MONOTECH GREEN TECHNOLOGY

NOVEMBER 2023

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I. Introduction of Monotech

Introduction of Monotech

A research-oriented company with expertise in eco-friendly technology of polymer/inorganic materials and industrial waste recycling

CategoryD	Information
Company Name	Monotech
Esteblishment	05.Aug.2016.
Equity	1 billion Korean Won
Main Biz.	Development of Ecofriendly Technology - Polymer/inorganic materials(Polybutene-1/POE) - Industrial waste recycling(Waste Aluminum dross, Spent catalyst, Industrial slag Recycle)
R&D/Plant site	283, Saneop-ro, Gwangyang-si, Jeollanam-do, Korea (Gwangyang National Industrial Complex)

Monotech Main Technology

List of Main Technology

Ecofriendly Materials	▪ Technology of Polybutene-1/Polyolefin elastomer(PB-1/POE) Production ▪ Technology of Hydrometallurgical Nickel Ore Concentration for battery raw material production
Industrial waste recycling	▪ Waste Catalyst Treatment Technology for Precious Metal(Mo, V, Ni) Recovery
Non-Ferrous Metal Recycling	▪ Non-ferrous Metals Recycling and Trading

II. Technology of Ecofriendly Materials

Technology of Polybutene-1/Polyolefin elastomer(PB-1/POE) Production

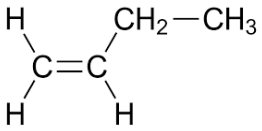
- Sole International Licensor of PB-1/POE Production Technology
- Eco-friendly alternative plastics of rubber which can be recycled
- High-functional pipe materials which has the best physical properties in existence

Polybutene-1/Poly Olefin Elastomer

- Recyclable & High functional Polymer Material Production Technology
- Sole International Licensor of PB-1/POE swing plant technology
- PB-1/POE is a highly functional polymer product that can be recycled as unique alternative of PE-XL and rubber that cannot be recycled.

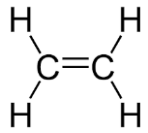
PB-1/POE Manufacturing

Polymerization



1-butene

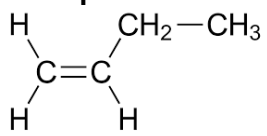
PB-1



Co-Polymerization

Ethylene

+



1-butene

POE

Application of PB-1/POE

▪PB-1

➔ pipe : Hygiene(water/hot water supply), M/S 80%

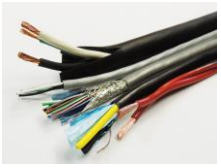
➔ Under floor heating Pipe : M/S 30%

➔ Packaging film(Easy opening)

▪POE

➔ Alternative of Rubber (Shoe, cable etc)

➔ Impact modifier : Interior & Exterior material for automobile



PB-1 Plant License (Korea Yeosu)

- Capacity : 10,000TON/년

- Establishment : 2009. 04

- Location:

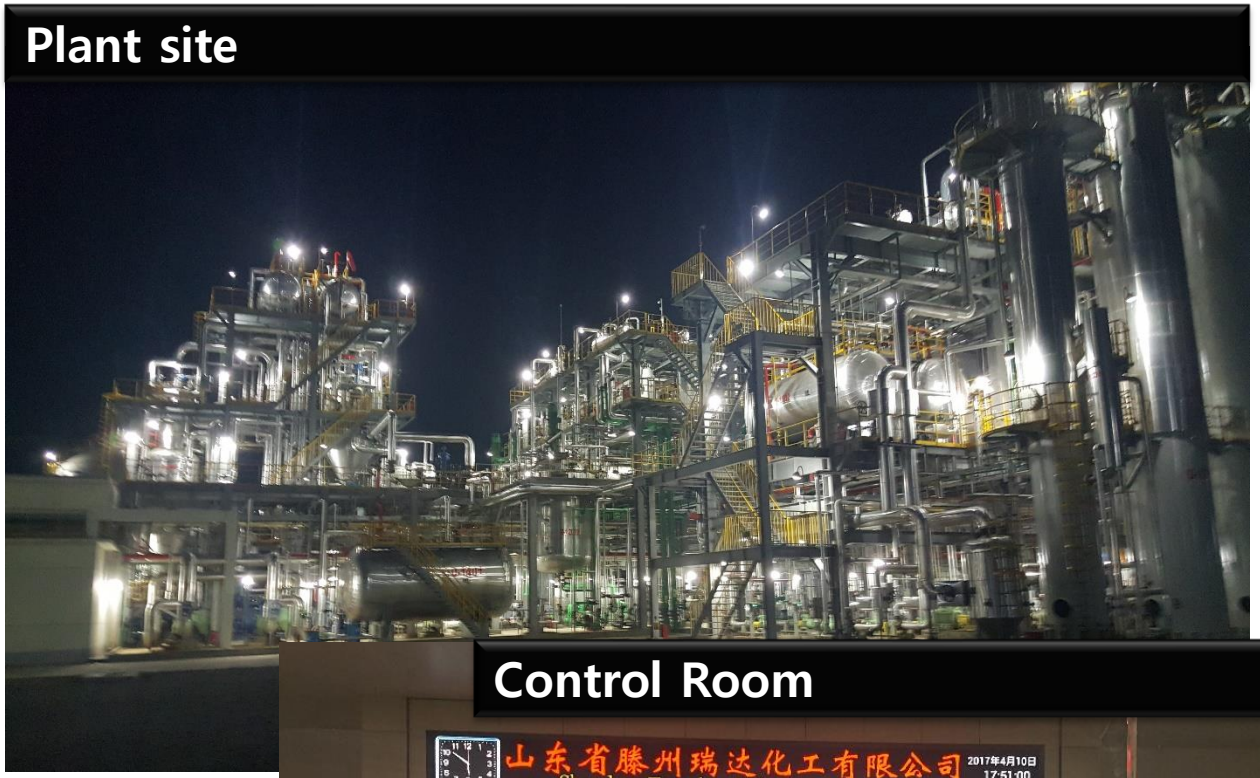
  Ylem Technology

  Yeosu Industrial Complex,

  Korea

PB-1 Plant License (China)

