Large Capacity PFC Catalytic Abatement

Contents

EcoPro HN

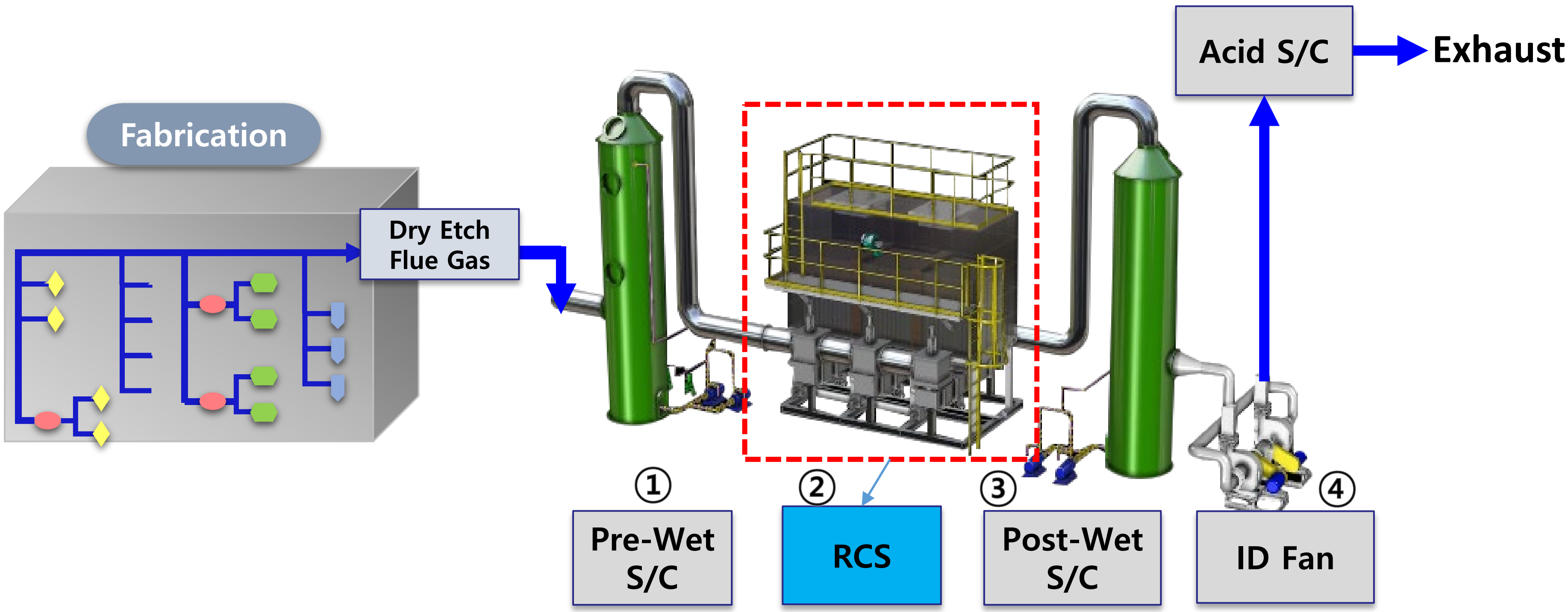
Green House gases(GHG) & Global Warming Potential(GWP)

6 Major GHG	 CO_2	 CH_4	 N_2O	 HFCs	 PFCs	 SF_6
Sources of Emission	Fuel use	Waste, Agriculture, Landfill	Fertilizer use, Nitric acid, Caprolactam	Refrigerant, Foaming agent	Semiconductor manufacturing	LCD Electrical insulator
GWP	1	21	310	140 ~ 11,700	6,500 ~ 9,200	23,900
Green House Effect(%)	55	15	6		24	

*** Global Warming Potential**

GWP is a measure of how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon, relative to carbon dioxide. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide and is expressed as a factor of carbon dioxide (whose GWP is standardized to 1.

1. Technical Overview



◆ RCS(Regenerative Catalyst Oxidation is a technology jointly developed by Samsung Engineering and EcoProHN

① Pre-Wet SCR	② RCS	③ Post-Wet SCR	④ ID Fan
Catalytic poisoning Removal (HF, Cl_Gas, Dust, etc.)	CF_4, SF_6 etc.. PFCs Gas decomposition Eff. : 95% based on CF_4 Operation Temp. : 780℃	Treatment of by-product of PFCs (HF, SOx, etc.)	Maintain Process flow and static pressure

Differences from Existing Technologies

List	Burn / Electric Heat Type	Central RCS
Characteristic	· Degradation of greenhouse gases at high temperature above **1,300 ℃**	· Degradation of greenhouse gases at high temperature above **700 ℃**
Remark	· High operation cost · Excessive energy consumption · Maintenance and fire hazard↗	· Low operation cost (Amount of energy generated↘) · Implemented large capacity integrated processing on the **roof and ground** · Eliminating the fluorine compound, environment friendly equipment · NOx Emission minimized · Much less risk on fire hazard · Available for RCS installing at existing FAB running 24 hours

