



# Technologies to Enhance Ethylene Production

SINOPEC Corp.

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November 2021



# Outline

**I**

**Who we are**

**II**

**SERT™ for Steam Cracking Furnace**

**III**

**Related Catalysts & Technologies**

**IV**

**Cold Oil Absorption Technology (COAT™)**

# Who we are

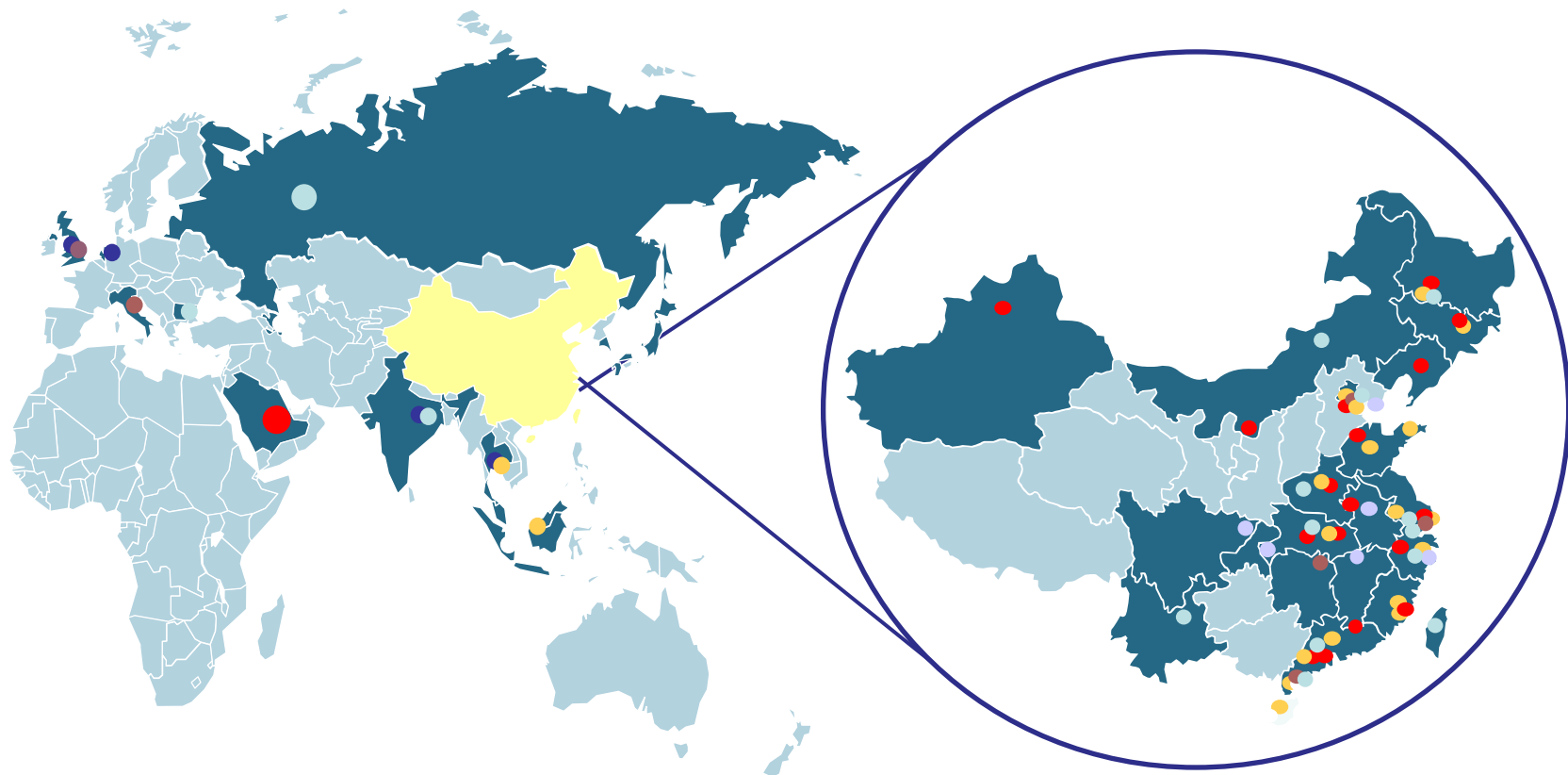
## SINOPEC R&D Capability

- ✓ SINOPEC has a complete system for scientific R&D, engineering and intellectual property management.
- ✓ 8 Research Institutes
- ✓ 5 Engineering companies (Sinopec Engineering Group)



# Who we are

**BRICI: Beijing Research Institute of Chemical Industry**  
**We provide technology & products package solutions!**

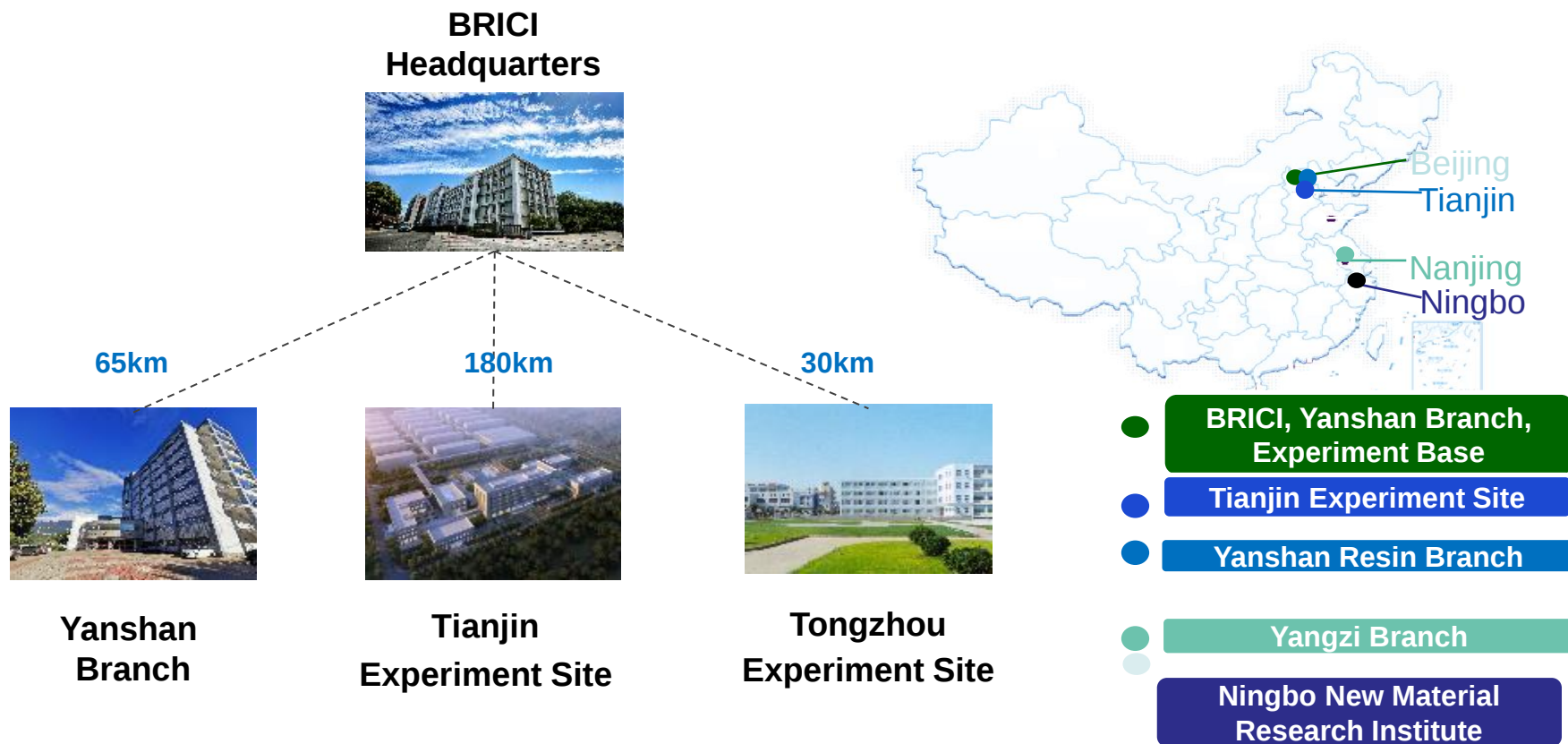


● Olefin Technology 
 ● Chemical & Fine Chemicals 
 ● Polyolefin Technology 
 ● Environment Protection 
 ● Synthetic Rubber

# Who we are

We have multiple operation sites in China

Multiple-site operation for coordinated development



# Outline

I

Who we are

II

**SERT™ for Steam Cracking Furnace**

III

Related Catalysts & Technologies

IV

Cold Oil Absorption Technology (COAT™)

# SERT™ For Steam Cracking Furnace



**SINOPEC Cracking Furnace**



**Concept of SERT™**



**Commercial Performance of SERT™**

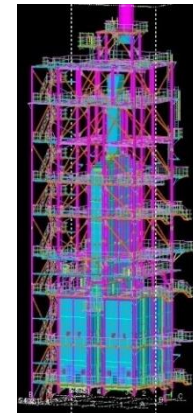


**Summary**

## Sinopec Cracking Furnace

- Sinopec has plenty of experiences in cracking furnace design and development (CBL technology). The furnace capacity is up to 200 kta.
- The raw materials are from **light feedstock**, such as ethane and light hydrocarbons, to **heavy feedstock** as diesel and HVGO.
- Till now, **113 furnaces** have been built by using CBL technology. The total capacity is **11.3 Mt**. The total number of Gas Furnace designed using CBL Technology is **23**. Total capacity is **2.7 Mt**.