Plant site

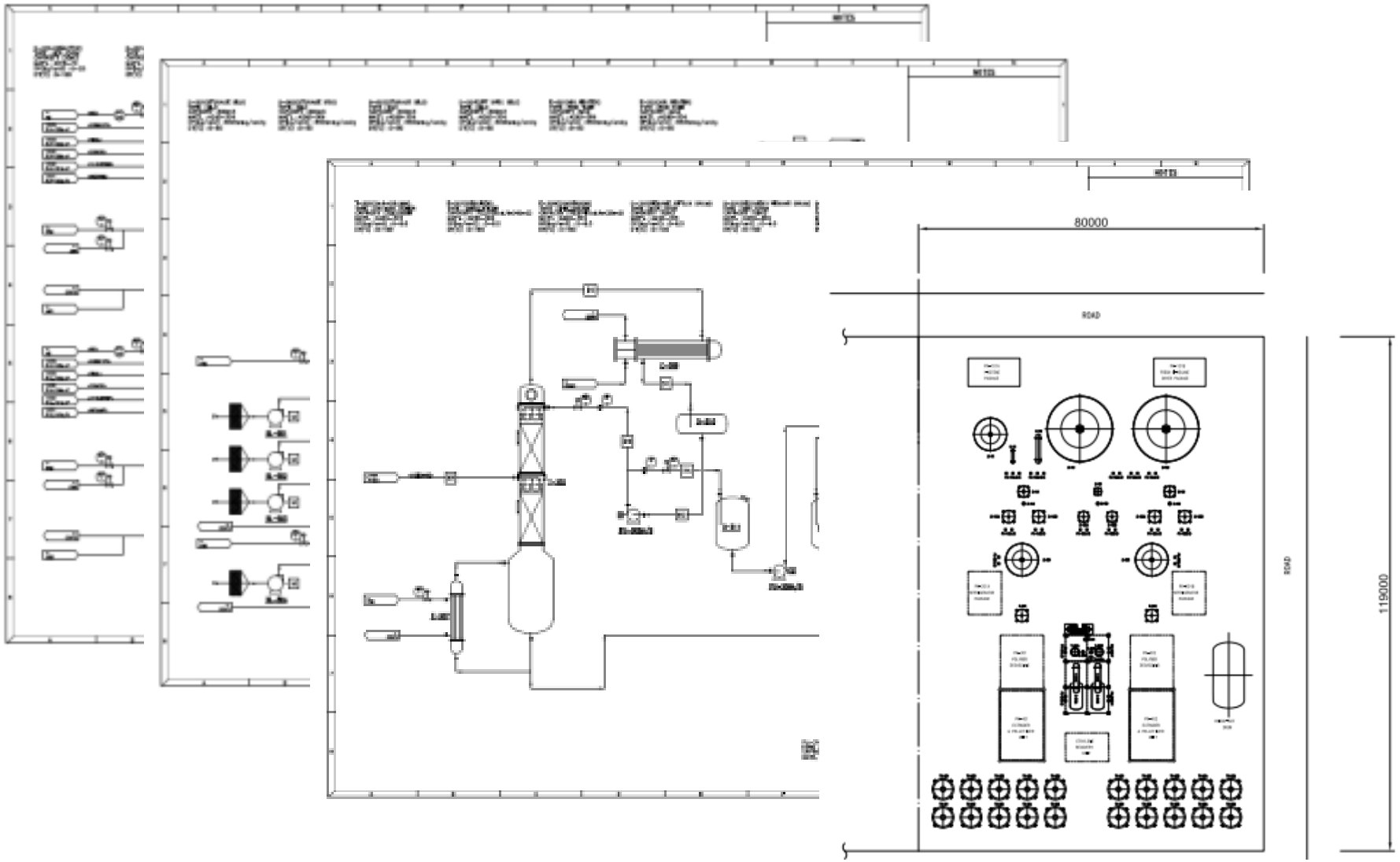


Control Room

- Capacity : 30,000TON/yr
- Establishment : 2017. 05
- Location:
  RIDA Chemical Co., Ltd.
  Tengzhou, Shandong
  Province, China

Licensing Document(P&ID) of Chinese PB-1 Plant

A part of Chinese PB-1 Plant Design(P&ID)



Technology of Hydrometallurgical Nickel Ore Concentration for battery raw material production

(MACH Process: Advanced Clean Hydro-metallurgy Process)

- New technology that significantly reduces CO_2 emissions
- Very low investment cost compared to existing smelting plant
- Waste-Zero eco-friendly process different from the existing process that generates toxic waste

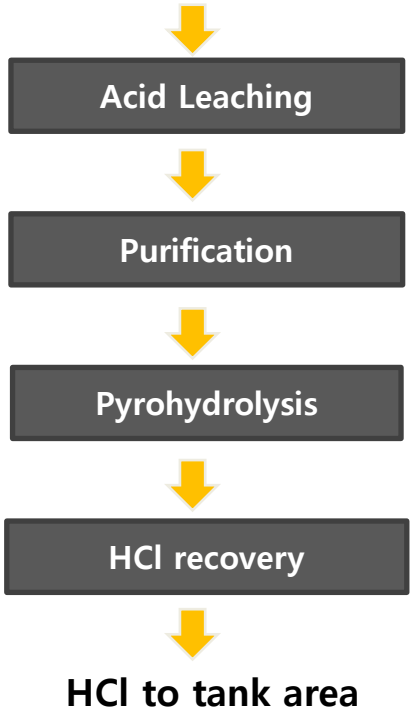
Comparison of Ni Ore Treatment Technology

Process	Smelting	HPAL (High Pressure Acid Leach)	Developing Tech.(MACH)
Raw Material	Laterite Ore	Laterite Ore	Laterite Ore
Technology	Production of ferronickel by smelting/reduction process	Nickel concentration by acid leaching at high temp.(250~270℃), high pressure(40~50bar)	Nickel concentration and to other product from waste at atmospheric, mild temp. (~80℃)
Process	Nickel ore → Drying → Preliminary reduction → Melting (>1,500 ℃) & reduction → Separation of FeNi slag → Refining → Casting → FeNi	Nickel ore → water mixing → autoclave → Neutralization → Precipitation of sulfide metal → autoclave → Solvent extraction → autoclave (hydrogen reduction) → Ni powder	Nickel ore → Acid leaching → 1st Purification → 2nd Purification → Highly concentrated Nickel compound
Investment Cost (100 million ton/yr)	800 million USD	800 million USD	200 million USD
Final Products	FeNi	Ni metal	Ni compounds, Fe_xO_y, SiO_2, MgO
Issue	- High electric cost - High investment cost - Enormous waste	- High electric cost - High investment cost - Complicate process step	- Low energy cost - Lowest investment cost - Simple process - Various high purity products
Energy consumption & Global warming gas emission	High	Medium	Very Low