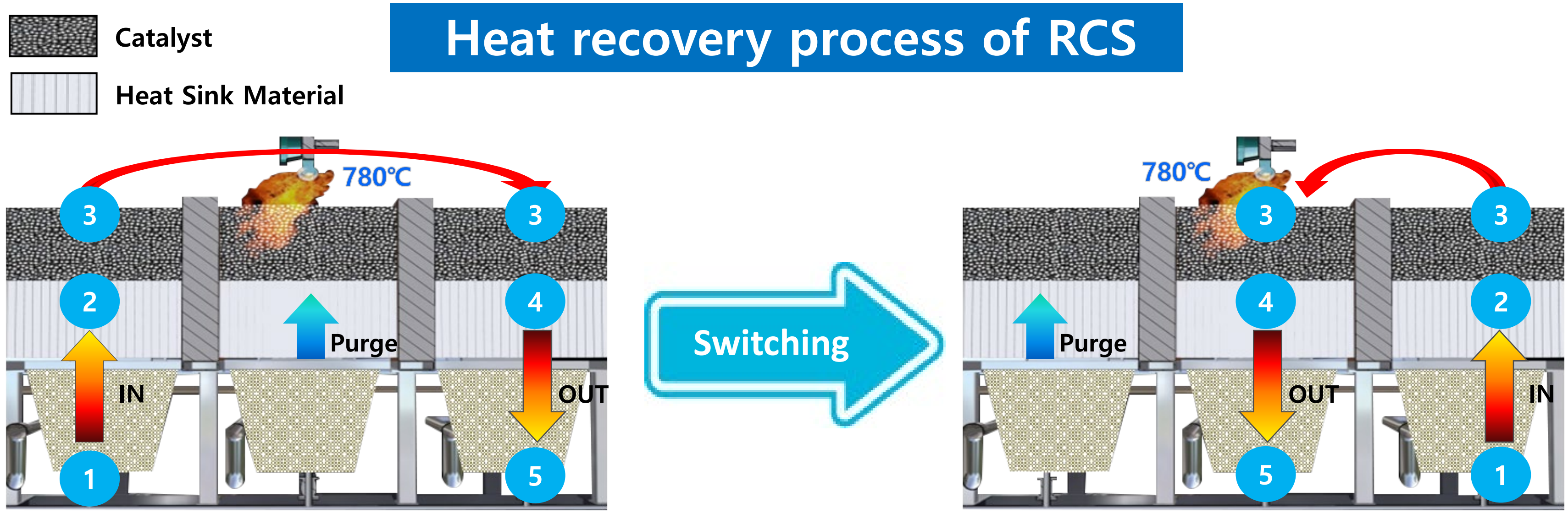
2. System Configuration

Consist of RCS and Function

Name	Description
① Catalyst	Catalytic reaction degrades PFCs GAS decomposition temperature Over 1300℃ ▶ Over 700℃ (Energy Saving)✓
② Heat Sink Material	PFCs gas recovers high-temperature heat after passing through catalyst ,so that saving operating costs even at high temperatures Heat recovery efficiency 95%↑ (Energy conservation)✓
③ Refractory Material	Uses special refractory materials with high corrosion resistance against PFC and HF
④ Casing	Application of strong corrosion resistant material Casing to HF
⑤ In/Out Damper	Poppet type damper with the best durability applied for periodic switching operation

3. Heat Recovery Technology

Heat recovery process of RCS



① Input process gas (25 ℃~30 ℃)

② It absorbs heat at almost the decomposition temperature level (over 700℃)

③ PFC gas is decomposed by passing through catalyst layer

④ And then, the PFC gas of high temperature release hot heats to the HSM.

That is the Heat recovery technology.

(In other words, Heat regenerator is recovered thereby the HSM absorbs the hot heats.)

⑤ Exhaust gas (high temperature : 60 ~ 70 ℃) is higher than the input gas.

Thus, the heat recovery rate is about 95%.