**Our new generation cracking technology CBL to realize value cracking and increase feedstock flexibility**



# SERT™ For Steam Cracking Furnace

## Sinopec Technology Features of CBL Furnace

- **Feed flexibility:** From ethane to HVGO
  - DS injection: Single stage (light feed) / two-stage (heavy feed)
- **Enhanced heat transfer technology:**
  - **Swirling Element Radiant Tube (SERT™)**
  - **High thermal efficiency:** up to 94~96%
  - **Longer operating days:** increased more than 30%
- **Radiant coil:** High selectivity coil
- **Coil hanging:** Constant spring hanger
- **Cracked gas quench:** Linear quench cooler
- **Firing**
  - Combined hearth and side wall firing, hearth burner duty about 60~80%
  - 100% hearth firing
- **I.D Fan :** Inverter drive for fan speed control
- **Low investment**

# SERT™ For Steam Cracking Furnace

## Enhanced heat transfer technology



### Challenges

- ✓ **Harsh Reaction Conditions**
  - a) High temperature(780~900°C)
  - b) Short residence time
  - c) Lower hydrocarbon partial pressure
- ✓ **Poor heat transfer**
  - a) Due to the flow boundary layer and coke
  - b) Resulting in over temp. and shortened operating days



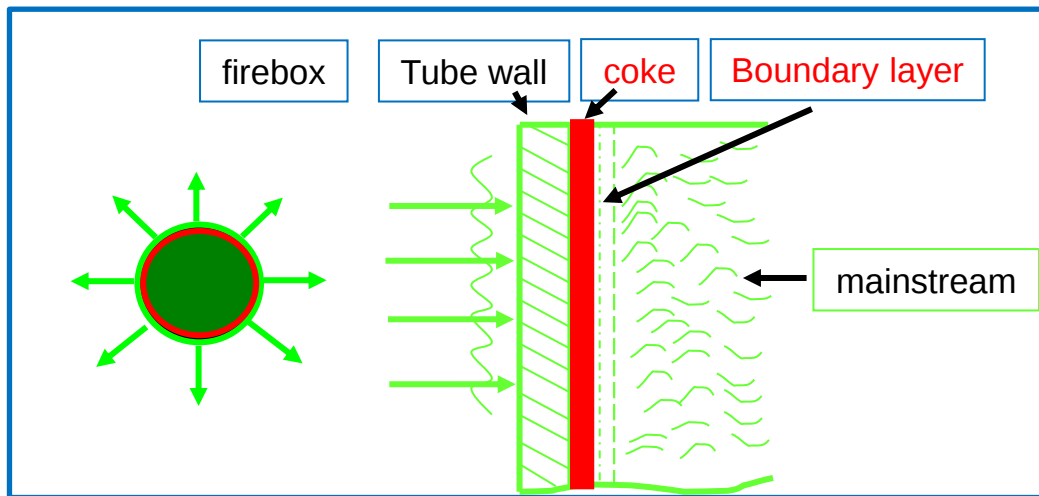
### Targets

- ✓ Quick heat transfer through tube wall into the fluid body?
- ✓ Reduce coking?
- ✓ Extend Operating days?

**Swirling Element Radiant Tube technology (SERT™)  
for extending the furnace operating days**

## Heat transfer theory

- $q = -kA \frac{dT}{dy}$ 
  - ✓ To increase the heat transfer area, A
  - ✓ To increase the temperature gradient,  $dT/dy$
  - ✓ To increase the heat transfer coefficient, k



- The **coke layer** and the **boundary layer** is the biggest resistance in pyrolysis Tube
- **Thinning the boundary layer** and **reducing the coking rate** is a **difficult problem** in pyrolysis technology.

- $\frac{1}{k} = r_{coil} + r_{boundary} + r_{coke}$



$$r_{boundary} \downarrow, r_{coke} \downarrow \Rightarrow k \uparrow$$

# SERT™ For Steam Cracking Furnace

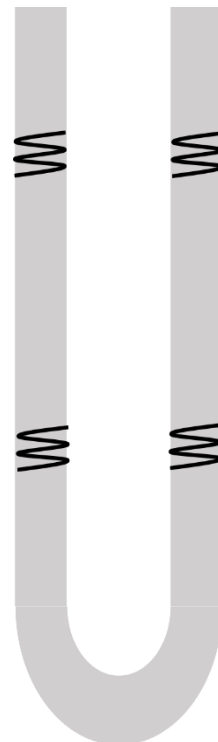
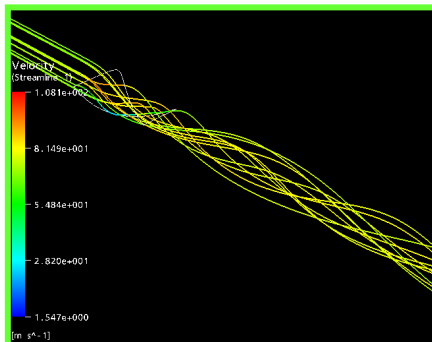
To change the flow pattern of the fluid body

Thinner boundary layer

Reduced coking rate

Reduce Tube Metal Temperature (TMT)

Extend run length



## Swirling Element Radiant Tube technology (SERT™)

Hydrocarbon feedstock is impelled from plug flow to swirling flow through it. Flow velocity along the tube perimeter is increasing and laminar boundary layer is getting thinner because of the scouring of hydrocarbon feedstock, and coke formation is reduced.



# SERT™ For Steam Cracking Furnace

## Development History of SERT™

Bench Scale  
Experiment

1995



Industrial Scale  
Experiment

2004



Commercial Promotion  
(2<sup>nd</sup> gen SERT™)

2015



1999

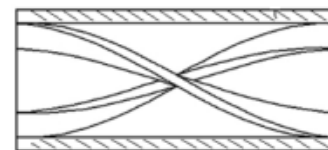
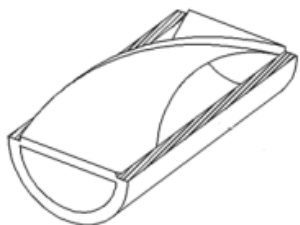


2007



Pilot Scale  
Experiment

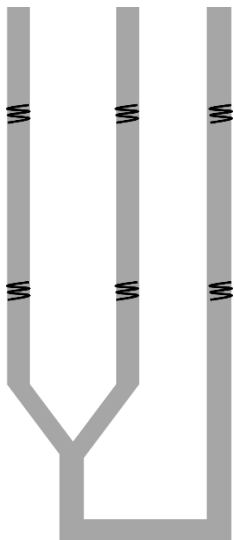
Commercial Promotion  
(1<sup>st</sup> gen SERT™)



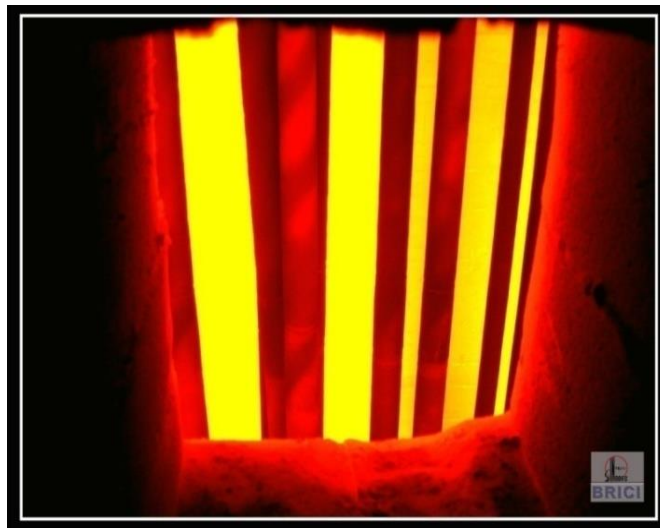
# SERT™ For Steam Cracking Furnace

## Case 1 Liaohua Petrochemical (Ba-115)

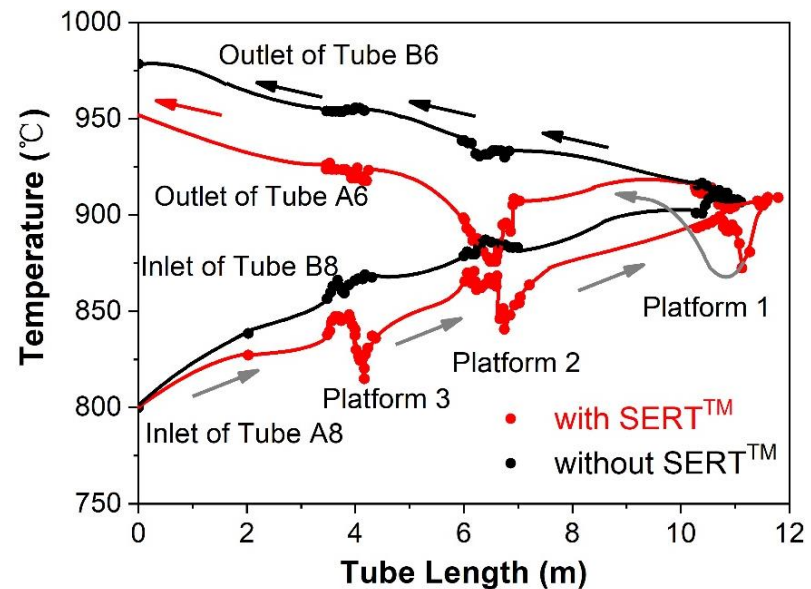
- CBL-I Cracking furnace with **1<sup>st</sup> gen SERT™**
- Coil configuration: **2-1**
- Capacity: 2 kta
- liquid feedstock: Naphtha



2-1 coil configuration



The SERT™ in the online furnace



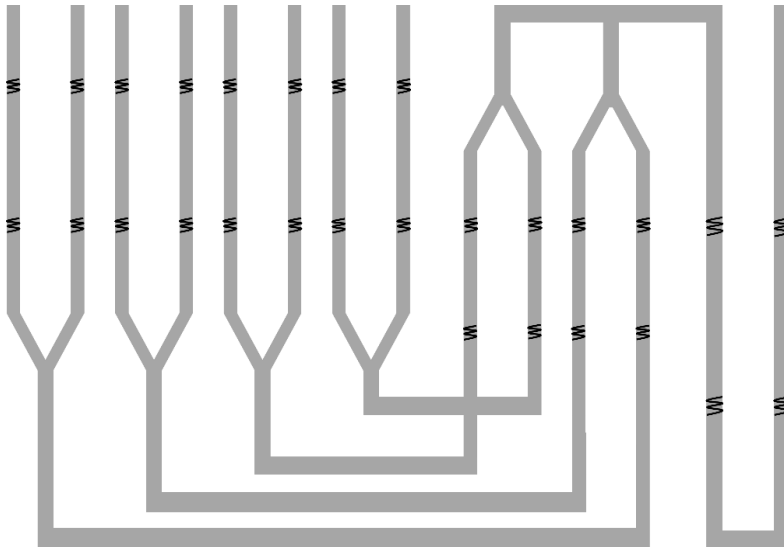
Temperature distributions in the two neighboring tubes