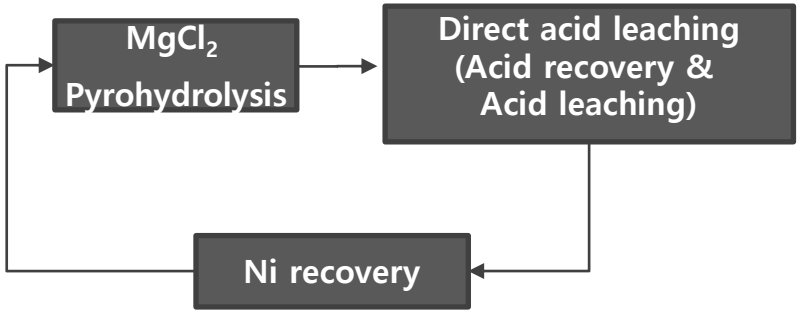
Key Technology of MACH process

- MACH process combines hydrochloric acid recovery and acid leaching step into one step. (direct acid leaching using HCl gas)
- There is no liquid HCl storage tank and no risk of HCl leakage because of HCl transfer in process area.

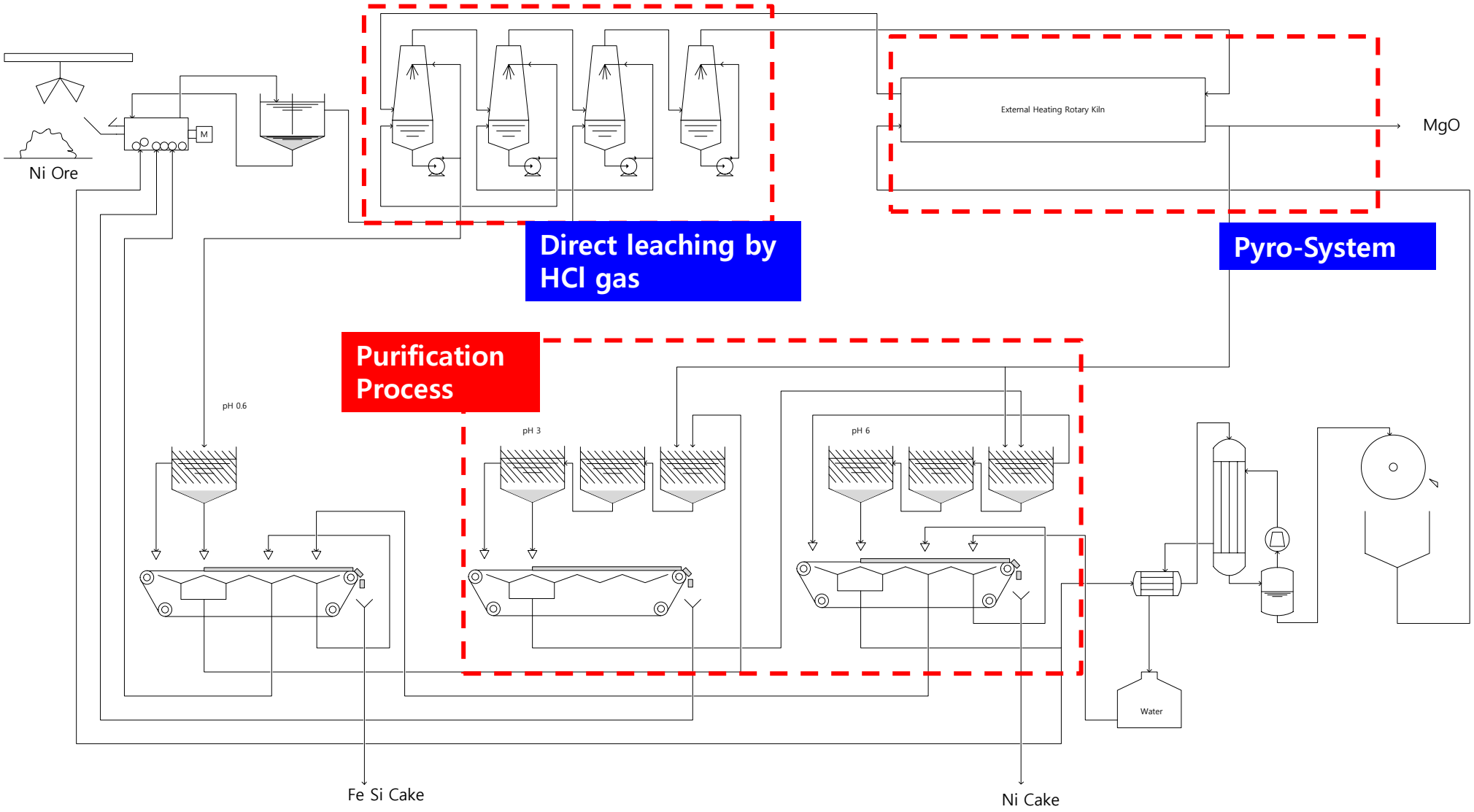
Conventional Process



MACH Technology

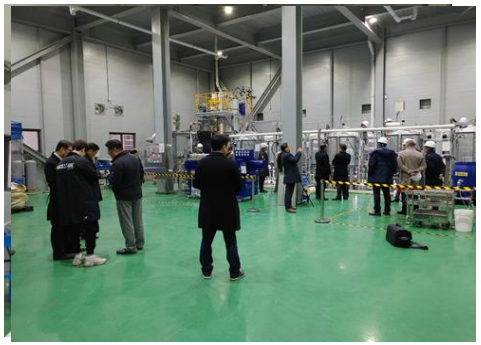


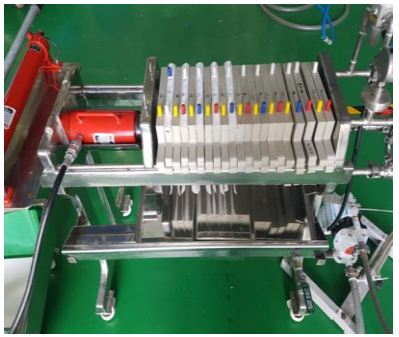
Process Block Diagram



Pilot Plant Facilities

Equipment	Amount	Usage
Pyrohydrolysis System	1 EA	MgCl2 pyrohydrolysis HCl gas generation
Leaching System	2 EA	Acid Leaching
Reactor	10 EA	Mixing/ Purification
Filter Press	3 EA	Solid/Liquid Separation



III. Technology of Industrial waste recycling

Waste Catalyst Treatment Technology for Precious Metal(Mo, V, Ni) Recovery

- Applying Monotech Waste Minimizing Technology
- The world's best technology preventing precious metal resources from overseas leakage
- Clean technology without toxic waste (Solid,Liquid waste zero)
- Essential core technology for refineries to comply with the Basel Convention in the future
- CAPEX/OPEX minimize

SPENT CATALYST

We offer commercially attractive and environmental approved recycling for all your catalysts. Depending on specific metal compounds and impurities the most competitive terms will apply.