4. Performance (Lab. Data)

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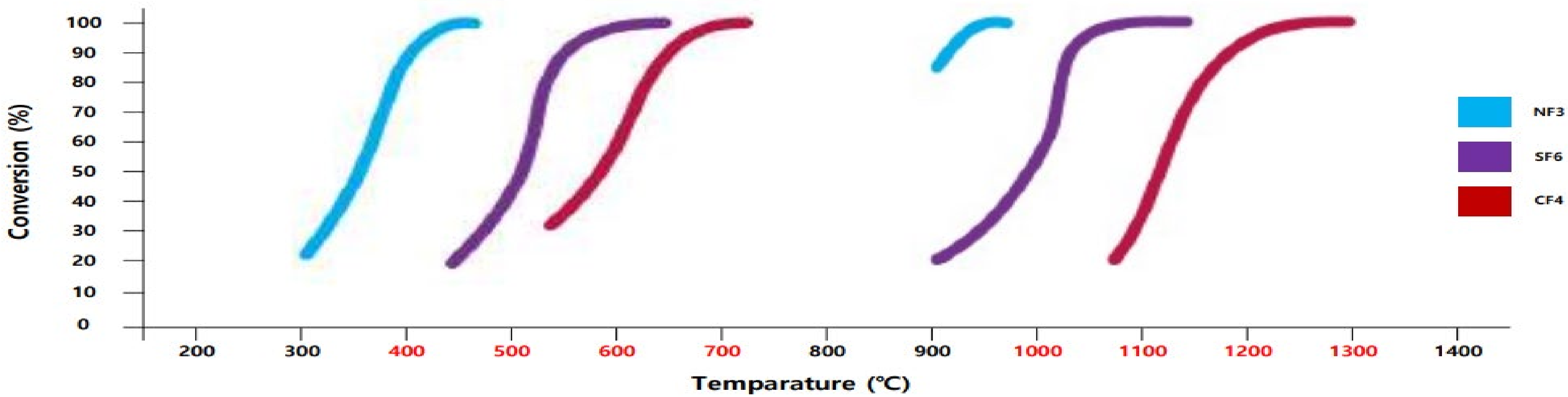
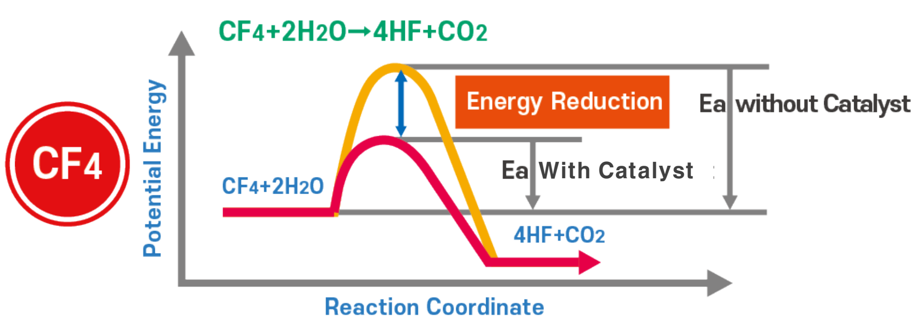
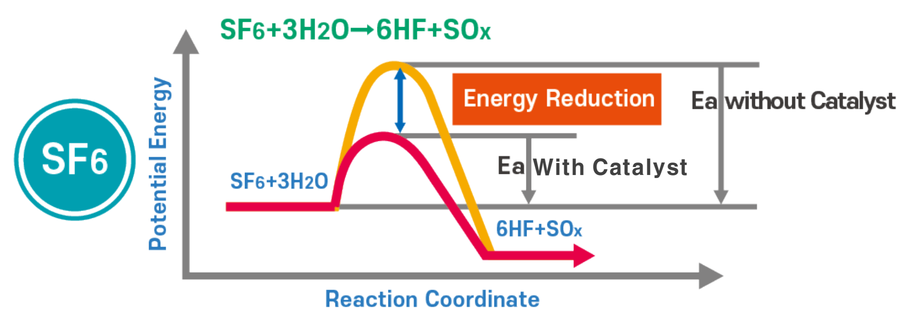
Catalytic Decomposition

Thermal Decomposition







5. Field Data for PFCs Gas Removal Efficiency

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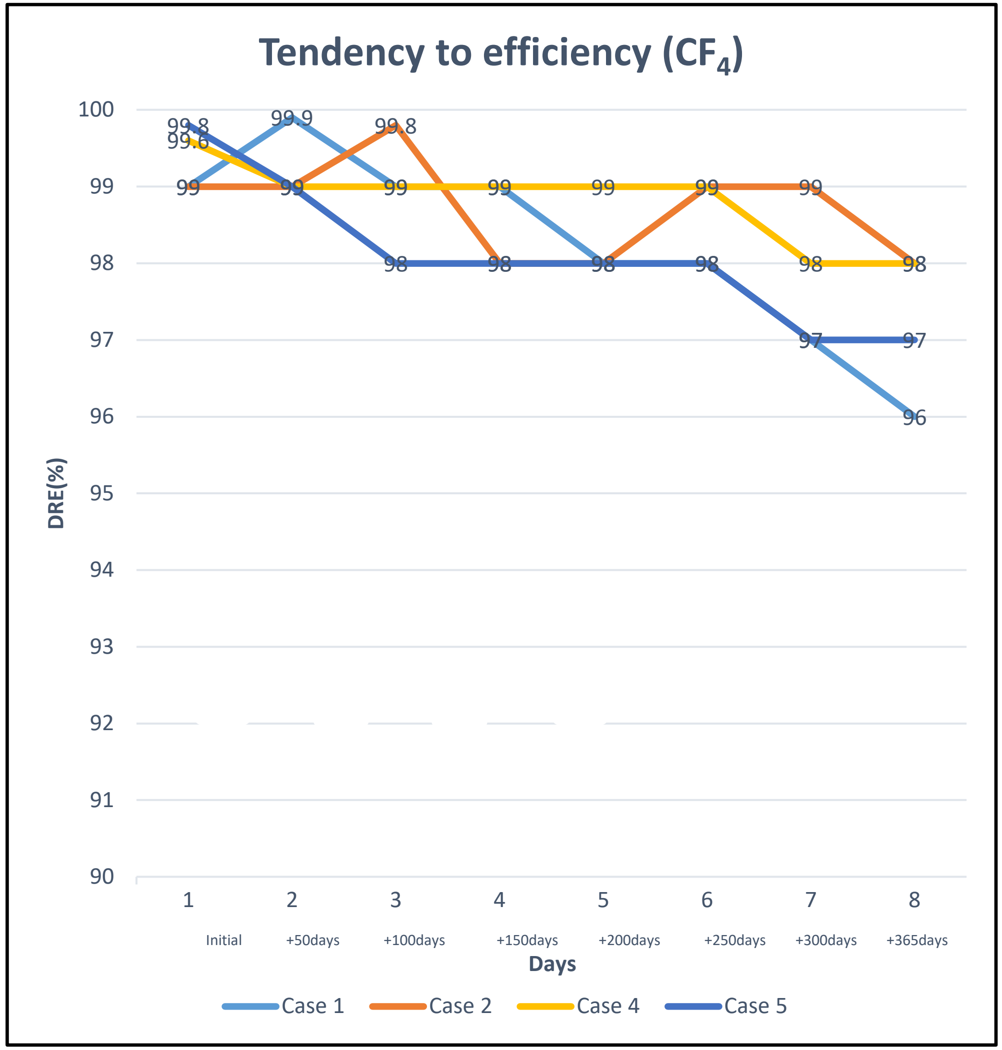
1. Possibility and Effectives on RCS treatment