The coil surface temperature drop 20 °C

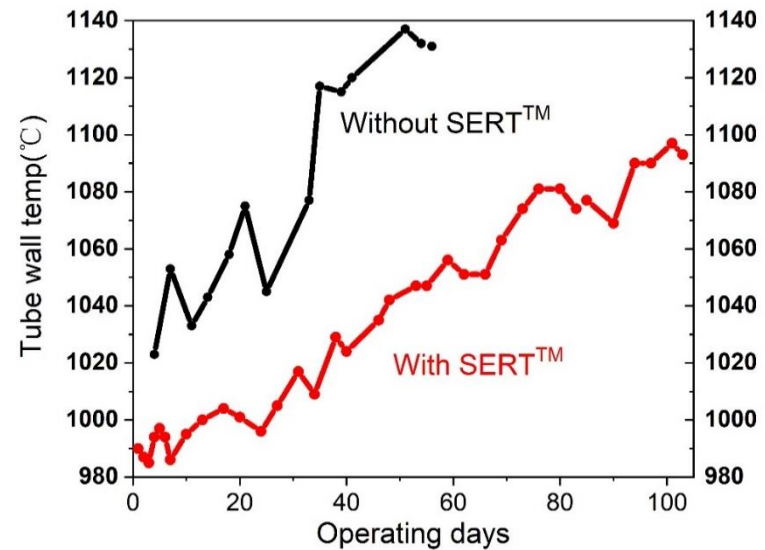
# SERT™ For Steam Cracking Furnace

## Case 2 Yanshan Petrochemical (Ba-115)

- **SRT-IV furnace** with **1<sup>st</sup> gen SERT™** in whole furnace
- Coil configuration: **8-4-1-1**
- Feedstock: Naphtha and Ethane
- Capacity: 100 kta, liquid feed or gas feed



8-4-1-1 Coil configuration

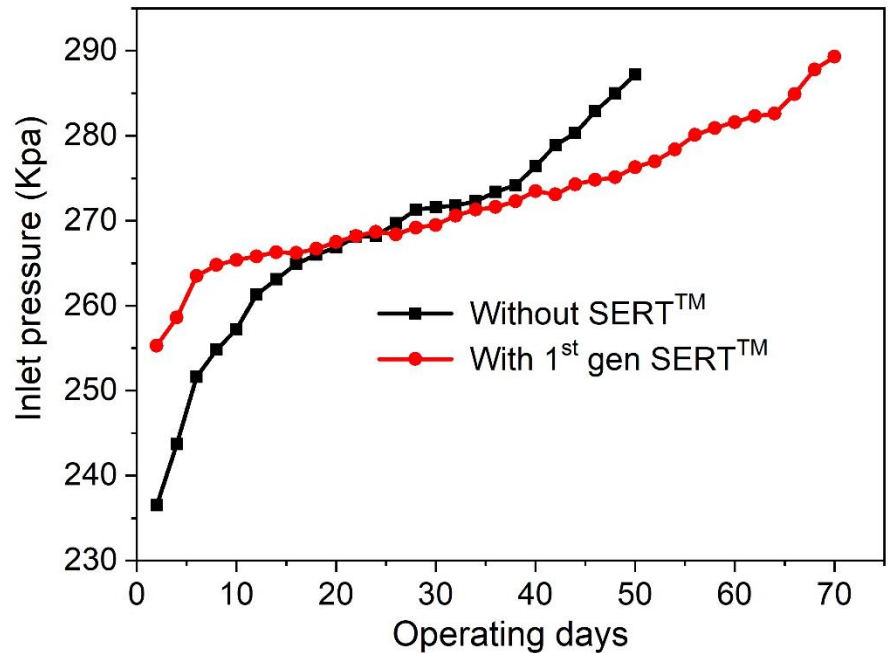


Tube Wall Temperature (TMT) Comparison

The operating days is extended twice

# SERT™ For Steam Cracking Furnace

## Case 2 Yanshan Petrochemical (Ba-115)



Coil Inlet Pressure Between Bare Tube and SERT™

Product Yield With or Without SERT™

| Product         | SOR with SERT™ | EOR with SERT™ | Bare Tube |
|-----------------|----------------|----------------|-----------|
| COT (°C)        | 822            | 822            | 822       |
| Ethylene (wt%)  | 28.92          | 28.78          | 28.81     |
| Propylene (wt%) | 15.89          | 15.50          | 15.86     |
| Butadiene (wt%) | 4.77           | 4.83           | 4.71      |

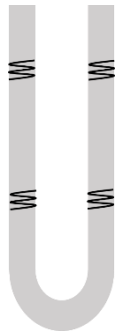
**Pressure rise smoothly**

**Nearly no negative impact on product yield**

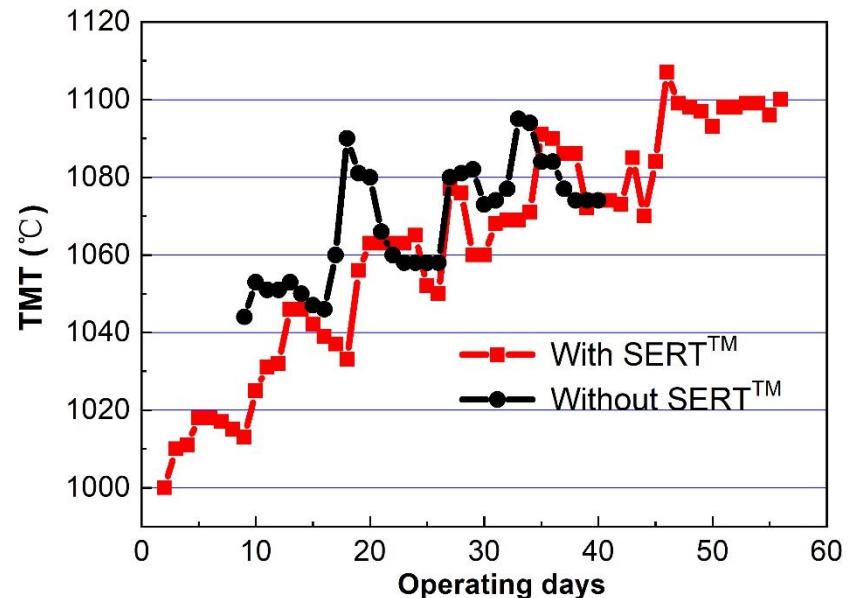
# SERT™ For Steam Cracking Furnace

## Case 3 BASF-YPC, Nanjing, China (Ba-116)

- **SW-U furnace:** whole furnace replaced with **1<sup>st</sup> gen SERT™**
- Coil configuration: **1-1**
- Capacity: 60 kta, Liquid feed
- Feedstock: Naphtha



1-1 Coil Configuration



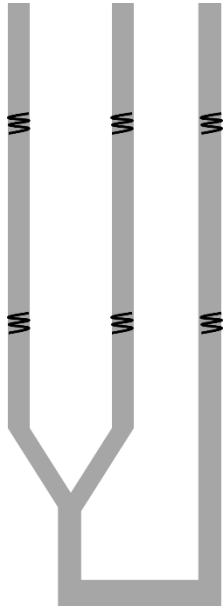
### Operating cycle in a Bare Tube contrast to SERT™

|        | SERT | Feed (kg/h) | COT(°C) | P/E   | Operating days       |
|--------|------|-------------|---------|-------|----------------------|
| BA116  | NO   | 28679.5     | 825     | 0.574 | 40(2008.07.14~08.22) |
| BA116  | YES  | 29923.5     | 830     | 0.568 | 56(2008.09.30~11.24) |
| Remark |      | 105%        |         |       | 140%                 |

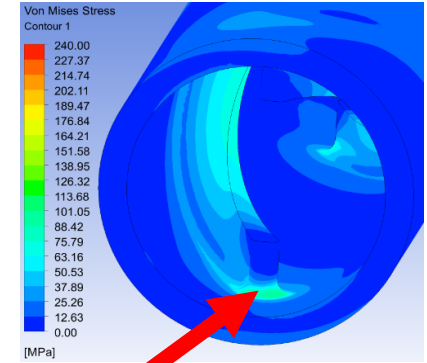
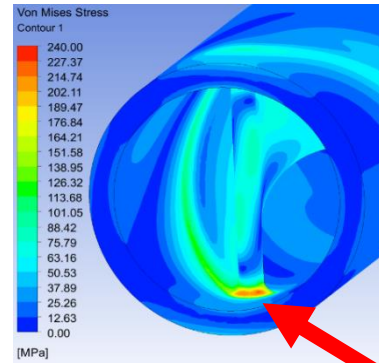
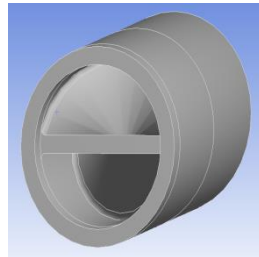
# SERT™ For Steam Cracking Furnace

## Case 4 Yanshan Petrochemical (Ba-112)

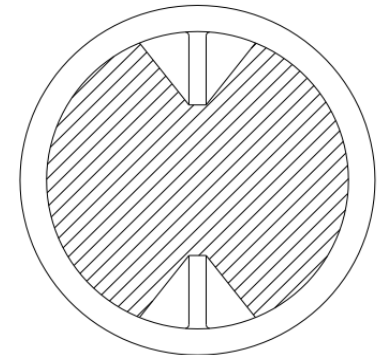
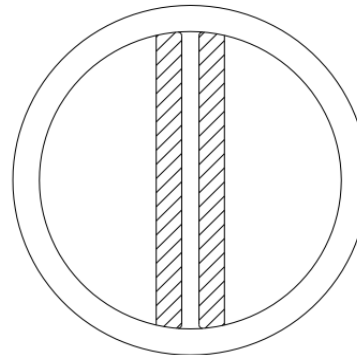
- CBL-III furnace with **2<sup>nd</sup> gen SERT™** in whole furnace
- Coil configuration: **2-1**
- Feedstock: Naphtha
- Capacity: 100 kta, liquid feed



