Asahi Kasei's R&D towards carbon neutrality

Asahi Kasei Corporation

Our vision for a carbon-neutral sustainable world

Solar power

Wind power

Hydroelectric power

GHG Reduction

Renewable energy

Alkaline water electrolysis system

H_2 Hydrogen

Biomass

Consumers

Resource Circulation

Reduce
Reuse
Recycle

Chemical products

Chemical recycling
Material recycling

CO_2

CO_2 separation, recovery, and utilization

Household electricity consumption

Industrial electricity consumption

Electric vehicles

Methanol CH_3OH

Green fuels

Development of carbon and hydrogen recycling technologies to realize a decarbonized society

AsahiKASEI

CO_2

CO_2 separation and recovery system

CO_2 conversion and utilization

CO_2 Chemistry

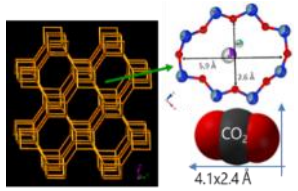
- EC process for PC
- DRC process for DPC
- Agent process for HDI

Specialty Chemicals and Resins
- Polycarbonate
- Isocyanates
- Materials for LIB electrolyte
- Functional coating agents
- High performance polymers, fibers

FH2R FUKUSHIMA HYDROGEN ENERGY RESEARCH FIELD

10MW-class water electrolysis system
(Namie, Fukushima)
NEDO commissioned work

Aqualyzer™



CO_2 adsorption zeolites

Chemical feedstocks

Hydrogen production system by alkaline water electrolysis

Green hydrogen

Existing technologies
External innovative technologies

Basic Chemicals and Fuels
- Methanol → DME, gasoline
- Methane → Ethylene/propylene
- BTX

N_2

Renewable energy
Surplus electricity

H_2O

Hydrogen fuel cell
Hydrogen gas turbine

Ammonia synthesis

Green Ammonia
Ammonia co-firing power generation
Ammonia gas turbine
Basic chemicals and fertilizer

Other R&D items
- Direct conversion of CO_2 to basic chemicals using renewable power
- Biomass chemicals based on chemical catalyst technology and biotechnology
- Conversion of bioethanol to basic chemicals by zeolite catalyst

Green Chemsitry

CO_2 chemistry

CO_2 utilization to produce specialty chemicals

- ✓ Asahi Kasei was the first in the world to establish the polycarbonate production process from CO_2. (technology licensing)
- ✓ Commercial operation of the first phase plant began in 2002. Currently, 10 plants are in operation.
- ✓ In 2018, Asahi Kasei's process had expanded to 16% of global production capacity. (approximately 800,000 tons)

The first phase plant (commercial operation started in 2002)

Major applications of PC

- Enclosures for smartphones and home appliances
- Headlamp covers
- Shinkansen and aircraft windows
- DVDs and BDs

5,000,000 tons worldwide in 2018

Shinsuke Fukuoka was awarded the Medal with Purple Ribbon in 2008.

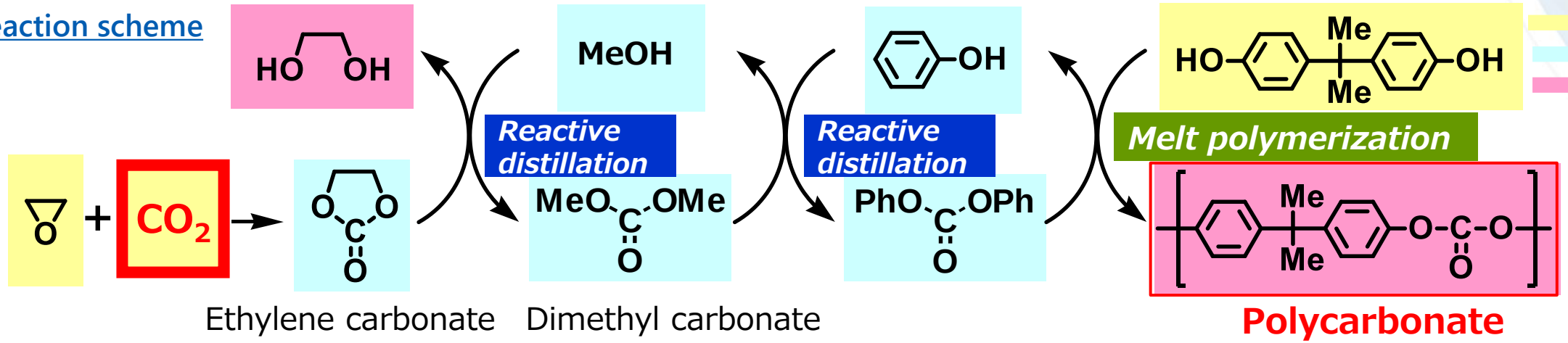
Characteristics and advantages of Asahi Kasei's process to produce polycarbonate from CO_2 as starting material