In case no valuable metals are present, we offer competitive treatment charges.

Our proposal is most competitive for catalyst containing;
•Precious metals (Pd, Pt, Au, Ag, Rohdium, Ruthenium) (, etc.)
•Molybdenum (NiMo, CoMo, etc.)
•Nickel (including Nickel Raney)
•Tungsten
•Copper
•Zinc
•Cobalt
•Vanadium

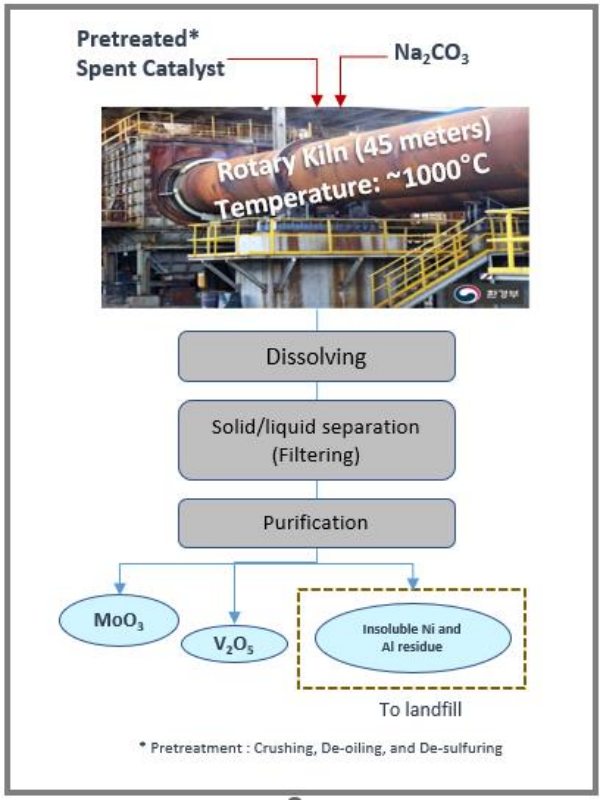
Comparison of conventional and Monolith processes

Excellent economic efficiency.

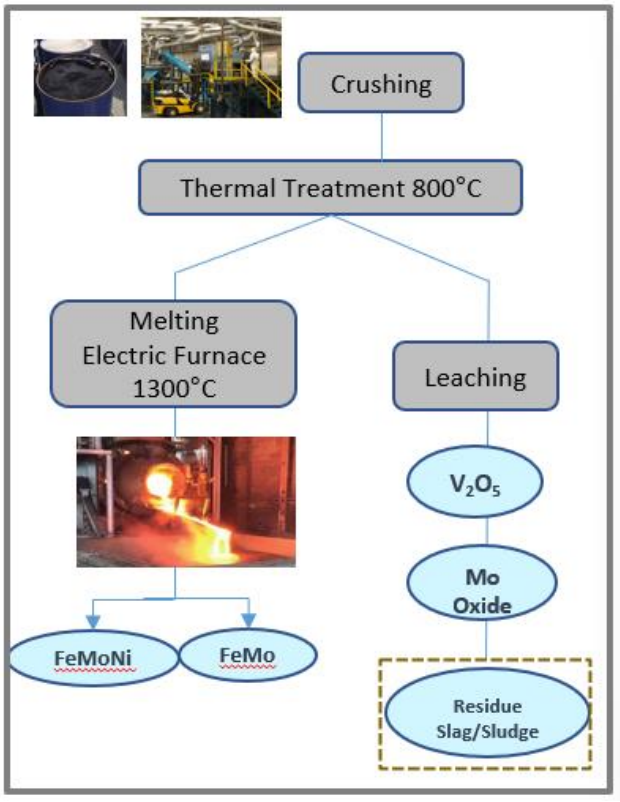
Processed at low temperature (90˚C).

Reduce carbon emissions.