2-1 Coil Configuration



Max thermal stress

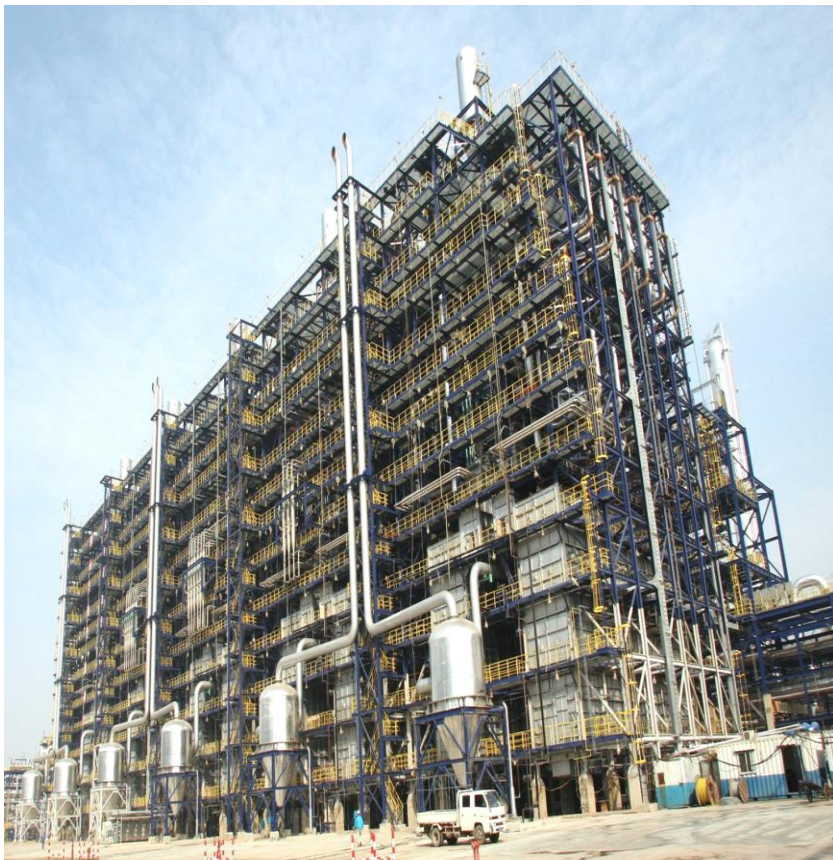


The permeability of the SERT

**Thermal stress decreased 60%**

# SERT™ For Steam Cracking Furnace

## Case 5 SSTPC 1,000 KTA Ethylene complex (SINOPEC-SABIC) (1<sup>st</sup> gen SERT™)



1. **Feed:** HVGO, NAP, C2/C3, LPG
2. **Thermal Efficiency:** 93.8-95.5%
3. **Operating days**
  - HVGO: 96 days
  - NAP: 120 days
  - C2/C3: 122 days
4. **Liquid furnace:** CBL-III
5. **Gas furnace:** CBL-R
6. **Capacity:**
  - 100 kta each
  - Total 11 cracking furnaces
7. **Operated on** Jan. 16, 2010

# SERT™ For Steam Cracking Furnace

## Case 6 ZHONGKE, 800 KTA Ethylene complex (Sinopec- Sabic)

### (2<sup>nd</sup> gen SERT™)

1. **Feed:** HVGO, NAP, C2/C3, LPG
2. **Capacity:** 80 KTA each, Total 7 furnaces, **double firebox**
  - 30 kta ethane feed
  - 15 kta gas feed
  - 15 kta liquid feed
3. **Operating days**
  - HVGO: 78 days
  - NAP: 85 days
  - C3/C4: 93 days
  - C2: 118 days
4. **Thermal efficiency:** 93.8-95.5%
5. **Liquid furnace :** CBL- VII
6. **Gas furnace:** CBL-R
7. **Operated on** Sep.20, 2020



# SERT™ For Steam Cracking Furnace

## SERT™ in different Type Furnaces

| Company | Furnace Type      | Capacity<br>(10KTA) | Opera. Days<br>(NO USED) | Opera. Days<br>(USED) | Remarks       |
|---------|-------------------|---------------------|--------------------------|-----------------------|---------------|
| A       | LUMMUS/SRT-IV(HC) | 6                   | 55                       | 105                   | Coil replaced |
| B       | LUMMUS/SRT-VI     | 10                  | 40                       | 79                    | Coil replaced |
| C       | SINOPEC/CBL       | 8                   | -                        | 75                    | New, 1070 °C  |
| D       | SINOPEC/CBL-III   | 6                   | 60                       | 99                    | Coil replaced |
| E       | LUMMUS/SRT-IV(HS) | 4                   | 55                       | 110                   | Coil replaced |
| F       | S&W/SUC-80U       | 6                   | 40                       | 60                    | Coil replaced |
| G       | SINOPEC/CBL       | 10                  | -                        | >100                  | New           |
| H       | SINOPEC/CBL       | 10/15               | -                        | >100                  | New           |
| Q       | SINOPEC/CBL       | 15/30               | -                        | >80                   | New           |
| J       | SINOPEC/CBL       | 15/30               | -                        | >80                   | New           |
| K       | S&W/SUC-40U       | 3.5                 | 30                       | >80                   | Revamp        |
| L       | TECHNIP/GK-VI     | 5                   | 50                       | 100                   | Revamp        |

## Economics

### Case Description:

- 100,000 ton/yr SL-1 Furnace in Yanshan, Petro-Chemical Company,
- Feedstock: Naphtha
- Same Operating Condition
- TMT is decreased by 20°C and **operating days** is extended **twice** than **normal** (60days -> 120days)
- Both **fuel gas usage** and **steam production rate** were decreased 1%-3%

### Results:

| Description            | Benefit               | Unit           | Saving (1000\$) |
|------------------------|-----------------------|----------------|-----------------|
| Furnace Decoking Times | ↓3                    | Times/Yr       | +180            |
| Furnace Operation Days | ↑6                    | Days           | +300            |
| Fuel Gas Usage         | ↓6.4× 10 <sup>4</sup> | Ton Nature Gas | +428            |
| Steam Made             | ↓                     |                | -340            |

Total Saving: \$268,000(Min)-\$568,000(Max)/Furnace per year)

\*Yield improvement was not considered in this evaluation

# SERT™ For Steam Cracking Furnace

## SERT™ Installed Commercial Furnace

- By the end of 2020, the 1<sup>st</sup> gen SERT™ has been applied to 122 cracking furnaces, with a production capacity of 8.615 million tons of ethylene per year.
- The technology of 2<sup>nd</sup> gen SERT™ has been applied 74 cracking furnace in total with a production capacity of 7.26 million tons of ethylene per year.
- At present, the longest operating time of the cracking furnace in which this technology is applied is 11 years.

# SERT™ For Steam Cracking Furnace

## To sum up:

- **Lower cost!** (comparing with other heat transfer technologies)
- Can be installed on **current tubes or built the new cracking furnace**
- Tubes with SERT™ can **handle flexible feeds** (naphtha, propane, etc.)

| Feature        | Without SERT™ | With SERT™                   |
|----------------|---------------|------------------------------|
| Product yields | BASE          | <b>No negative effects</b>   |
| TMT            | BASE          | Reduce at least <b>20°C</b>  |
| Operating days | BASE          | Increase at least <b>30%</b> |
| Capacity       | BASE          | Increase about <b>7%</b>     |
| Pressure drop  | BASE          | Increase about 8%            |
| Operation      | BASE          | No additional workloads      |

\* Under the same operation conditions, with insertion of the tube with twisted-tape

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**Related Catalysts & Technologies**

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Cold Oil Absorption Technology (COAT™)

# Related Catalysts & Technologies



**Introduction to C1/C2/C3 Catalysts**



**C1 Low Temperature Methanation Catalyst**



**C2 Selective Hydrogenation Catalyst**



**C3 Selective Hydrogenation Catalyst**



**Commercial Performance of C1/C2/C3 Catalysts**

## Introduction to C1/C2/C3 Catalysts

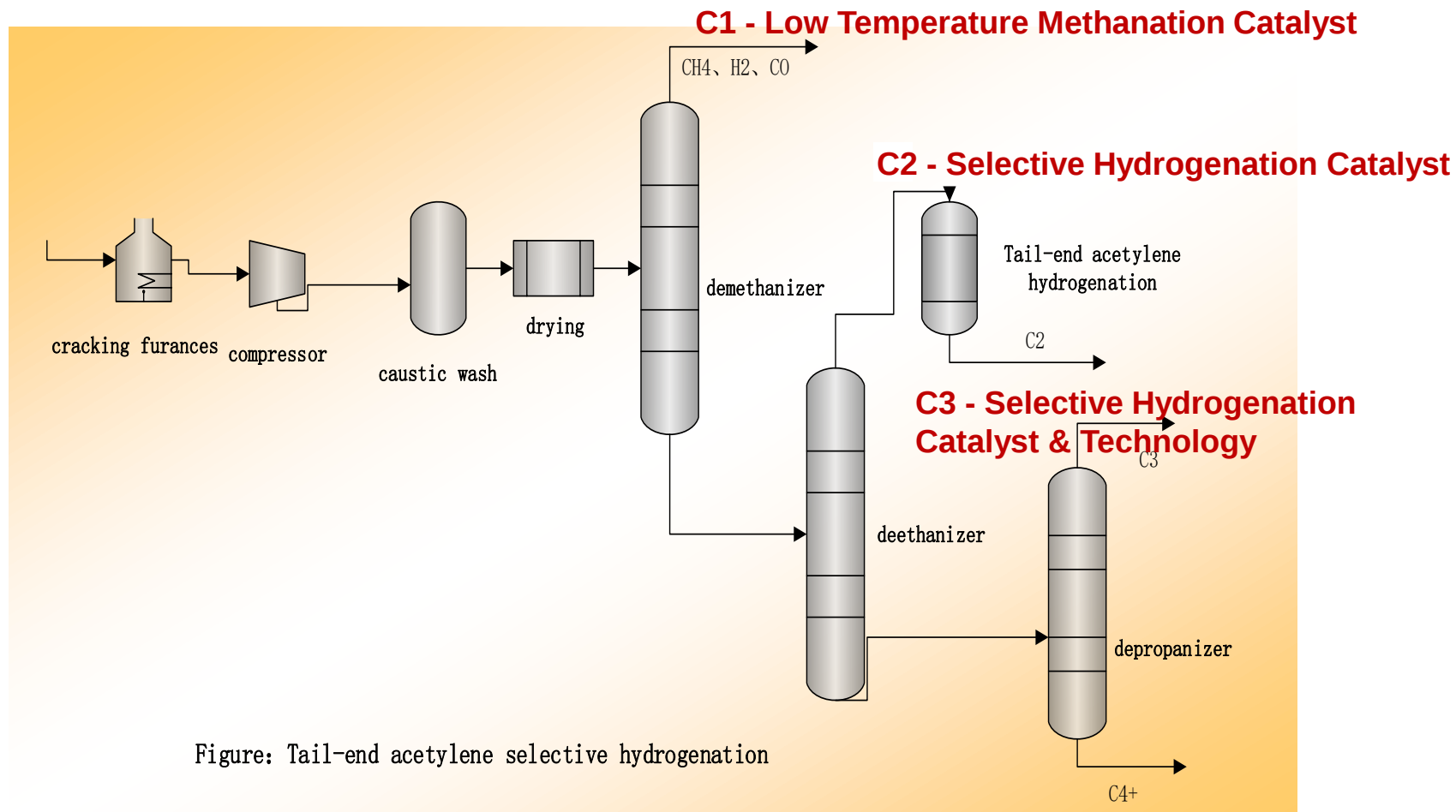


Figure: Tail-end acetylene selective hydrogenation

## Sequential Separation process in ethylene Plant

## Introduction to C1/C2/C3 Catalysts



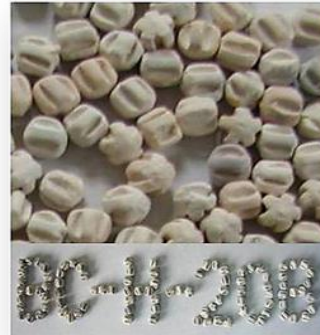
### C1 - Low Temperature Methanation Catalyst

- High activity in low temperature 150 ~ 200°C
- Adapting to various reactor and process
- Excellent operation flexibility & low cost



### C2 - Selective Hydrogenation Technology

- Front-end Selective Hydrogenation Technology for Removal of Acetylene in Depropanizer Process



### C2 - Selective Hydrogenation Technology

- Tail-end Selective Hydrogenation Technology for Removal of Acetylene in C2 Fraction



### C3 - Selective Hydrogenation Technology

- Liquid-phase Selective Hydrogenation Process and Catalyst for the Removal of Methyl Acetylene and Propadiene in C3 Fractions

## Introduction to C1/C2/C3 Catalysts

### Research resource and equipments

- ✓ Professional research team and advanced equipments.
- ✓ Small scale, pilot scale and industrial sideline experiments can be performed in lab to test the catalyst performance.
- ✓ Catalyst industrial production company.