AsahiKASEI

Key points that enabled practical application

- ✓ Application of Asahi Kasei's catalytic and process technologies that enabled high selectivity and lower energy consumption process.
- ✓ This process produces high-purity and high-quality PC from CO2 as starting material instead of using highly toxic phosgene that need wastewater treatment.
  ⇨ Environment-friendly, energy saving and resource saving process.

Reaction scheme

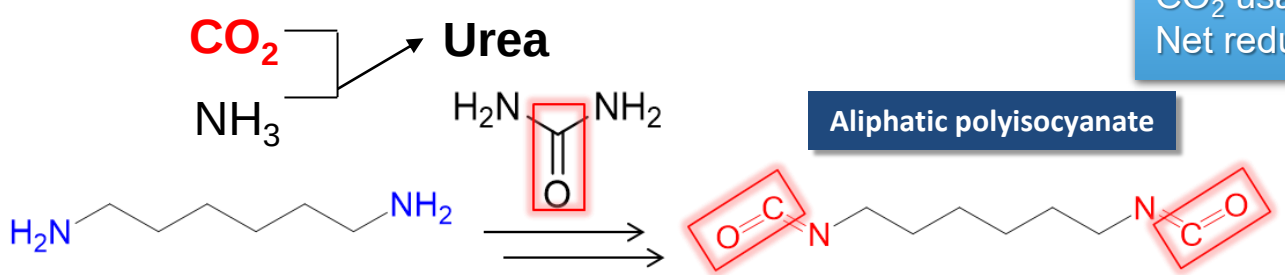


Isocyanates production from CO_2 as starting material (under development)

AsahiKASEI

- ✓ **Asahi Kasei is developing the world's first sustainable process to produce raw materials of polyurethanes (isocyanates) using CO2-derived urea.**
- ✓ **This technology is also applied to polyfunctional isocyanates which have advantages such as transparency, low viscosity, superior appearance, and low temperature curing at 80℃. Low temp. curing is expected to help the reduction of CO2 in automotive coating.**

Hexamethylene diisocyanate (HDI)



Hexamethylene diamine (HMD) **Hexamethylene diisocyanate (HDI)**

Amount of CO_2 reduction in LCA

CO_2 usage: 0.73 t-CO_2/t-HDI
Net reduction (emissions − usage)

20% reduction compared to conventional phosgene process

Applications of polyurethanes

- ➢ Foam, cushion
- ➢ Heat insulation
- ➢ Elastomer
- ➢ Paints, adhesives
- ➢ Fibers

Isocyanates 9,520,000 tons in 2018

Aliphatic	HDI	240,000 tons
	IPDI	50,000 tons
Aromatic	MDI	7,050,000 tons
	TDI	2,180,000 tons

Polyfunctional isocyanates

Polyfunctional isocyanates
$R\text{-}(NCO)_n$
under development

- ・Transparency
- ・Ultra-low viscosity
- ・Non volatility
- ・Low temp. curing
- ・Superior appearance