Design Parameter		Possibility of RCS Treatment	Effectives on RCS
HF, BCl_3, Cl_2, HBr		X	Catalyst performance degradation
CF_4		O	
C-F compound	C_4F_6	O Proposing to ≥95%	
	C_4F_8		
	CH_2F_2		
	CH_3F		
	CHF_3		
SF_6		O Proposing to ≥95%	
NF_3		O Proposing to ≥95%	Occur NOx
CO		O	
Sulfur compounds (COS, SO_2)		X	No problem RCS itself (Cause catalyst performance decrease)
Silica compounds (SiH_4, Si_2H_6, SiF_4, $(SiH_3)_3N$)		X	Masking, (Cause catalyst performance decrease)
O2		X	X
Inert Gas (N_2, He, Ar, etc)		X	X

2. Field Data for 1 year



6. PFC Catalyst (Next Generation)

Everyday Everywhere EcoPro HN

PFC Catalyst

Removal of Green House Gases (GHG)

PFCs removal technology emitted from semiconductor and display manufacturers

- The 1st world supplier of large-scale catalytic system for PFCs removal
- ECOPRO HN's proprietary rights on "RCS system"
- Offer exceptional expertise in the entire RCS system over 20 yrs
- Develop our specialized products and technology for customer satisfaction

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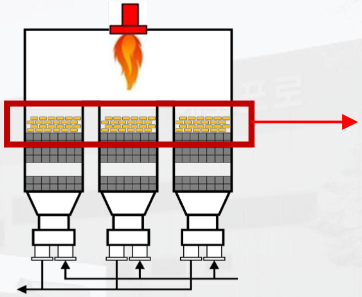
- Principal Characteristics (vs. thermal decomposition)
  - Lower the PFCs removal temperature (780℃) by hydrolysis catalytic reaction in RCS system



ITEM	Thermal	Catalytic
Removal Temp. (℃)	1,300-1,400	700 - 800
CF_4 removal rate (%)	< 90	> 90
Relative fuel usage	20	1

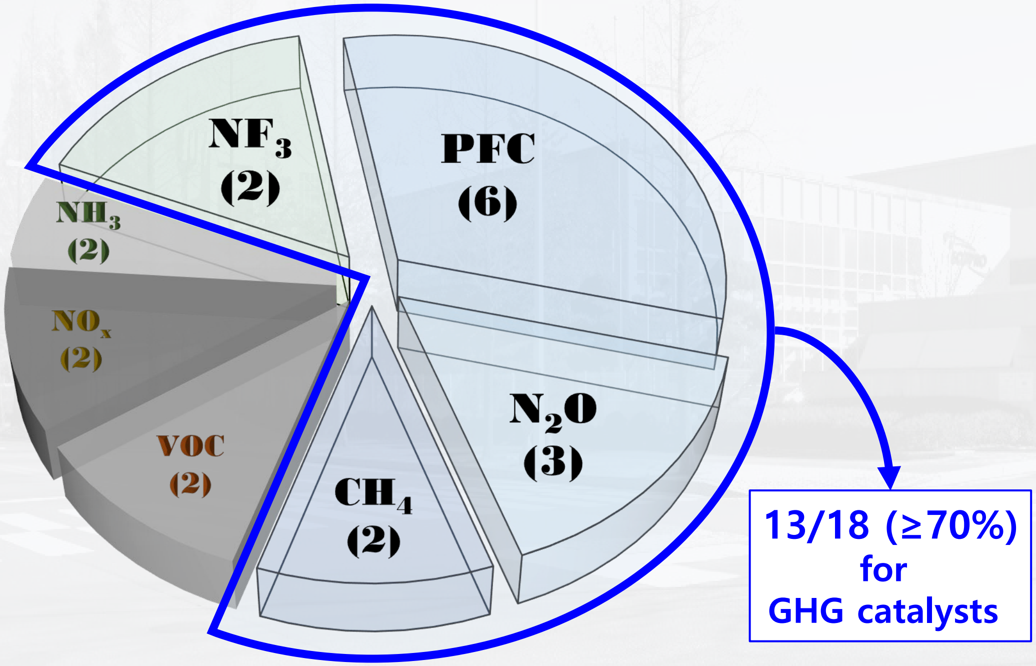
Removal Rxn.	
	• $CF_4 + 2H_2O \rightarrow 4HF + CO_2$ • $SF_6 + 2H_2O \rightarrow 4HF + SO_2$