# Related Catalysts & Technologies

## C1 Low Temperature Methanation Catalyst: BC-H-10

### Physical Properties

|             |                                   |
|-------------|-----------------------------------|
| Composition | Ni/Al <sub>2</sub> O <sub>3</sub> |
| Appearance  | Black granular                    |
| Life        | ≥5 Years                          |

| SOR  | CUSTOMER                     | CAPACITY/KTA |
|------|------------------------------|--------------|
| 2008 | Zhongyuan Petrochem.         | 200          |
| 2011 | Guangzhou Petrochem.         | 200          |
| 2012 | Tianjin Petrochem.           | 200          |
| 2012 | Yangzi Petrochem.            | 300          |
| 2013 | Sinopec-SK(Wuhan) Petrochem. | 800          |
| 2013 | Fujian Petrochem.            | 1100         |
| 2017 | Shanghai Petrochem.          | 400          |
| 2020 | Zhongke                      | 80           |
| 2021 | Fujian Gulei Petrochem.      | 800          |



### Industrial Application

- Initial used in **Zhongyuan** plant since May 2008.
- Use the original **High-pressure steam**.



1

2

3

4

- Used in **Guangzhou** since April 2011.
- Change HS to MS for energy saving.

**HS** → **MS**  
**3.53MPa, 385°C** → **1.08MPa, 270°C**

- 2012/9, used in Tianjin ethylene with the original HS.
- 2012/9, use in Yangzi petrochemical with the original SHS.

- Many ethylene plants are planning to use.

## C2 Catalysts

the C2 fraction  
selective  
catalyst  
hydrogenation

Development

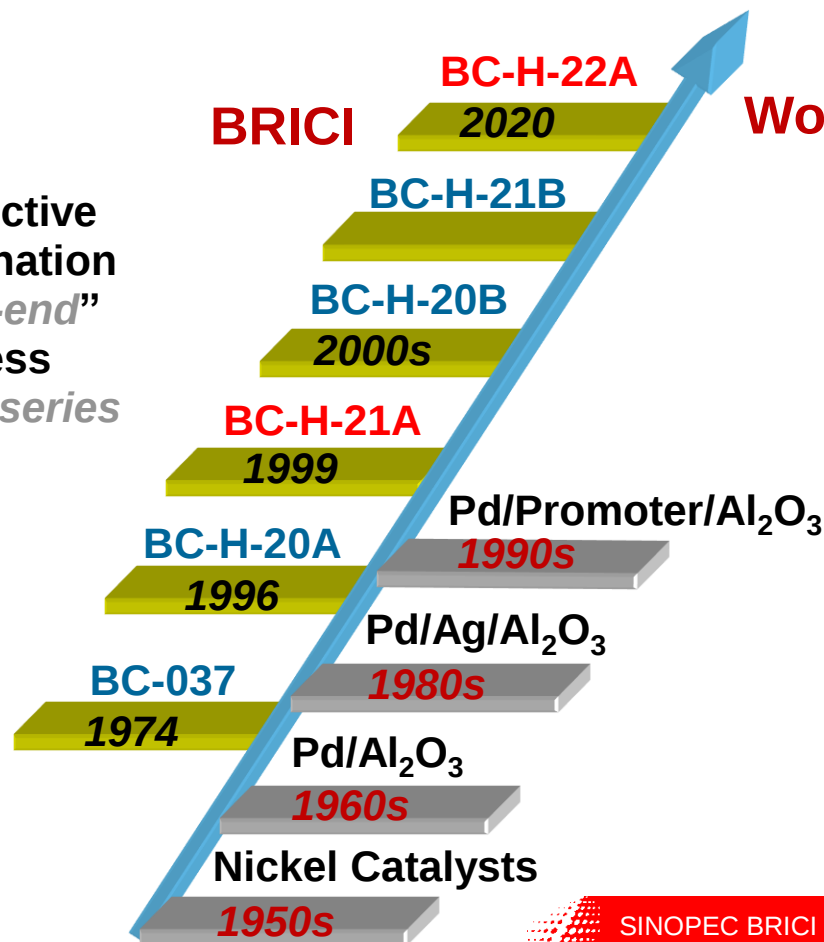
World

the selective  
hydrogenation  
for “*front-end*”  
process

the selective  
hydrogenation  
for “*tail-end*”  
process  
*BC-H-20 series*

the selective  
hydrogenation in  
front-end  
*depropanization*  
process *BC-H-21*

the selective  
hydrogenation in  
front-end  
*deethanization*  
Process *BC-H-22A*



## C2 Catalysts: BC-H-20B

### Tail-end Acetylene Hydrogenation Catalyst

#### Physical Properties

|                    |                                             |
|--------------------|---------------------------------------------|
| Appearance         | yellowish gray granule                      |
| Composition        | Pd/Promoter /Al <sub>2</sub> O <sub>3</sub> |
| Regeneration Cycle | ≥6 Months                                   |
| Lifetime           | ≥ 5 Years                                   |



#### Advantages of BC-H-20B

1. Allowing a wide range of operating conditions
2. High space velocity
3. Low pressure drop
4. High selectivity and excellent activity
5. Less green oil produced and adhesion to the catalyst
6. Longer cycle of operation
7. Longer life

#### A Wider Range of Operating Conditions

|                           |                                               |
|---------------------------|-----------------------------------------------|
| Temperature:              | 40~95 °C (Inlet)<br>65~135 °C(Outlet)         |
| Pressure:                 | 0.9~3.0 MPa                                   |
| GHSV: (Adiabatic Reactor) | 2300~6500 NM <sup>3</sup> /M <sup>3</sup> /h  |
| (Isothermal Reactor)      | 8000~13000 NM <sup>3</sup> /M <sup>3</sup> /h |

#### Inlet C<sub>2</sub>H<sub>2</sub> concentration:

< 0.8 % (single-stage bed)



< 1.8 % (two-stage bed)



< 2.5 % (three-stage bed)



# Related Catalysts & Technologies

## BC-H-20B Commercial Application

In China, **BC-H-20B** catalyst has been successfully used in **15** ethylene plants and **9** MTO plants until 2020.



Commercial Application Overseas (BC-H-20B)

## C2 Catalysts: BC-H-21B

### Front-end depropanization Acetylene Hydrogenation Catalyst

| Physical Properties |                                             | Operating Conditions of BC-H-21B                        |                             |
|---------------------|---------------------------------------------|---------------------------------------------------------|-----------------------------|
| Appearance          | yellowish gray granule                      | Inlet C <sub>2</sub> H <sub>2</sub> Concentration:      | < 1.0 %(mol )               |
| Composition         | Pd-Promoter /Al <sub>2</sub> O <sub>3</sub> | <b>Outlet C<sub>2</sub>H<sub>2</sub> Concentration:</b> | <b>&lt;0.5ppm</b>           |
| Lifetime            | ≥5 Years                                    | MAPD Conversion:                                        | > 50 %                      |
|                     |                                             | Temperature:                                            | 55 ~ 120 °C                 |
|                     |                                             | Pressure:                                               | 1.0~3.5MPa                  |
|                     |                                             | GHSV:                                                   | 8000~15000 hr <sup>-1</sup> |
|                     |                                             | Response to <b>CO</b> Range:                            | <b>200 ~ 2000 ppm</b>       |

### Advantages of BC-H-21B

Higher stability during CO fluctuations to avoid runaways  
 High Selectivity  
**Less green oil production**  
 Lower pressure drop, higher SV.  
 Wider operating conditions  
 Good stability  
 Appropriate activity, easy to startup

The key properties are better than other catalysts

- **selectivity, catalyst life,**
- **CO fluctuation resistance,**
- **Lower pressure drop,**
- **higher space velocity**

# Related Catalysts & Technologies

## BC-H-21B Commercial Application

- ✓ Currently, our catalyst has been applied in **11** Ethylene plants in China .
- ✓ The most capacity of the ethylene project is **1,100 kta**.