✓ Application in the automotive coating process

- ・low baking temperature
- ・reduction of step of coating process

✓ lower energy consumption
✓ CO_2 reduction

CO_2 separation and recovery

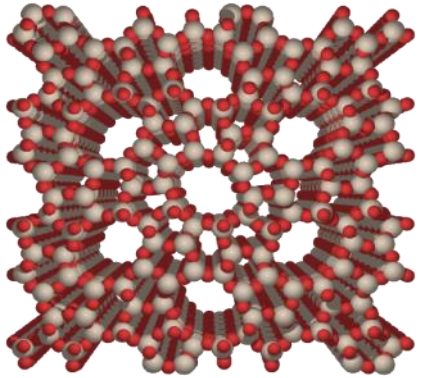
Application of zeolite technology to environment and energy

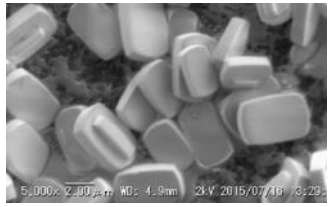
AsahiKASEI

Zeolite technologies

Core technology

MFI (ZSM-5)

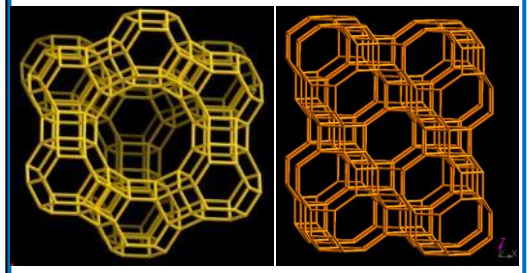




- Synthesis
- Production without templates
- Crystalline shape and particle size control
- Modification
- Cation exchange
- Shape forming with spray-drying process

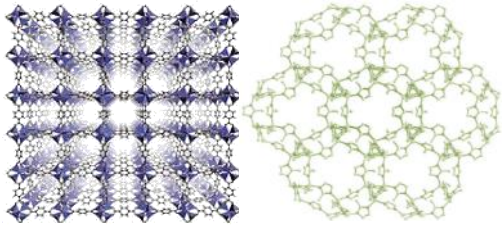
Deepening of synthetic technology

MWF, FAU
CHA(SAPO-34, SSZ-13),
hybrid, core-shell



Zeolite-like porous materials

Acquisition and application of MOF technologies



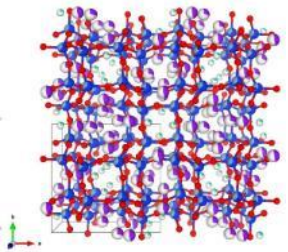
Petrochemicals

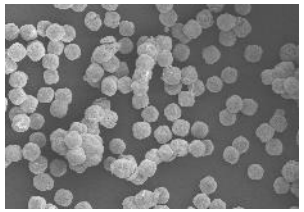
Commercialization
CH process (cyclohexanol)
Alpha process (BTX)
Omega process (propylene)

Verification
E-Flex process (BTX, propylene)