Catalyst R&D Organization

GHG Catalyst Specialized Team Organization

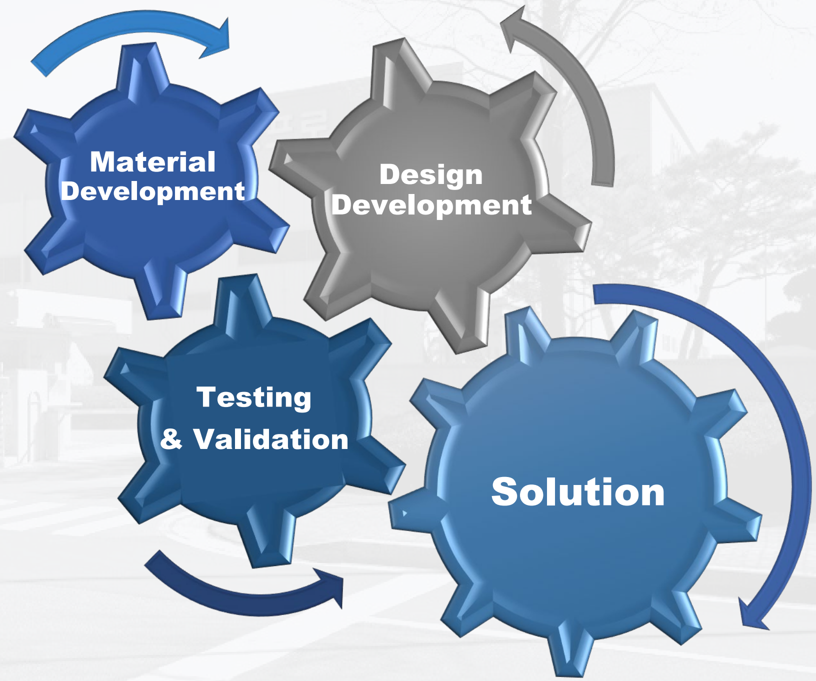
◎ Catalyst R&D Team

: Focus on developing GHG catalysts for 100% DRE



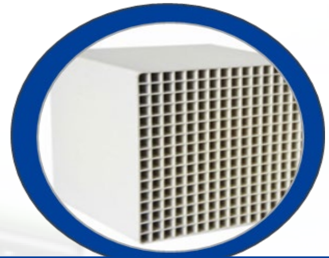
◎ PFC Catalysts

: 6 specialists with other 7 GHG researchers



History of PFC Catalysts

Core value of PFC catalyst: From catalyst itself to integrated system (Cat. + Sys.)

