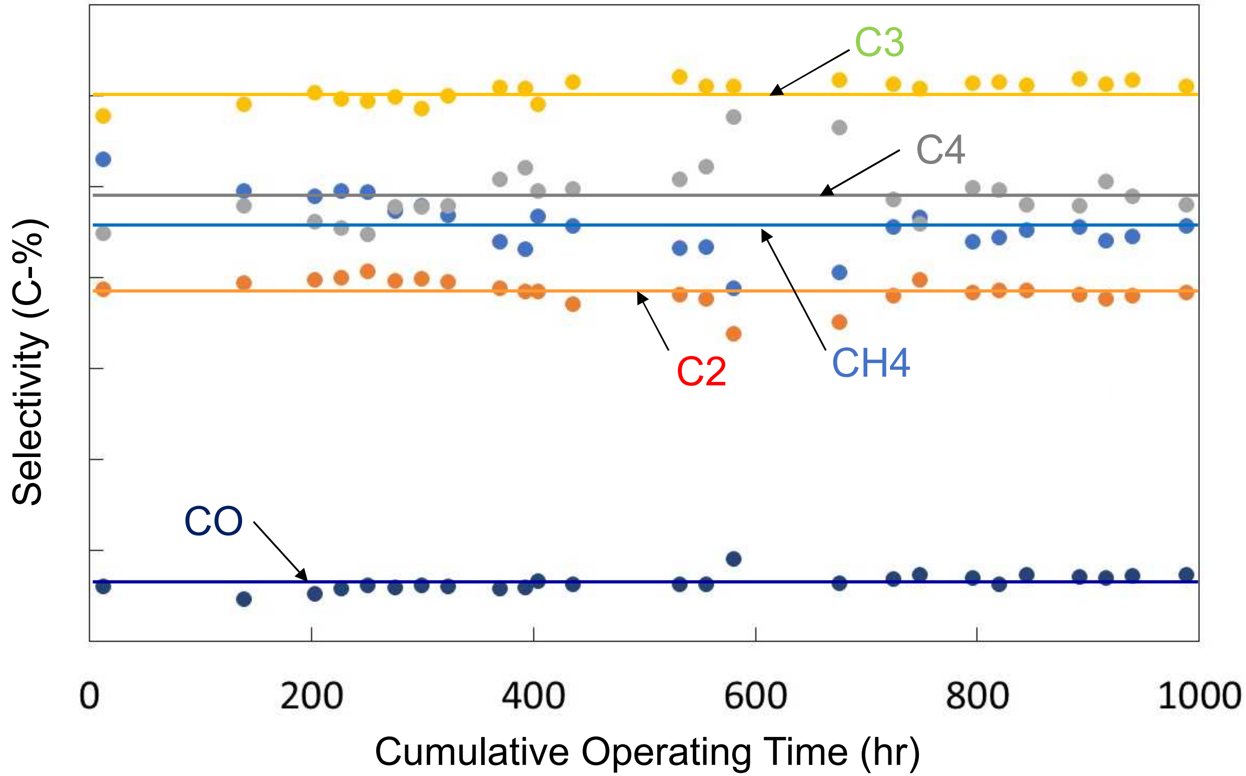


	CO_2 Capture Module	Olefin Reactor Module
Service	Capture CO_2 from naphtha cracker flue gas	Synthesizes lower olefin gas from CO_2 and H_2 with multi-stage reactor
Dimensions	W:4.7 m x D:1.9 m x H:4.1 m	W:7.0 m x D:2.0 m x H:2.4 m
Weight	5.0 ton	8.0 ton
Features	・Adopted amine absorption system ・Can be separated into upper an lower sections	・Equipped with gas–liquid separators and gas analyzer ・Explosion-proof

Key Result – Catalyst Performance in 1st Campaign



Key Result – Catalyst Performance in 1st Campaign



The shaped catalyst exhibited stable performance for 1000 hours under conditions using real flue gas.

For Future

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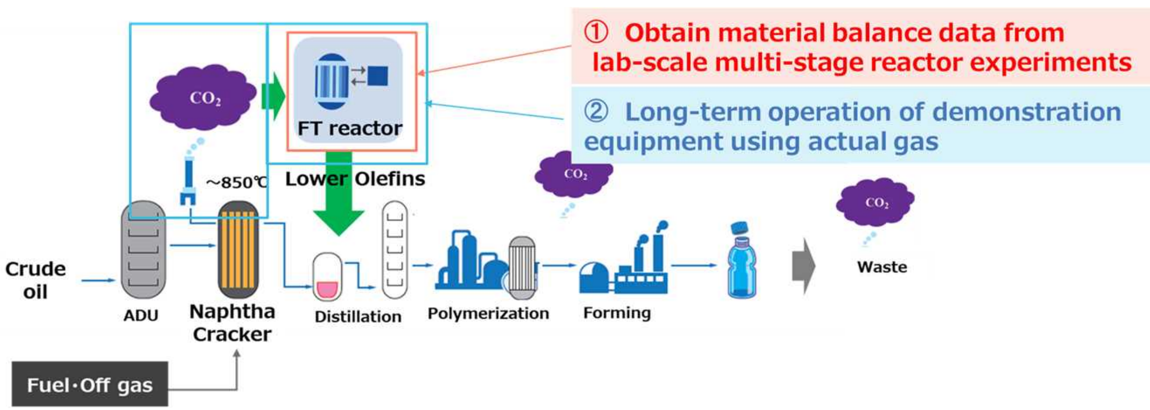

Acknowledgement

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olefin synthesis technology.

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for their outstanding cooperation in conducting the pilot tests.

Realize your dreams