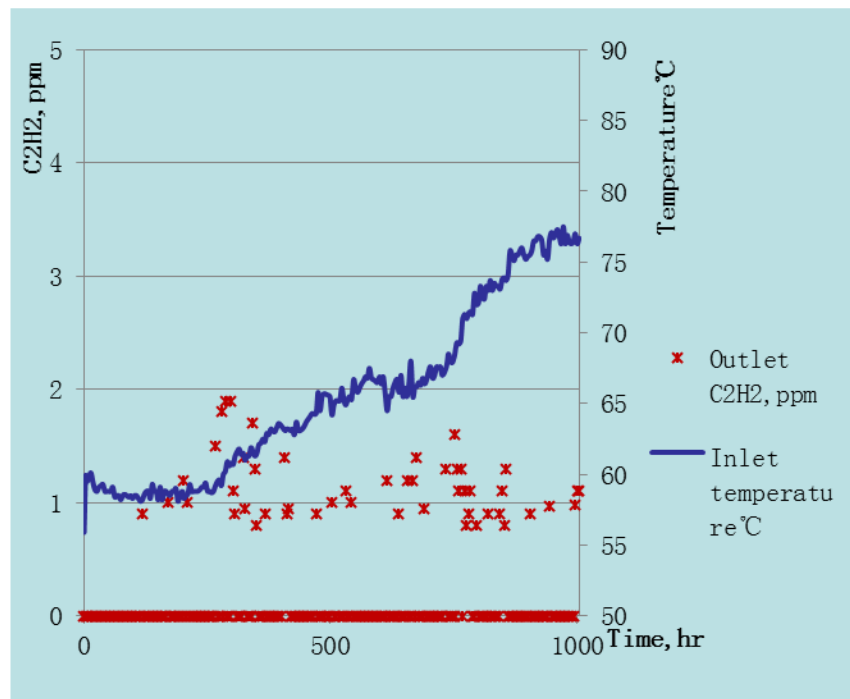


## C2 Catalysts: BC-H-22A

### Front-end deethanization Acetylene Hydrogenation Catalyst

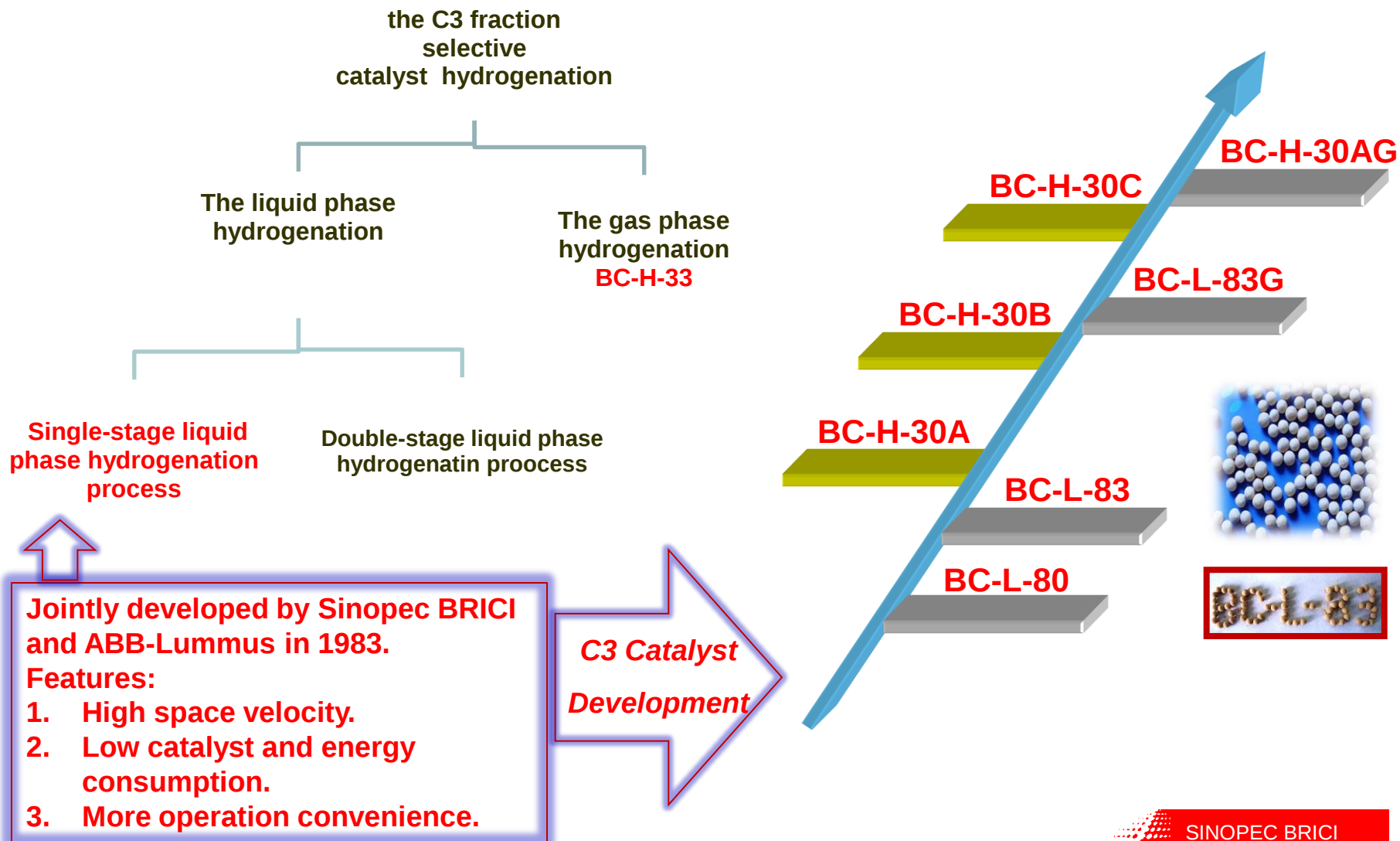
#### Physical Properties

|             |                                                   |
|-------------|---------------------------------------------------|
| Appearance  | yellowish gray granule                            |
| Composition | Pd-Ag/Promoter<br>/Al <sub>2</sub> O <sub>3</sub> |
| Lifetime    | ≥5 Years                                          |



**Sideline Test**

## C3 Catalysts



## C3 Catalysts

| Physical Properties |                                   |                                                |                                   | Operating Conditions |                          |
|---------------------|-----------------------------------|------------------------------------------------|-----------------------------------|----------------------|--------------------------|
| Brand               | BC-L-83                           | BC-H-30A                                       | BC-H-30B                          | Inlet MAPD :         | 1.4 ~ 2.8%(mol )         |
| Appearance          | yellowish granule                 |                                                | gray granule                      | Inlet Temperature :  | 30 ~ 45 °C               |
| Composition<br>s    | Pd/Al <sub>2</sub> O <sub>3</sub> | Pd-Promoter<br>/Al <sub>2</sub> O <sub>3</sub> | Pd/Al <sub>2</sub> O <sub>3</sub> | Outlet Temperature:  | 50 ~ 65 °C               |
| Regen. Cycle        | >6 months                         |                                                |                                   | Pressure:            | 2.1 ~ 2.7 MPa            |
| Life                | 5 years                           |                                                |                                   | LHSV:                | 20 ~ 70 hr <sup>-1</sup> |
|                     |                                   |                                                |                                   | H2/MAPD:             | 1.2 ~ 2.0                |

| Advantages |                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                      |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Brand      | BC-L-83                                                                                                                                                                                                                                                                                                                                                                                       | BC-H-30A                                                                                                                                                                                                                                                                | BC-H-30B                                                                                                                                                                                                                                             |
| Feature    | <ul style="list-style-type: none"> <li>• <b>High space velocity</b><br/>--- Low catalyst used</li> <li>• <b>High activity, selectivity, stability, less polymers formed</b><br/>--- Longer regeneration cycle and catalyst life</li> <li>• <b>More convenient operation</b><br/>---used in single-stage, or double-stage.</li> <li>• <b>Energy saving, Remove propylene cooler</b></li> </ul> | <ul style="list-style-type: none"> <li>• <b>Higher selectivity</b></li> <li>• <b>Higher inlet MAPD</b><br/><b>Excellent resistance to MAPD fluctuation</b></li> <li>• <b>Wider range of operating conditions</b></li> <li>• <b>Longer regeneration cycle</b></li> </ul> | <ul style="list-style-type: none"> <li>• <b>50% reduced of Pd</b><br/><b>Higher Pd dispersion, higher activity</b></li> <li>• <b>Higher selectivity and propylene production</b></li> <li>• <b>Reduction is not needed before startup</b></li> </ul> |

# Related Catalysts & Technologies

## C3 Catalysts Commercial Application

In China, C3 catalyst has been successfully used in **18** ethylene plants by the end of 2020.





## Commercial Case 1

**ZHENHAI 1,000 kta Ethylene**

**C2 catalyst: BC-H-20B**

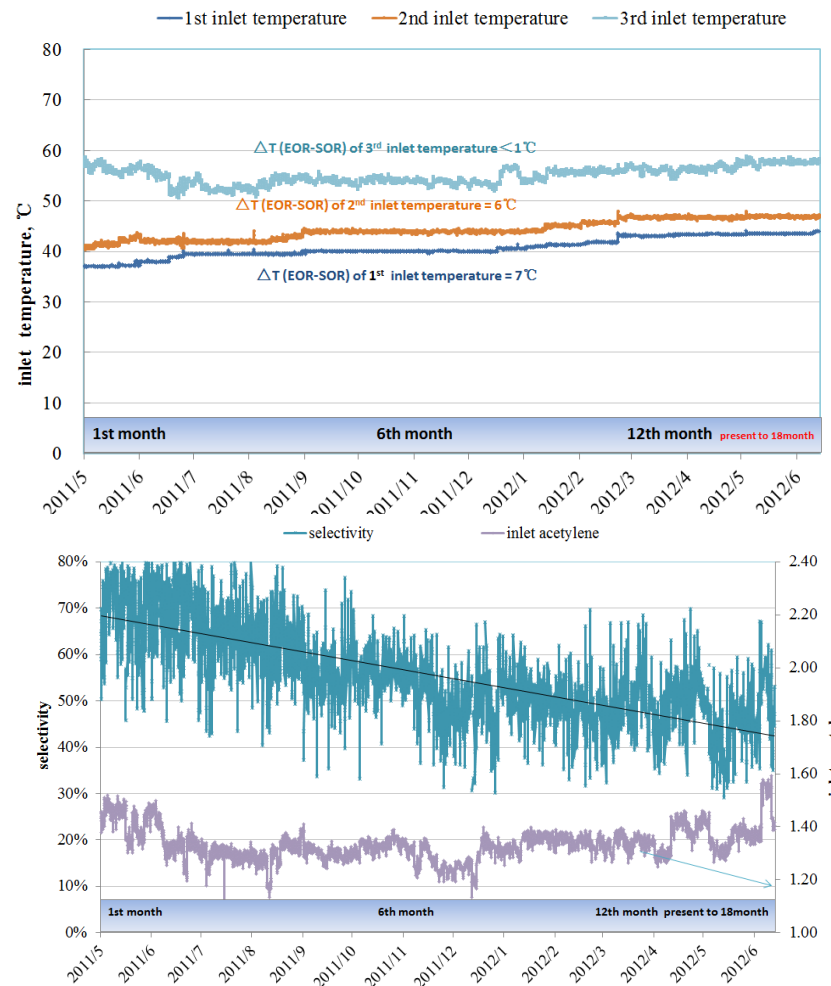
### Reactor: DC-401A/B

|                                       |                      |
|---------------------------------------|----------------------|
| GHSV                                  | ≈6000h <sup>-1</sup> |
| Flowrate                              | 160~180ton/h         |
| DC-401A regen (1 <sup>st</sup> cycle) | <b>12 months</b>     |
| DC-401B regen (1 <sup>st</sup> cycle) | <b>24 months</b>     |