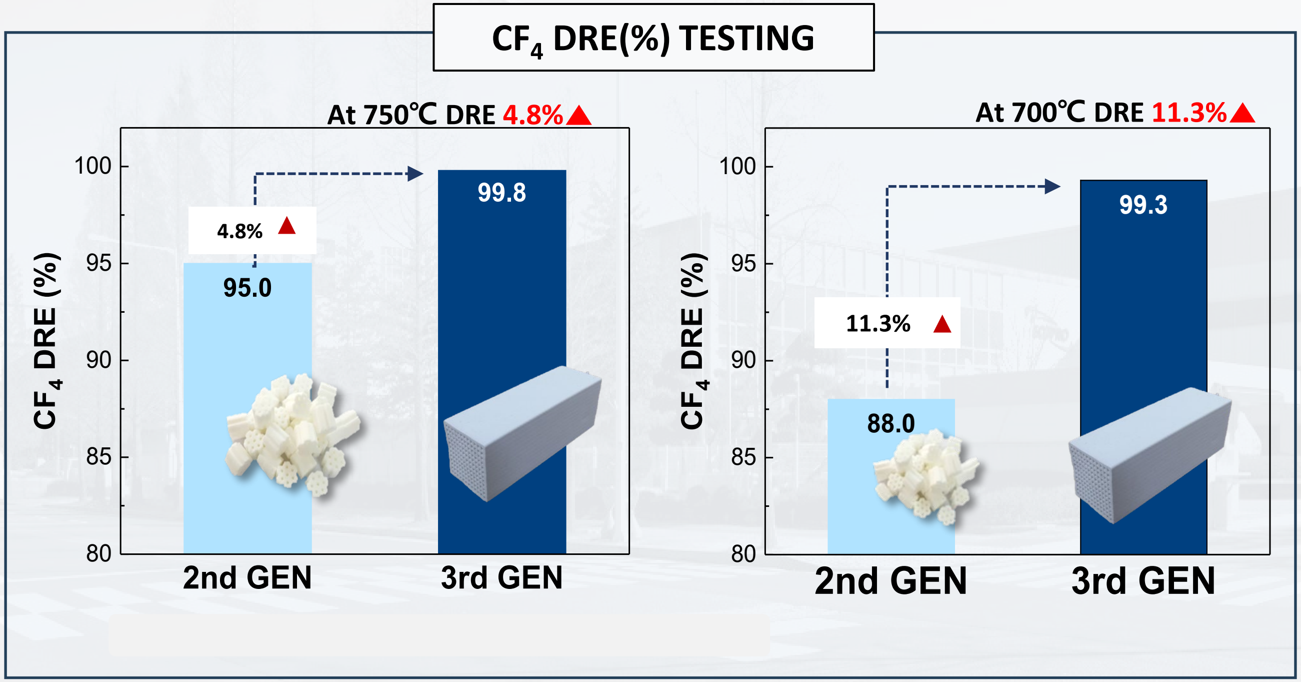
2007	2009	2017	2023	2026
				NEXT Gen?
Pre-Testing	1st Gen	2nd Gen	3rd Gen	Next Gen
Φ 4mm Pellet	Perforate	Perforate	Honeycomb	On going
Target DRE* ≥90%	Target DRE* ≥90%	Target DRE* ≥90%	Target DRE* ≥95%	Target DRE* ≥99%
Pressure Drop ↓ PM ↑	Shape change ↓ Pressure drop ↓	Resistance ↑ • Thermal • Acidic	Shape change ↓ Surface area ↑ Pressure drop ↓	Catalysts + System ↓ Remove PFCs & N_2O
Not commercialized	↓ MRO ↓	↓ Lifetime ↑	↓ CF_4 DRE ↑	↓ Lifetime ▲ MRO ▼