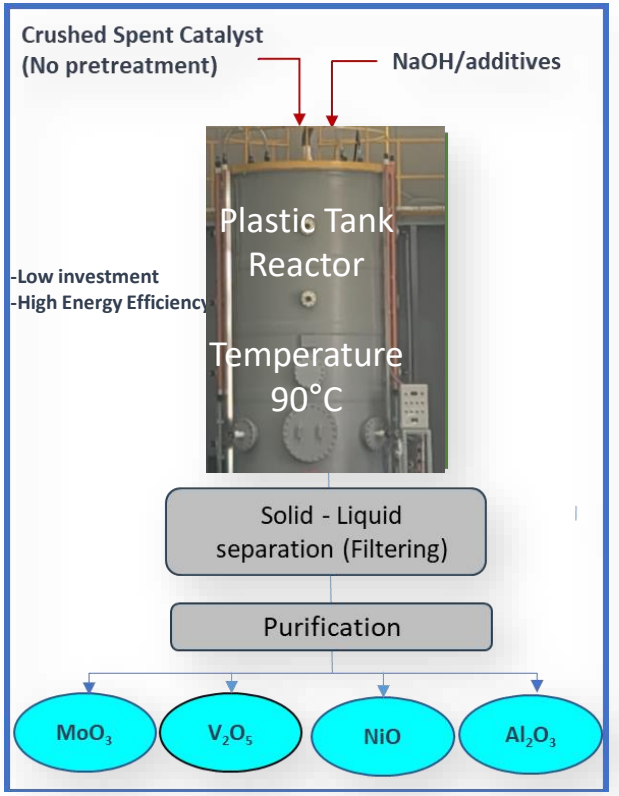
Conventional Tech. GS EcoMetal



Conventional Tech. Moxba Metrex

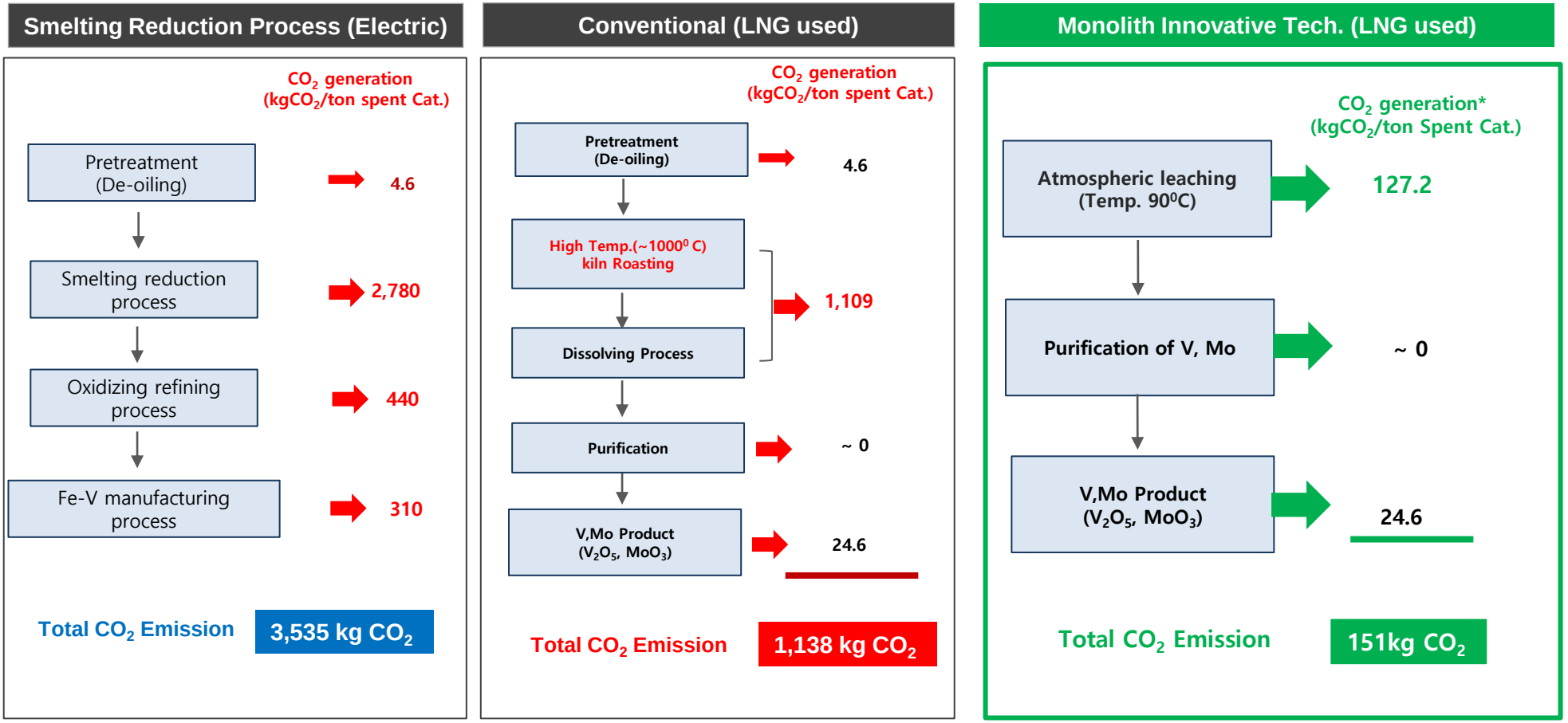


Monolith Innovative Tech.



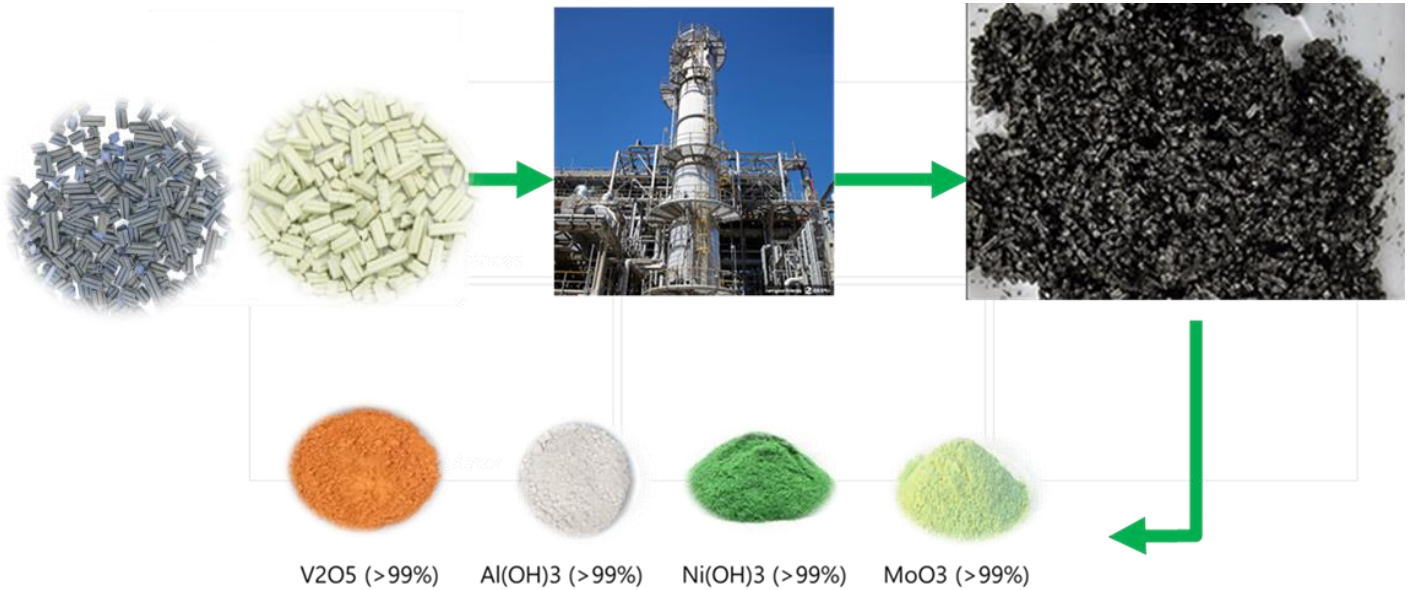
Comparison of CO2 emissions

Reduces carbon emissions by up to 3 tonnes per compared to conventional processes.



