



北京2022年冬奥会官方合作伙伴

Sinopec FRIPP Hydrocracking Technology

能源至净 生活至美
Cleaner Energy Better Life



中国石化大连（抚顺）石油化工研究院
SINOPEC Dalian Research Institute of Petroleum and Petrochemicals

1、 Introduction

2、 Hydrocracking Process of Sinopec FRIPP

3、 Hydrocracking catalyst of Sinopec FRIPP

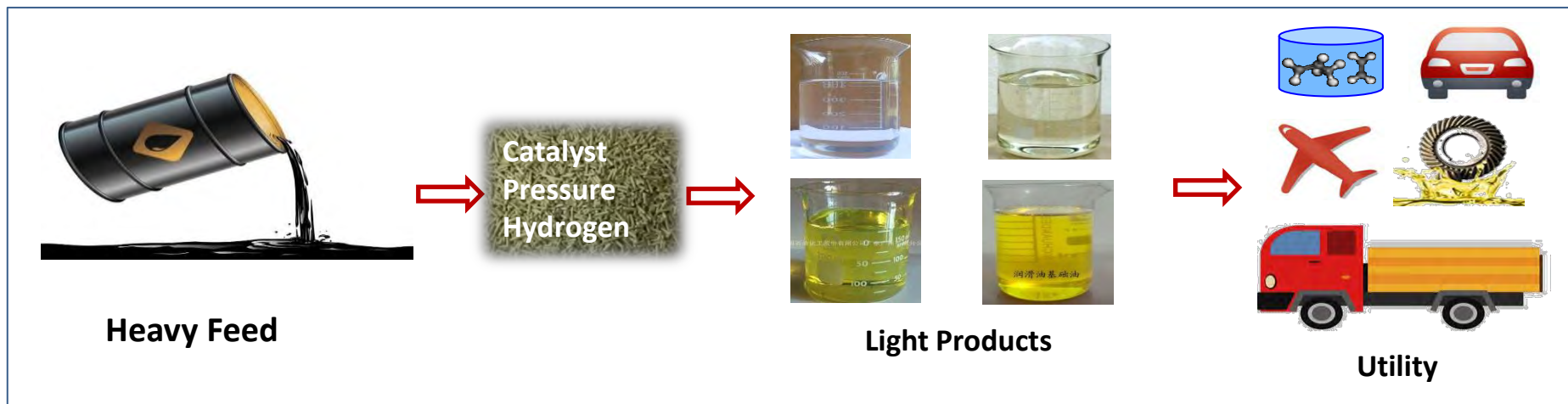
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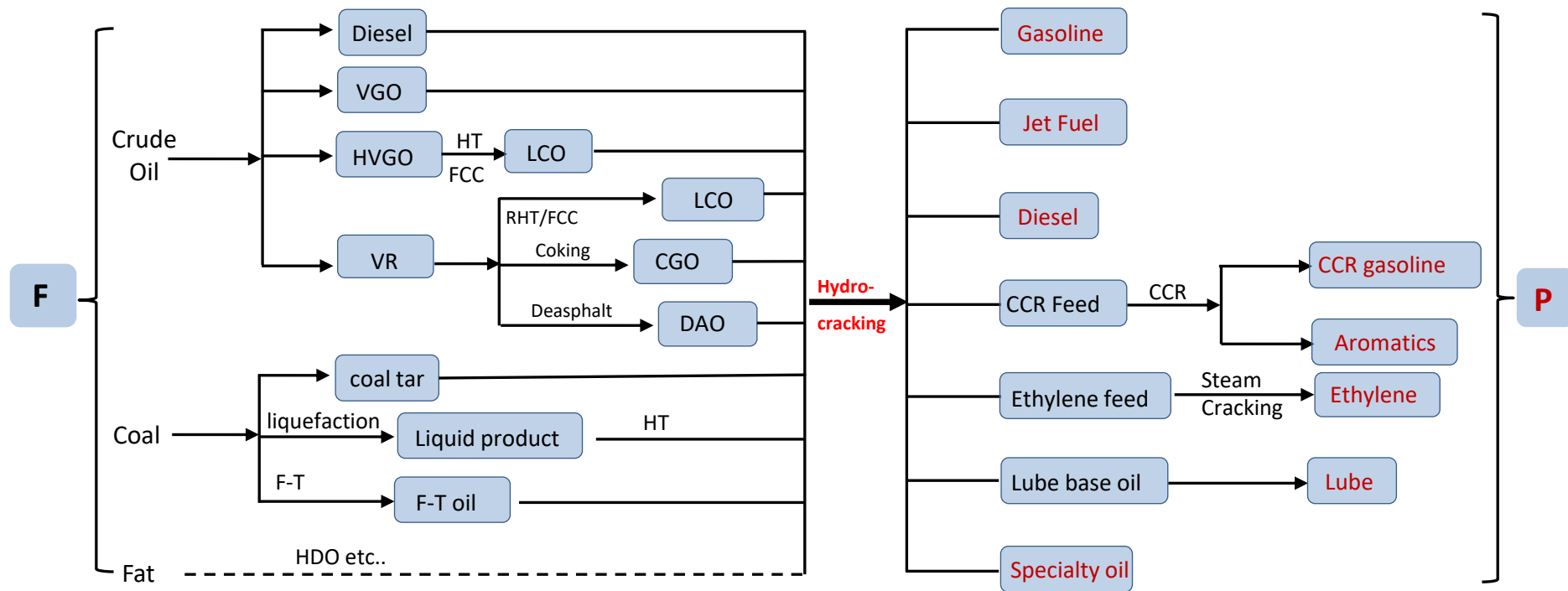