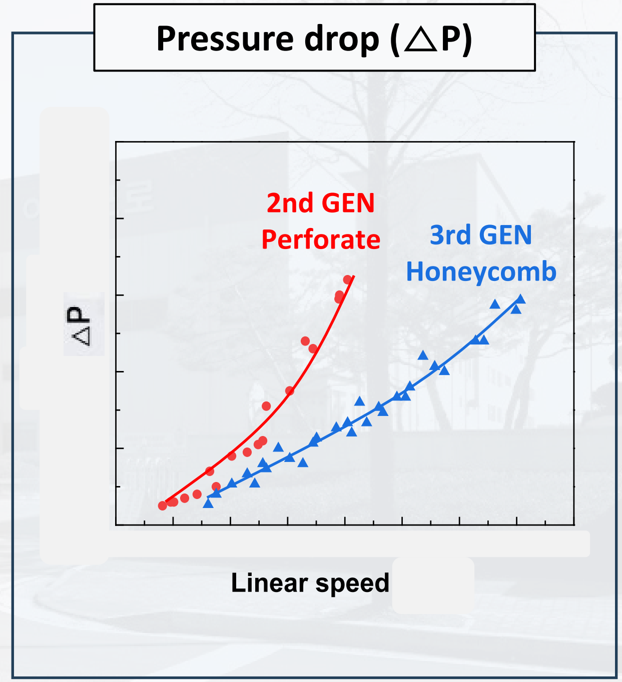
* Target DRE at 750℃

3rd GEN PFC Catalyst Performance

Enhancement of CF_4 DRE & pressure drop

Comparison 2nd GEN Perforate with 3rd GEN Honeycomb

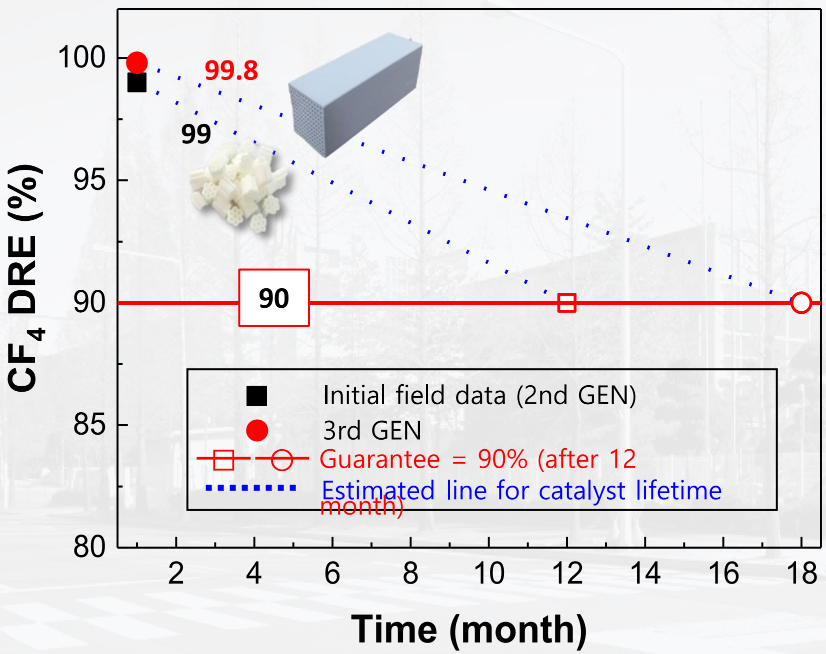




3rd GEN PFC Catalyst Performance

Estimate 6 month lifetime longer than 2nd GEN

Estimate 3rd GEN honeycomb lifetime based on the field data



Estimate a decay rate for 2nd GEN PFC catalyst (Perforate)			
PFC Catalyst	Initial CF_4 DRE (%)	Guarantee CF_4 DRE (%)	Decay rate (%/month)
Field data	99	90	0.75%▼/MON.

Estimate lifetime

PFC Catalyst	Initial CF4 DRE (%)	Guarantee CF4 DRE (%)	Lifetime (month)
2nd GEN	99.0	90	12
3rd GEN	99.8	90	18 (6 MON. ▲)
NOTE	* Lifetime is changed depending on gas condition.		

➢ When applying 3rd GEN PFC catalyst, extend ~6 months lifetime

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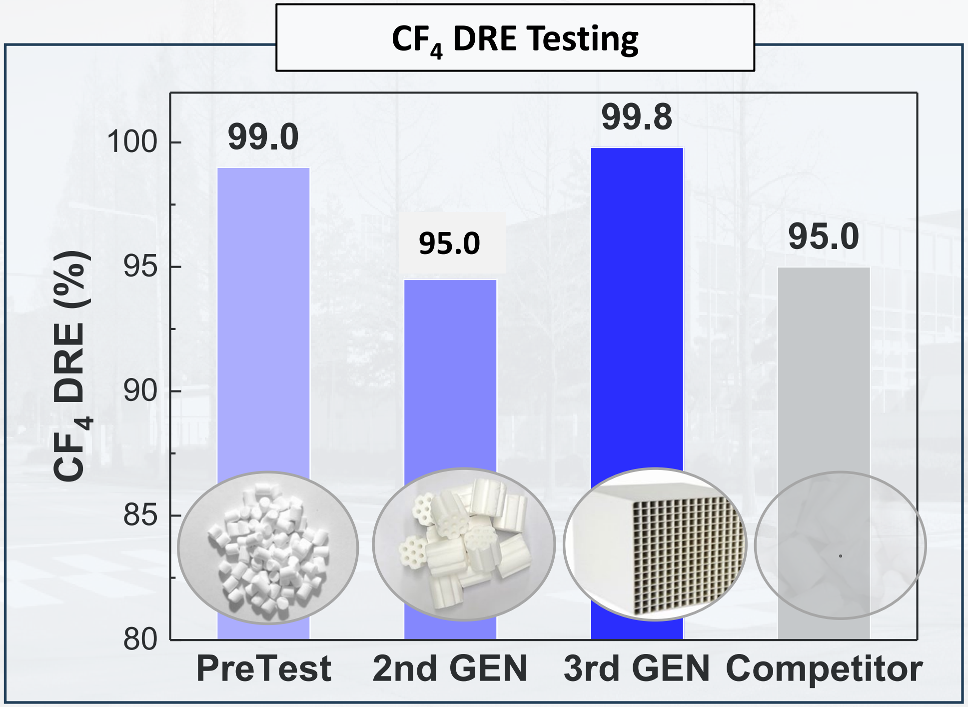
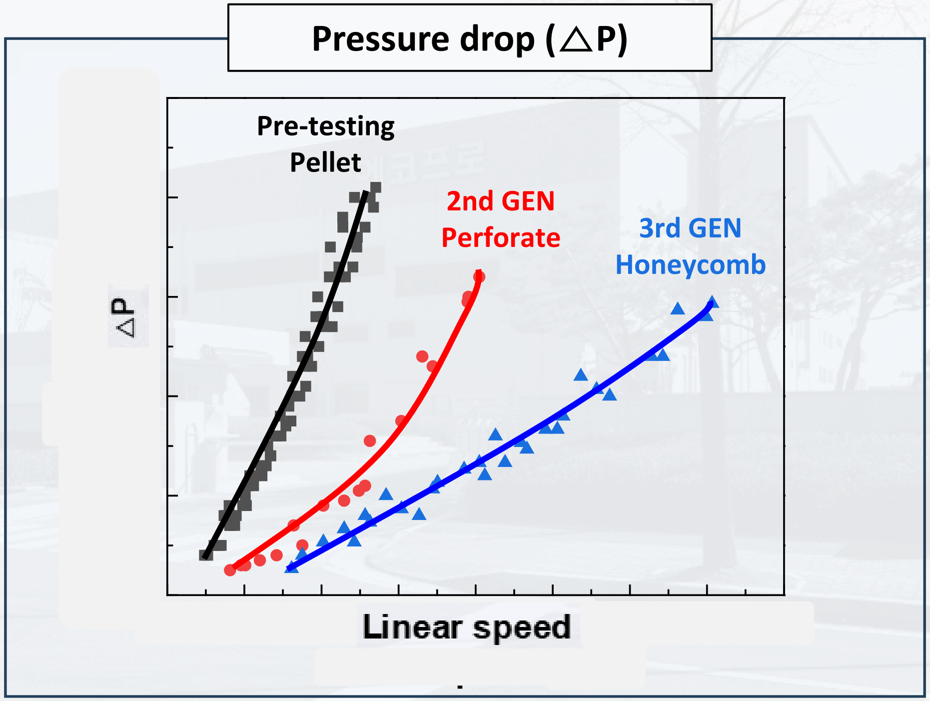
Compare ECOPRO HN vs. Competitor