### DC-401B (12th month)

|                                          | 1 <sup>st</sup> | 2 <sup>nd</sup> | 3 <sup>rd</sup> |
|------------------------------------------|-----------------|-----------------|-----------------|
| Inlet Temperature, °C                    | 43              | 47              | 56              |
| Outlet Temperature, °C                   | 75              | 73              | 67              |
| Inlet C <sub>2</sub> H <sub>2</sub> , %  | 1.4             | 0.7             | 0.2             |
| Outlet C <sub>2</sub> H <sub>2</sub> , % | 0.7             | 0.2             | < 0.3 ppm       |
| Average selectivity, %                   |                 | 50              |                 |

**No CO injection!**



## Commercial Case 1

**ZHENHAI 1,000 kta Ethylene**

**C2 catalyst: BC-H-30A**

| Reactor style          | Single bed (DC-402A/B) |
|------------------------|------------------------|
| Flow Rate, t/h         | 150~180                |
| LHSV, h <sup>-1</sup>  | 60                     |
| Pressure, MPa          | 2.3—2.5                |
| Regen. Cycle           | <b>12months</b>        |
| Inlet temperature, °C  | 36~42                  |
| Outlet temperature, °C | 59~61                  |
| H <sub>2</sub> /MAPD   | 1.2~1.8                |
| Inlet MAPD, %          | 1.9~2.5                |
| Outlet MAPD, ppm       | <500ppm                |
| Average selectivity    | <b>&gt;80%</b>         |



## Commercial Case 2

### Sinopec-SK(Wuhan) 800KTA Ethylene

Catalyst used:

1. C1 catalyst: BC-H-10
2. C2 catalyst: BC-H-21B
3. C3 catalyst: BC-H-30A



| BC-H-10                       | BC-H-21B                                        | BC-H-30A                      |
|-------------------------------|-------------------------------------------------|-------------------------------|
| Inlet CO: 0.3 vol%            | Inlet C <sub>2</sub> H <sub>2</sub> : 0.5%-0.7% | Inlet MAPD: 1.4-2.0mol%       |
| Outlet CO: < 1 ppmv           | Inlet MAPD: 0.7%-1.0%                           | Outlet MAPD: <100ppm          |
| Inlet Temperature: 170-175    | CO: 800ppm-1000ppm<br>(Startup CO Max 2000ppm)  | H <sub>2</sub> /MAPD: 1.3-1.8 |
| Life: 2013-2020; 2020-now     | Outlet C <sub>2</sub> H <sub>2</sub> : <1ppm    | Inlet temperature: 36-42°C    |
| SV: 3000-6000 h <sup>-1</sup> | Selectivity: 70%                                | Outlet temperature: <65°C     |
|                               | Life: 4 years                                   | SV: 30-90h <sup>-1</sup>      |

# Outline

I

**Who we are**

II

**SERT™ for Steam Cracking Furnace**

III

**Related Catalysts & Technologies**

IV

**Cold Oil Absorption Technology (COAT™)**

# Cold Oil Absorption Technology (COAT™)



**Introduction to COAT™**



**Technical Advantages**



**Commercial Performance**

## Introduction to COAT™



- ✓ Why to recover **Refinery off-gas**?
  - Most used as fuel gas
    - FCC dry gas, coking dry gas, PSA off-gas, etc.
    - ethylene and ethane content about 10~20%
- ✓ What will we recover ? **C2 fraction!**
  - Higher value than burned

How to recover?

# Cold Oil Absorption Technology (COAT™)

## Introduction to COAT™

Extract the C2-rich gas from refinery dry gas

**Cryogenic Separation**

(based on relative volatility)

**Pressure Swing Adsorption (PSA)**

(based on adsorption selectivity)

**Oil Absorption**

(based on solubility difference)

**Characteristic**

High recovery of C2

Large investment

High energy consumption

Complicated operation

**Characteristic**

Less energy consumption

More equipment

Complicated control

Short operating cycle

**Commercialized**

High recovery of C2

Less equipment

simple process

long operating cycle

Operating Temperature

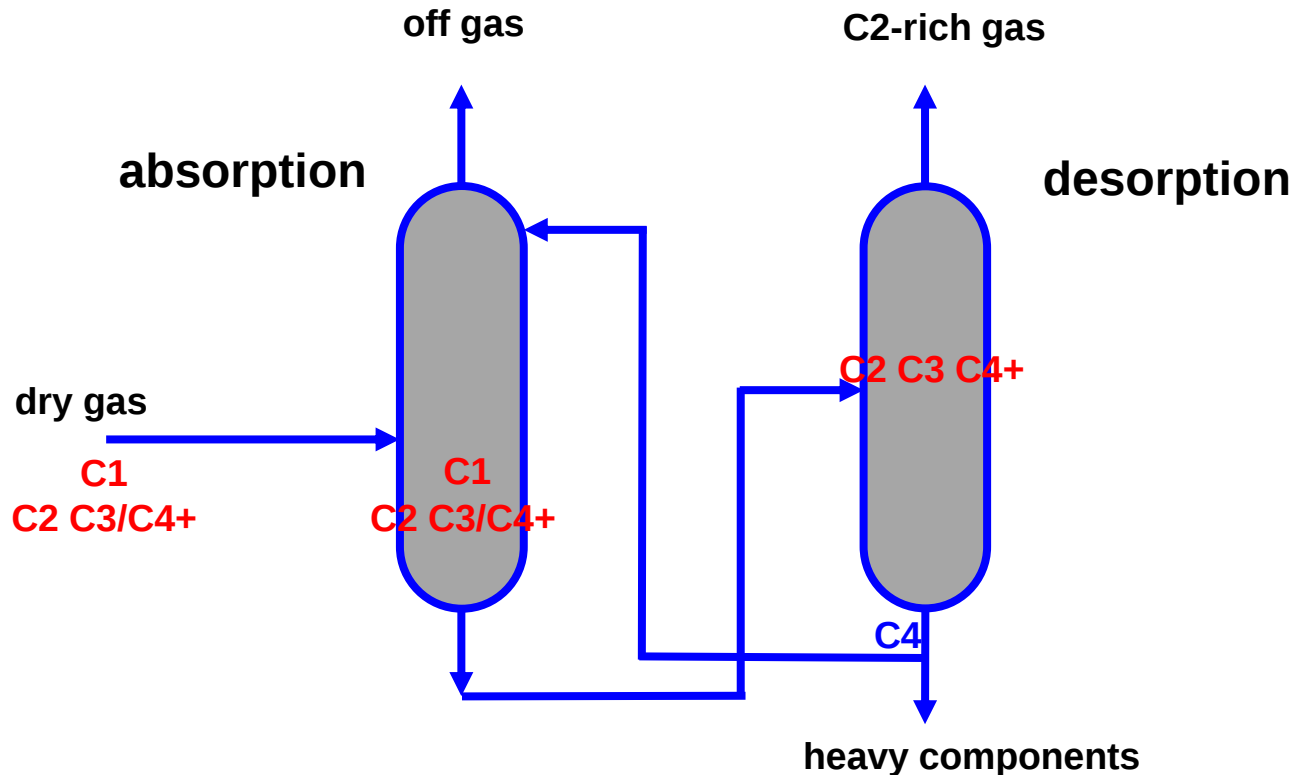
-99 °C ~ -130 °C

Operating Temperature

Above 0 °C (COAT™)

# Cold Oil Absorption Technology (COAT™)

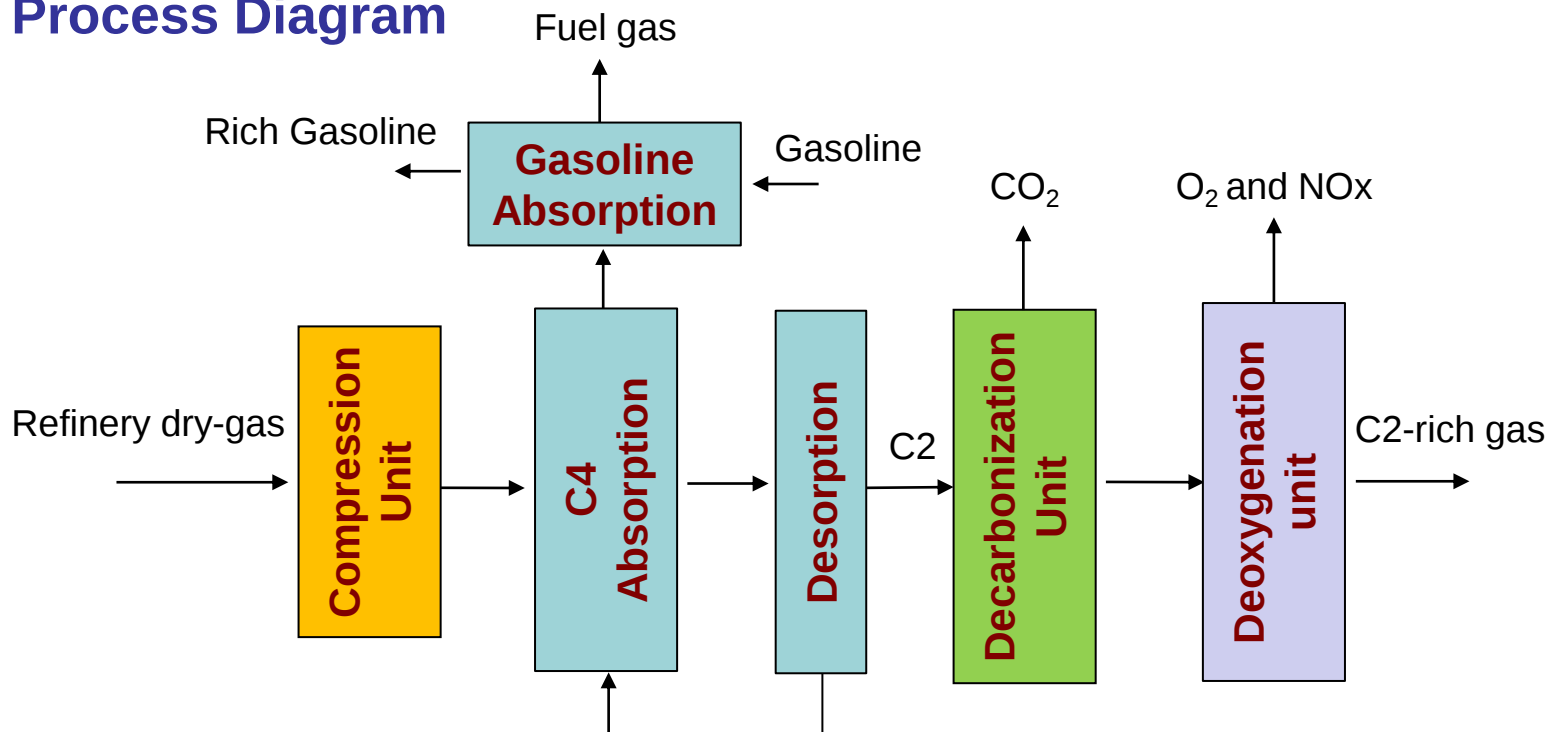
Advanced technology for recovery of C2 from refinery dry gas  
- Cold Oil Absorption Technology (COAT™)



The principle of COAT is the well-known 'Like Dissolves Like' Theory.