Based on Korea Environmental Industry & Technology Institute, 2009 : National LCI (Life Cycle Inventory) database Guideline

(* CO2 Generation : The amount of heat required for each process is converted into the amount of CO2 generated when using LNG.. (56,100kgCO2/TJ)


V2O5 (>99%)
Al(OH)3 (>99%)
Ni(OH)3 (>99%)
MoO3 (>99%)

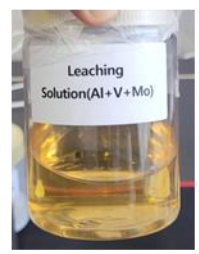

Fresh
사용후촉매 1


Oil X, Grainding
사용후촉매


Leaching
Slurry

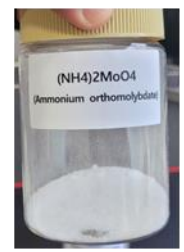

Wet Grainding
Slurry


Al Residue
(Aluminium hydroxide)

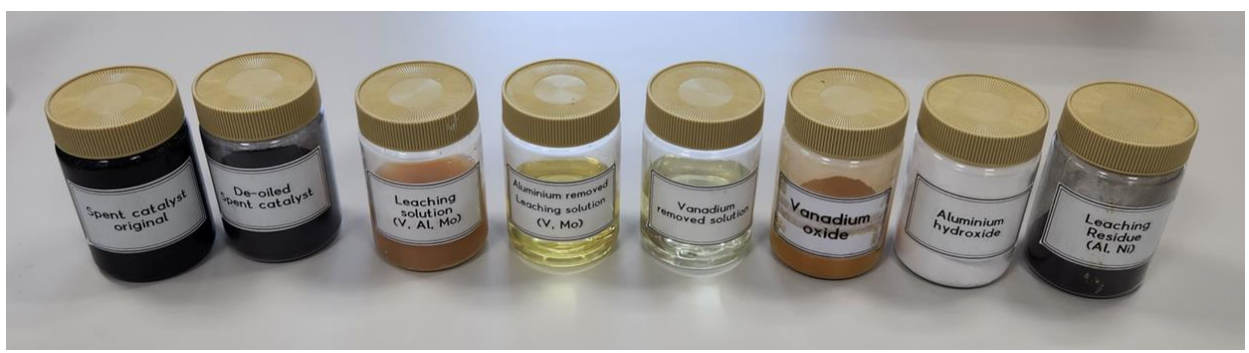

Leaching
Solution(Al+V+Mo)


NH4VO3
(Ammonium metavanadate)


V2O5
(Vanadium(V) oxide)


(NH4)2MoO4
(Ammonium orthomolybdate)


MoO3
(Molybdenum oxide)


Spent catalyst original
De-oiled Spent catalyst
Leaching solution (V, Al, Mo)
Aluminium removed Leaching solution (V, Mo)
Vanadium removed solution
Vanadium oxide
Aluminium hydroxide
Leaching Residue (Al, Ni)

Pilot Plant 5 tons ~ 3000 tons in Korea & Bahrain

Economic value of waste catalyst treatment technology

- Development of treatment technology is urgently needed due to the increase in landfill waste due to the increase in the amount of waste catalyst generated and the strengthening of environmental regulations.
- Technology development can create an economic effect of $200 million per year and environmental conservation
- GS Ecometal* Sales: KRW 69.7 billion in 2018, KRW 53 billion in 2019
- (*GS Ecometal : Korean Waste catalyst treatment company)

Necessity of developing technology for desulfurization waste catalyst treatment

Continuous increase in waste catalyst

- The air pollutant emission standard strengthened by about 30%
- Increase in desulfurization catalyst usage due to increase in sulfur content of crude oil

Increase in landfill waste

- Landfill waste increases in proportion to the increase in spent catalyst (1 ton of waste/1 tons of waste catalyst treatment)
- In the case of GS Ecometal, only Mo and V are recovered, and the excess solid waste disposed of in landfill.

Status of waste catalyst treatment in Korea

- Currently, exported overseas due to lack of domestic processing facilities
- When securing a treatment facility, it is possible to secure the waste catalyst that is exported in accordance with the Basel Convention

Economic Effects of Developing Technologies

Economic impact of 200 million USD/yr

International market price rise of V, Mo, Ni, as a major raw material for special alloys and secondary batteries

Precious Metal Compound	Recovery (Ton/yr)	Unit Price (USD $/TON)	Amount (USD $)
V_2O_5	8,000	15,232	121,856,000
MoO_3	4,000	12,053	48,212,000
$Ni(OH)_2$	2,250	9,429	21,215,250
$Al(OH)_3$	27,500	292	8,030,000
SUM	41,750		199,313,250