CF_4 DRE (%) for ECOPRO HN & Competitor

CF_4 2,000 ppm & Temp. 750℃





Evaluation of PFC Catalysts

Catalyst Evaluation System for achieving PFC 100% DRE

DRE Evaluation Testing for PFC Catalysts

Micro-Reactor	Bench-scale Reactor	Pilot-scale Reactor
0.06 m^3/h	0.1 m^3/h	1 m^3/h
10 units	2 units	2 units

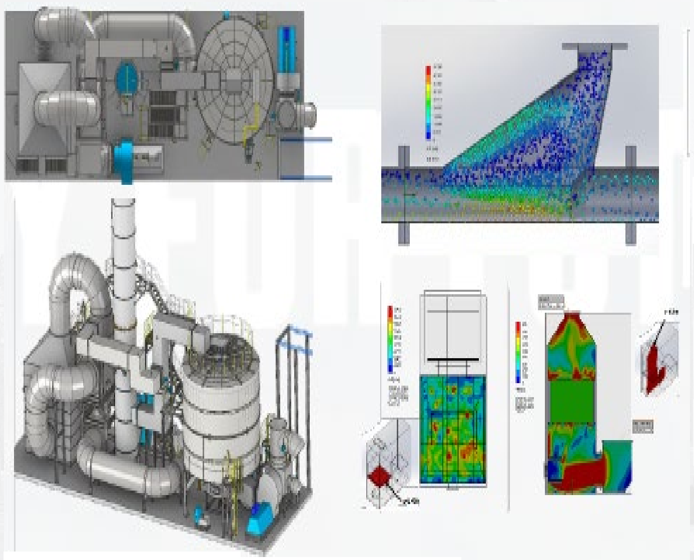
Pressure Drop

Bench-scale
Applied Vol. = 5L
1 unit

Characterization of PFC Catalysts

Various analytical instruments

Engineering Program Simulation

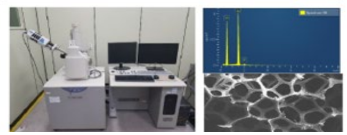


Model : Design Program

aspentech SOLIDWORKS midas Gen

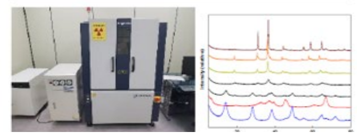
Characterization

• SEM / EDS



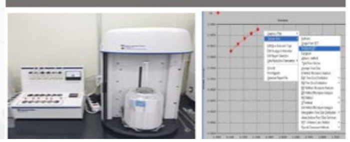
Model:Hitachi S3400N/X-MaxN20001
Purpose: surface Analysis

• XRD



Model:Rigaku Ultima IV
Purpose: Structure Analysis

• BET

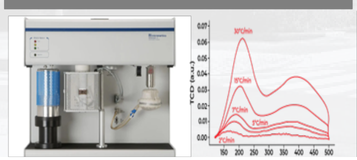


Model:Micromeritics Tristar II
Purpose: Specific surface area Analysis

• FT-IR

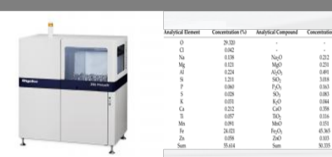
Model:IG-1000
Purpose: Efficiency Analysis

• TPD



Model:Micromeritics Chemisoption
Purpose: Chemical Adsorption Analysis

• XRF



Model:Rigaku XRF
Purpose: Material Analysis

Physical Characterization

Model: Universal Testing Machin (UTM)

7. WASTE <Catalyst / Heat Sink Material> RE–USE TECHNOLOGY

Major Application ECOPROHN is working on

Customer

Additive

Al2O3 Cement

Heavy Chemical Industry,
Incinerator Etc

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Everyday Everywhere