# Cold Oil Absorption Technology (COAT™)

## Process Diagram



- ✓ **C4 fraction** is used to absorb C2+ fraction. **The stabilized gasoline** is used to recover the C4 fraction entrained by fuel gas.
- ✓ H<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>, O<sub>2</sub>, NO<sub>x</sub>, CO, etc. are removed at the operating temperature **above 0°C**.
- ✓ The obtained C2-rich gas can be sent to **caustic washing tower of ethylene unit**.
- ✓ **lithium bromide water absorption refrigerating equipment** is used for cold water supply.

## Technical advantages of COAT™

### 1. *High recovery*

- ✓ More than 93% of C2 can be recovered

### 2. *Simple process*

- ✓ Less number of equipment are needed

### 3. *Stable operation*

- ✓ Simple operation, stable running and long operating cycle

### 4. *High quality product*

- ✓ Unique advantages in impurity removal; methane content is lower than 5%
- ✓ After treated by the deoxygenation unit,  $O_2 < 1\text{ppmw}$ ,  $NO_x < 10\text{ppbw}$

## Technical advantages of COAT™

### 5. *Less energy consumption*

- ✓ Both the lithium bromide absorption refrigerator and tower reboilers can be driven by the refinery surplus heat.

### 6. *Wide range of application*

- ✓ Adaptable to various types of refinery dry gas (i.e., FCC, atmospheric-vacuum distillation, delayed coking, catalyst reforming, ...) , coal-chemical gas and even oilfield gas.

### 7. *Low investment and Less floor space*

- ✓ All equipment are not complicated.
- ✓ Occupied less floor space.

**With so many advantages, COAT is reliable and has good prospects in application!**

## Commercial Application Case 1



**100 kta COAT™ Unit in Qilu, Sinopec**

\*The capacity is based on the feed stock.

- ✓ Qilu, SINOPEC:
  - COAT™ unit built in 2011
  - supplied high quality C2-rich gas.
- ✓ Ethylene recovery rate is **93%**
  - **>80%** ethylene and ethane
  - Oxygen content is lower than **1PPM**
- ✓ ROI is **less than 2 years.**
- ✓ Continue running smoothly and stably

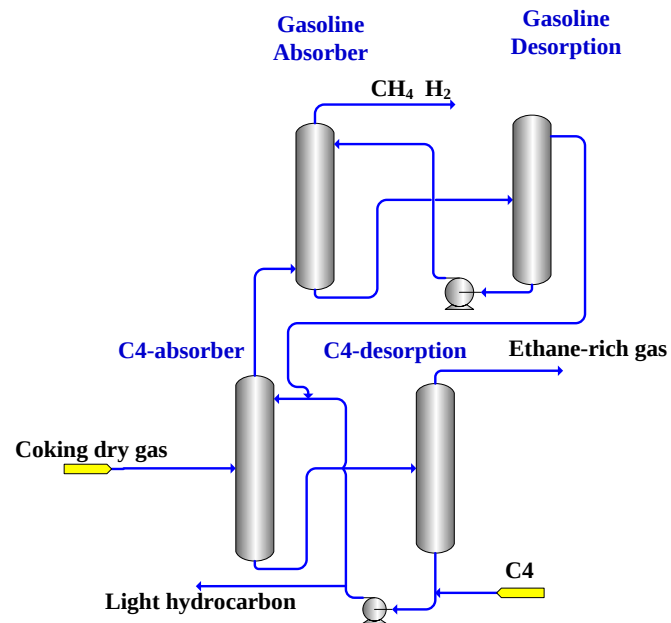
## Commercial Application Case 2



**220 kta COAT™ Unit in Qilu, Sinopec**

\*The capacity is based on the feed stock.

- ✓ Qilu, SINOPEC
  - Recovery of delayed coking dry gas
  - Started up in July 2015.



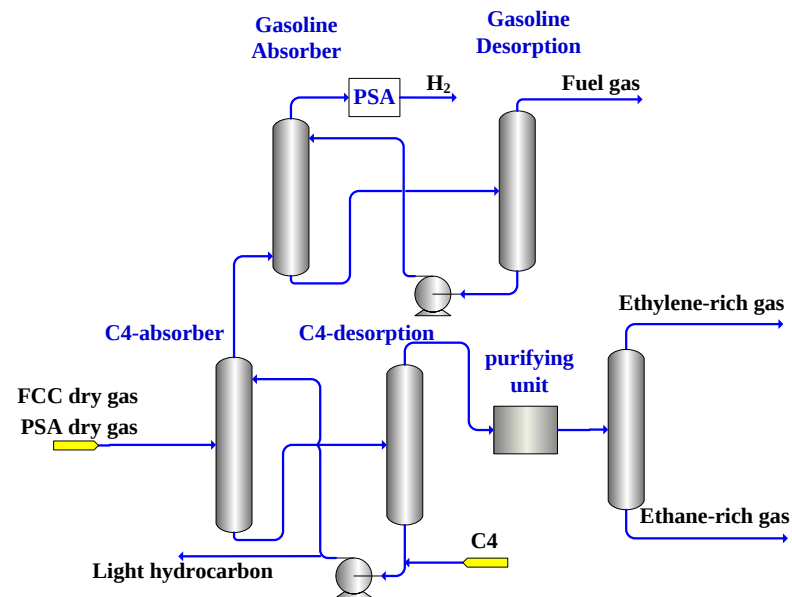
## Commercial Application Case 3



**230 kta COAT™ Unit in FREP, Fujian**

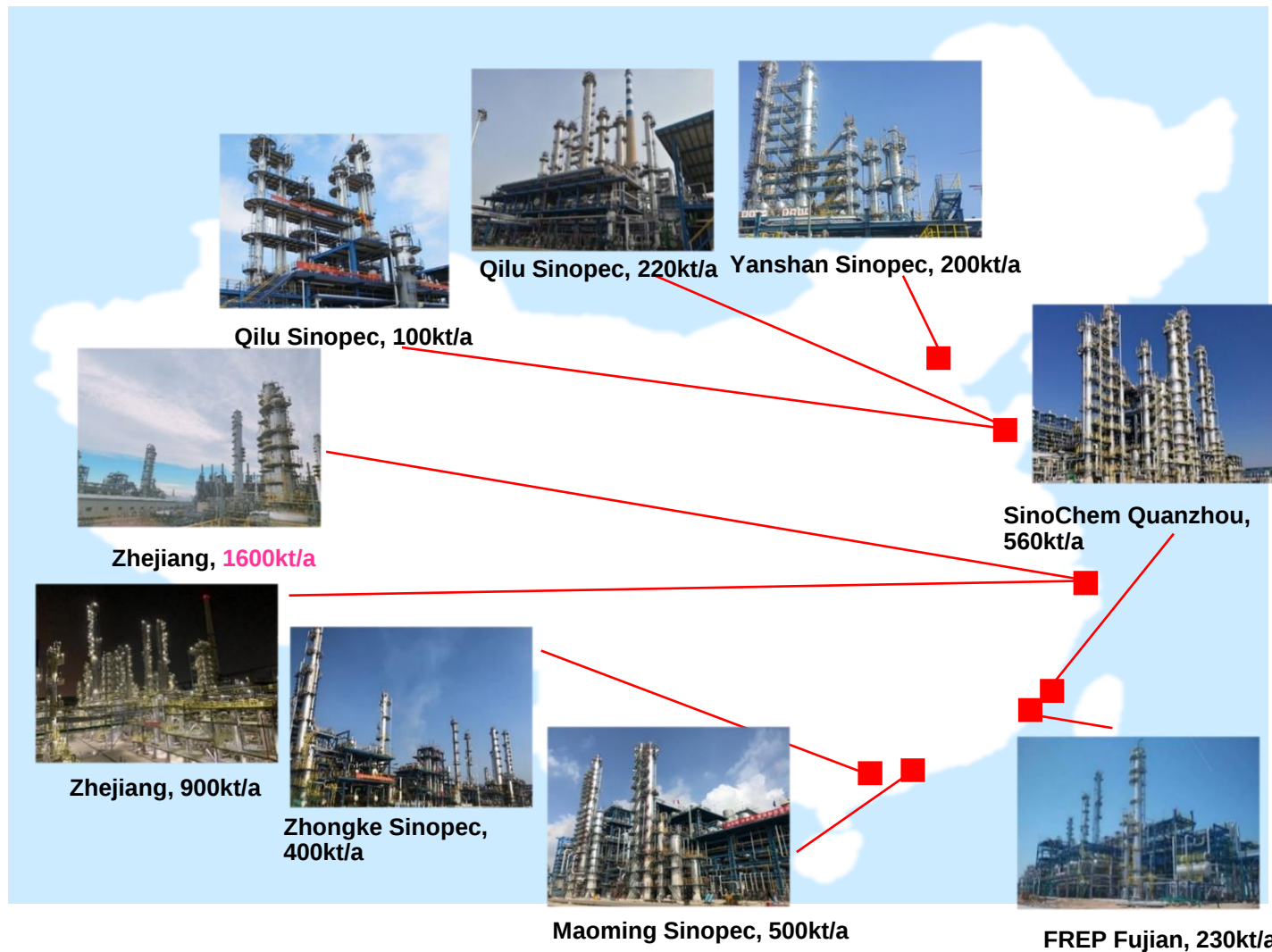
\*The capacity is based on the feed stock.

- ✓ Fujian Refining & Petrochemical Company Limited
  - Recovery of FCC, PSA dry gas and other dry gases
  - Started up in October 2015.



# Cold Oil Absorption Technology (COAT™)

## Application Examples - 9 units under operation



# Cold Oil Absorption Technology (COAT™)

## Other Application Cases - 7 units under construction

| NO. | Applied Enterprises                               | Capacity(кта) | Phase              |
|-----|---------------------------------------------------|---------------|--------------------|
| 1   | Tianjin, Sinopec                                  | 250           | Under construction |
| 2   | Guangdong, Petrochem                              | 350+600       | Under construction |
| 3   | Hainan, Sinopec                                   | 630           | Under construction |
| 4   | Shandong Yulong Petroleum Chemical Company., Ltd  | 650+900       | Under construction |
| 5   | Ningbo Zhongjing Petroleum Chemical Company., Ltd | 1000          | Under construction |

**More ...**

\*The capacity is based on the feed stock.

# Innovation, Development Cooperation & Win-Win Thank you

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