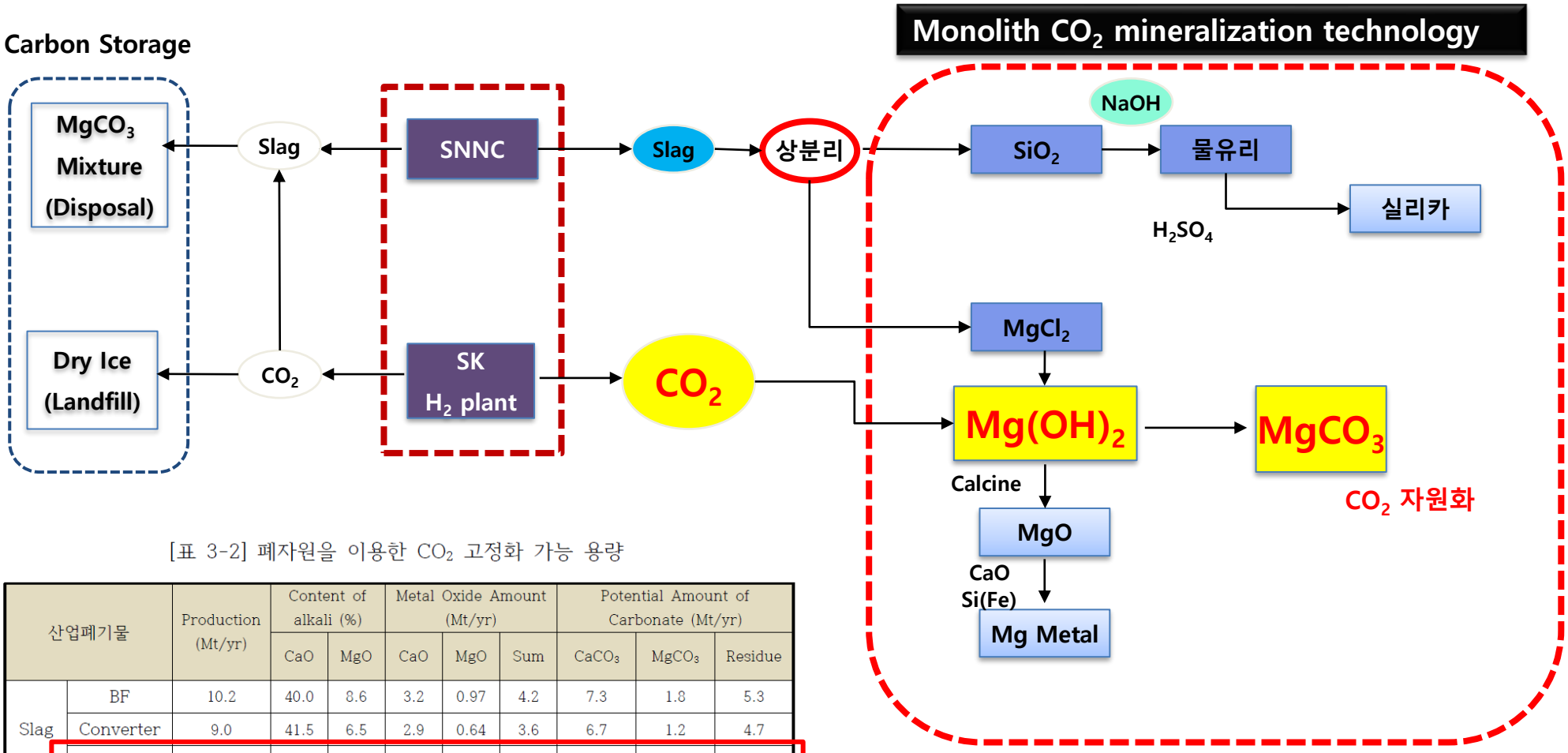
50,000 ton/yr Domestic waste catalyst treatment, price Source: LME

Magnesium hydroxide recovery from Fe-Ni slag and carbon dioxide fixation technology using it

- The only technology to solve the issue of toxic waste in the steel industry
- CO2 immobilization technology to secure blue hydrogen production base
- Securing raw materials of magnesium alloy for automobile weight reduction
- The world's sole economical toxic slag recycling technology
- Existing Pilot plant for verification of technology

Monotech's CO_2 mineralization technology using Monolith's Fe-Ni slag

- **Manufacture of magnesium carbonate (MgCO3) used as a building material by fixing/mineralizing CO2 with magnesium hydroxide (Mg(OH)2) recovered from monolith's existing slag treatment technology.**



[표 3-2] 폐자원을 이용한 CO_2 고정화 가능 용량

산업폐기물		Production (Mt/yr)	Content of alkali (%)		Metal Oxide Amount (Mt/yr)			Potential Amount of Carbonate (Mt/yr)		
			CaO	MgO	CaO	MgO	Sum	$CaCO_3$	$MgCO_3$	Residue
Slag	BF	10.2	40.0	8.6	3.2	0.97	4.2	7.3	1.8	5.3
	Converter	9.0	41.5	6.5	2.9	0.64	3.6	6.7	1.2	4.7
	Fe-Ni	1.0	0.3	31.3	0.002	0.34	0.35	0.005	0.66	0.68
Waste Concrete		30.0	15.0	1.4	3.5	0.46	4.0	8.0	0.88	25.0
Coal Ash		5.8	7.5	1.7	0.34	0.11	0.45	0.78	0.21	5.3
Asbestos		0.09	0	43.3	0	0.042	0.042	0	0.08	0.05
Total		56.1			9.9	2.6	12.6	22.8	4.9	41.0

Source: Report of Korea Institute of Geoscience and Mineral Resources(2011)

(Possible to produce 1.32 million $MgCO_3$, convert 690,000 tons of CO_2 into resources)

V. Appendix.

Appendix. Monolith R&D Facilities(Gwangyang)

MONOLITH

Laboratory

Bench Scale Facilities

10L/50L Reactors

Analysis Lab

PSA

ICP-OES

Pilot scale Facilities

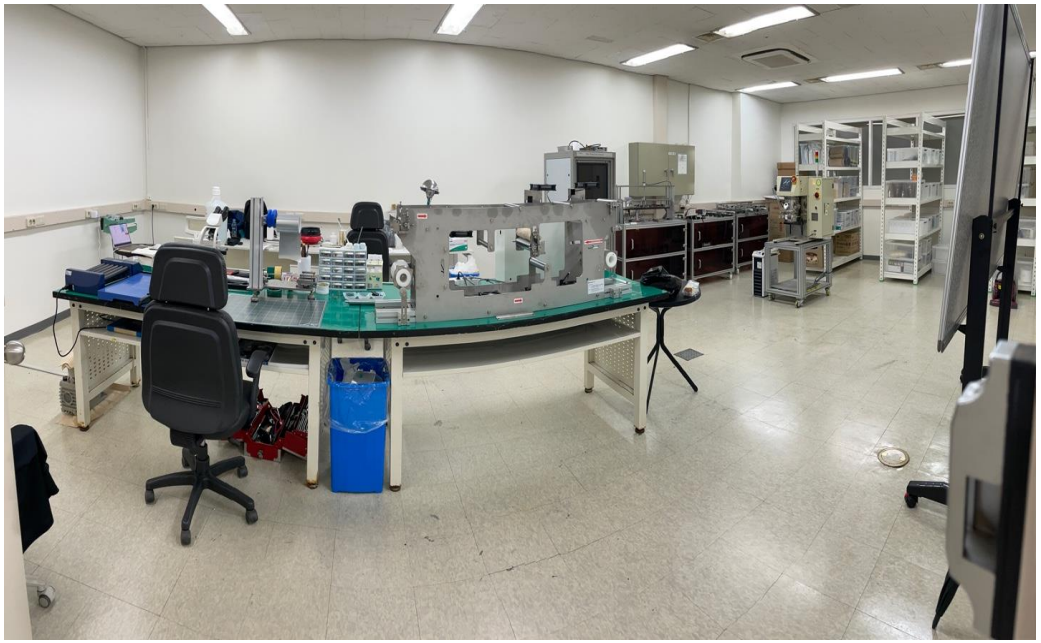
1m3 reactors system

Appendix. Monolith R&D Facilities(Suwon)

MONOLITH

Laboratory

(located in Suwon Univ.)