Environment and energy

- **CO_2 separation and recovery system (under development)**



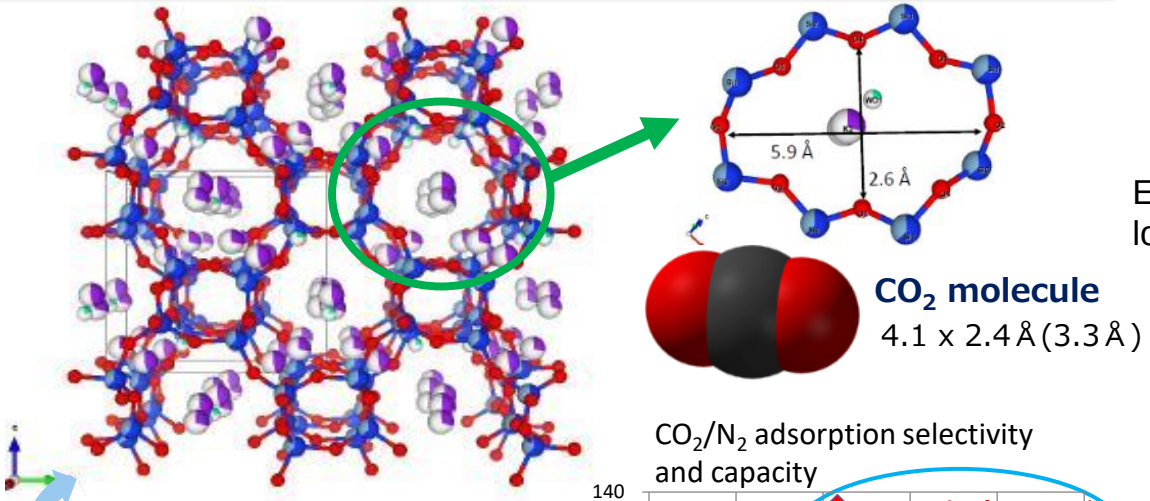


- **Conversion of bioethanol to basic chemicals**

CO_2 separation and recovery system using zeolite

K-GIS type zeolite to adsorb CO_2 from mixed gases such as CO_2/N_2 and CO_2/CH_4 was developed requiring about half the energy consumption of existing amine-based processes for CO_2 adsorption and desorption. CO_2 separation and recovery system is under development to achieve high purity CO_2 purification and CO_2 removal at lower cost.

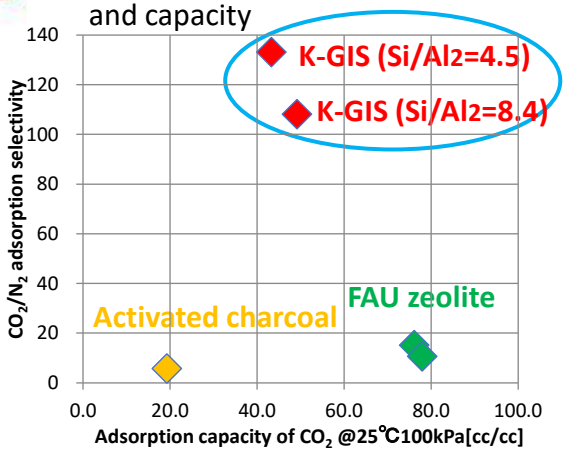
K-GIS type zeolite



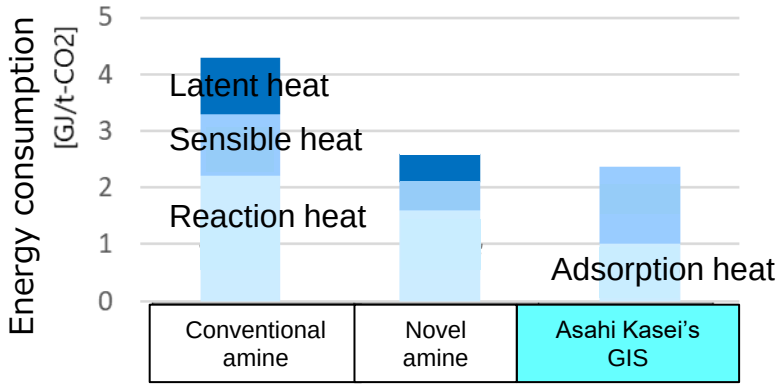
CO_2 molecule
4.1 x 2.4 Å (3.3 Å)

Zeolite for fixed bed VSA

CO_2/N_2 adsorption selectivity and capacity



Energy consumptions

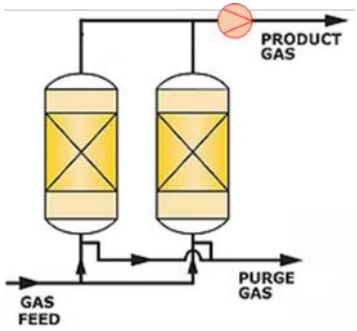


Energy consumption is lower than that of conventional amine-based processes, and lower cost and energy savings can be expected.