Equipment

Comma Coater

ESR 측정기

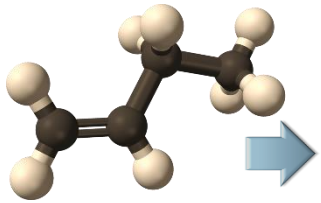
Planetary mixer

EDLC aging equipment

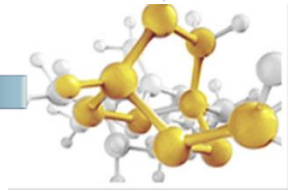
End of Document

Polybutene-1

PB-1 manufacturing



1-Butene
C4H8



Polybutene-1 **Polymerization**

Main Application & Market Forecast

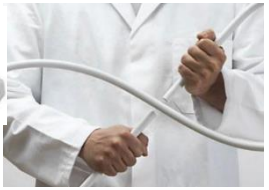
Main application

Piping materials

Packaging materials Additive Polymer

Electric Cable

Hot Melt Adhesive



Flexibility

Market Forecast

Market Drivers	2017-19	2019-21	2021-24
	Impact		
Increased application of Polybutene-1 (Resin)	Moderate	High	High
Growing demand for polybutene-1 from emerging economies	High	High	High

Source: Zion Market Research Analysis, 2018

Key Player(Only two Licensor)

LyondellBasell

Monotech Green Technology

Butene-1 is mainly used in the production of high-quality plastics such as polyethylene and polybutene-1. Important applications of Butene-1 are packaging materials such as films, bags, and food packaging.

PUSH FIT System: no bending tools, no naked flame, no fluxes or chemicals are needed.

Modification of PE-films with PB-1 .

HOT MELT ADHESIVE

MONOTECH CO., LTD Seoul, Korea
Middle East Operation Center, Bahrain

monotech@k-monotech.com
www.k-monotech.com

PB-1 Characteristics

- ✔Flexibility
- ✔Creep resistance
- ✔Thermal pressure resistance
- ✔Pipe weight saving
- ✔Acoustics / Noise absorption
- ✔Impact resistance
- ✔Chemical resistance

PB-1 added to concentrates can significantly lower the pressure needed to extrude PP fiber and reduce agglomeration in compounds.

PB-1 added directly to PP will improve the flow characteristics, especially in high molecular weight.

Downstream PB-1 Pipe & Fitting Production

Floor Heating System

Monotech
Green Technology

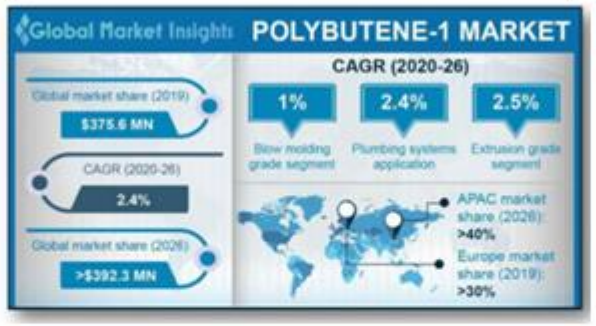
Polyolefins Technology & Scientific and Technical Services

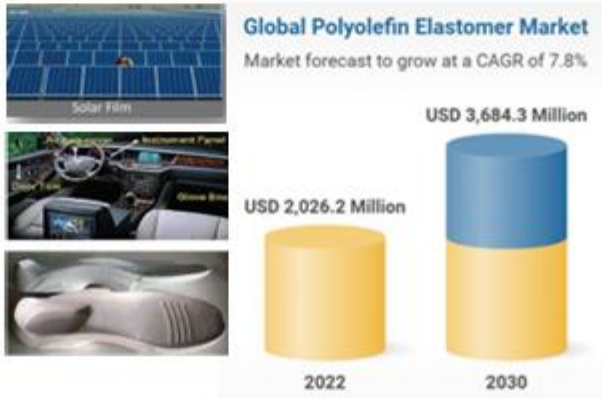
PB-1/ POE Licensor

Monotech
Advanced Energy Research Institute

What we do?

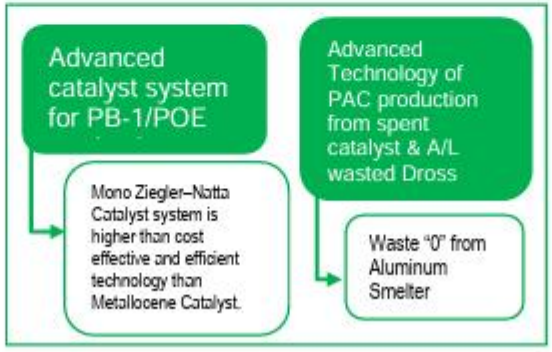
1. Polybutene-1/POE Production Technology **PB-1/PE-RT Pipe manufacturing Technology**
2. Technology of Hydrometallurgical **Nickel Ore** Concentration for battery raw material production
3. Spent Catalyst Treatment Technology for Precious **Metal Recovery -Co, Cu, Mo, Ni, V, W, Zn**
4. Technology of **PAC** (Polyaluminum chloride) Production from waste catalyst & A/L Dross Recycling.
5. Non-Ferrous Scrap Metals Trading & Recycling.





Expansion with production capability

Monotech is planning to start new differentiated polyolefin products to the marketplace by focusing on advanced catalyst and process technology and delivering value to our customers globally.



What is Polybutene-1(PB-1)

What is Polybutene-1(PB-1)

Polybutene-1 is produced by polymerization. of 1-butene using supported Commercial Ziegler–Natta catalysts.

PB-1 is a high molecular weight, linear, isotactic, and semi-crystalline polymer.

PB-1 combines typical characteristics of conventional polyolefins with certain properties of technical polymers.

What is C4-Polyolefin Elastomer?

- Polyolefin elastomers (or POEs) are a relatively new class of polymers that emerged with Monolith's advanced in Ziegler–Natta polymerization catalysts. Representing one of the fastest growing synthetic polymers.
- Polyolefin elastomers (POEs) have become one of the leading materials used in **automotive exteriors** and **interiors, wire and cable coatings, extrusion coating, films, injection molding, medical products, adhesives, footwear, and foams.**

Polybutene-1 /Polyolefin Elastomer Swing Plant Technology.

POE production plant in conjunction with Polybutene -1 production plant.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THANK YOU