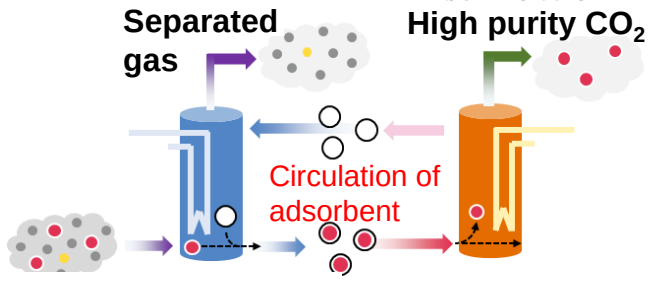
Development of CO_2 separation and recovery system

- **Fixed bed VSA (<100,000 t/y): Liquid CO_2, hydrogen production, biomethane purification**
- **Fluidized bed TSA (≥100,000 t/y): Exhaust gasses from cement/thermal power generation, natural gas purification**
- **Targets: Commercialization in 2025 and in 2030, respectively.**

VSA (vacuum swing adsorption)



TSA (thermal swing adsorption)



Digital platform for plastic resource circulation

Development of a blockchain-based digital platform for traceability of recycled plastics (Press release in Japan on May 25, 2021)

AsahiKASEI

Significance

- Recycled products have higher value in the world where resource recycling has been achieved.
- Behavior change of the customer is one of the key factors to achieve the resource-recycling society.

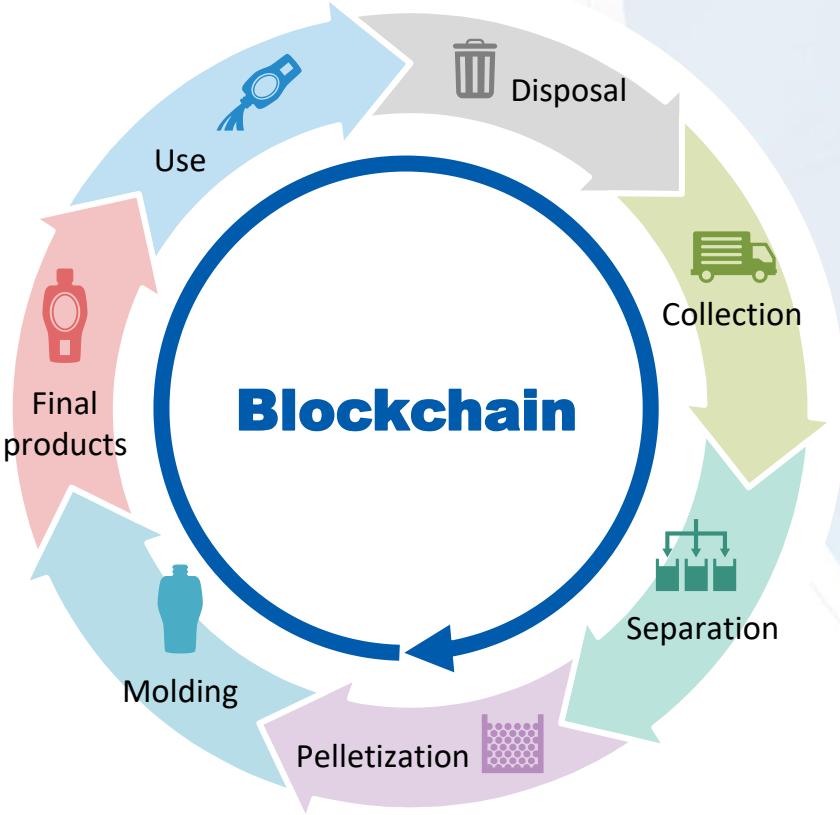
Technology

Blockchain

- Proving that the product is of recycled origin, which is difficult to prove by scientific analysis, through blockchain management.

Feature

Recycling certification, recycling chain transparency, consumer behavior change



AsahiKASEI

Creating for Tomorrow

THE COMMITMENT OF THE ASAHI KASEI GROUP:

To do all that we can in every era to help the people of the world
make the most of life and attain fulfillment in living.
Since our founding, we have always been deeply committed
to contributing to the development of society,
boldly anticipating the emergence of new needs.
This is what we mean by “Creating for Tomorrow.”