Introduction



Hydrocracking is the most effective method for oil cleaning and lightening

Introduction



- Varied feed
- Abundant products
- Flexible operation
- Better product quality

Introduction

Hydrocracking R&D process of FRIPP

6 national science and Technology Awards



1980s~1990s

Developed the 1st series of domestic commercialized HC catalysts and provided basic design data and catalyst for the 1st domestic HCU. Typical catalysts, **3824, 3825 for HC and 3936** for pretreat

1950s~1970s

The 1st HC R&D team in China. **106 amorphous catalyst and H-06 catalyst with zeolite** were developed.

2010s~2020s

Supported the transformation of refineries from oil refining to chemical industry. Domestic market share >50%. In 2017, catalysts were exported



Future

Directional conversion of hydrocarbon molecules

Domestic Market share

- Success bid in the 5.6 MMt/a hydrocracking unit, which is the largest in single series scale all over the world which adopts SINOPEC FRIPP Hydrocracking Technology
- 40 units are designed with FRIPP technology
- 12 units are revamped with FRIPP technology

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Hydrocracking Processes of Sinopec FRIPP

Classic HC processes

Middle Distillate selective processes

- FDC (single-stage double catalyst)
- FMD₁(single-stage in series)
- FMD₂(two-stage)
- FHC(flexible hydrocracking process)

Chemical material selective processes

- FMN(maximally producing heavy naphtha)
- FMC₁(single-stage in series)
- FMC₂(two-stage)
- Molecular-level controlled hydrocarbon conversion
- Jet fuel and chemical material enhanced production process with VGO
- Jet fuel and chemical material enhanced production process with SRGO

Hydrocracking Processes of Sinopec FRIPP

Energy-saving hydrocracking process

SHEER(Sinopec Hydrocracking Efficient Energy Reduction)

Wet start-up technology of Oxidation state hydrocracking catalyst

Combined HC Processes

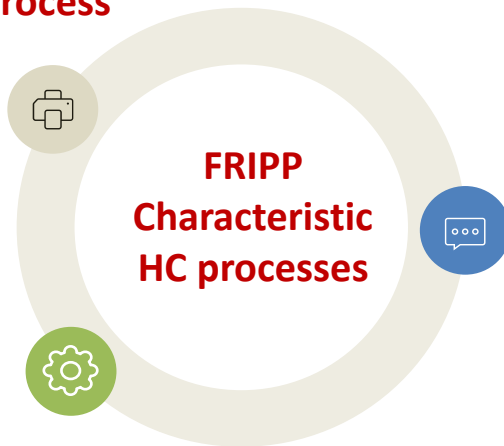
FHC-WSI(HC + iso-dewaxing)

FHC-FHF(HC + HT sectional feeding)

FHC-FHT(HC + HT reverse series)

FHC-HDS(HC + VGO HDS)

MHUG-HAD(hydro-upgrading + Jet Fuel hydro-finishing under moderate pressure)



Hydrocracking/hydro-upgrading processes at moderate Pressure

MPHC (Moderate pressure HC)

MHC(Mild Hydrocracking)

FDHC(HC of diesel under moderate pressure)

MHUG(Hydro-upgrading under moderate pressure)

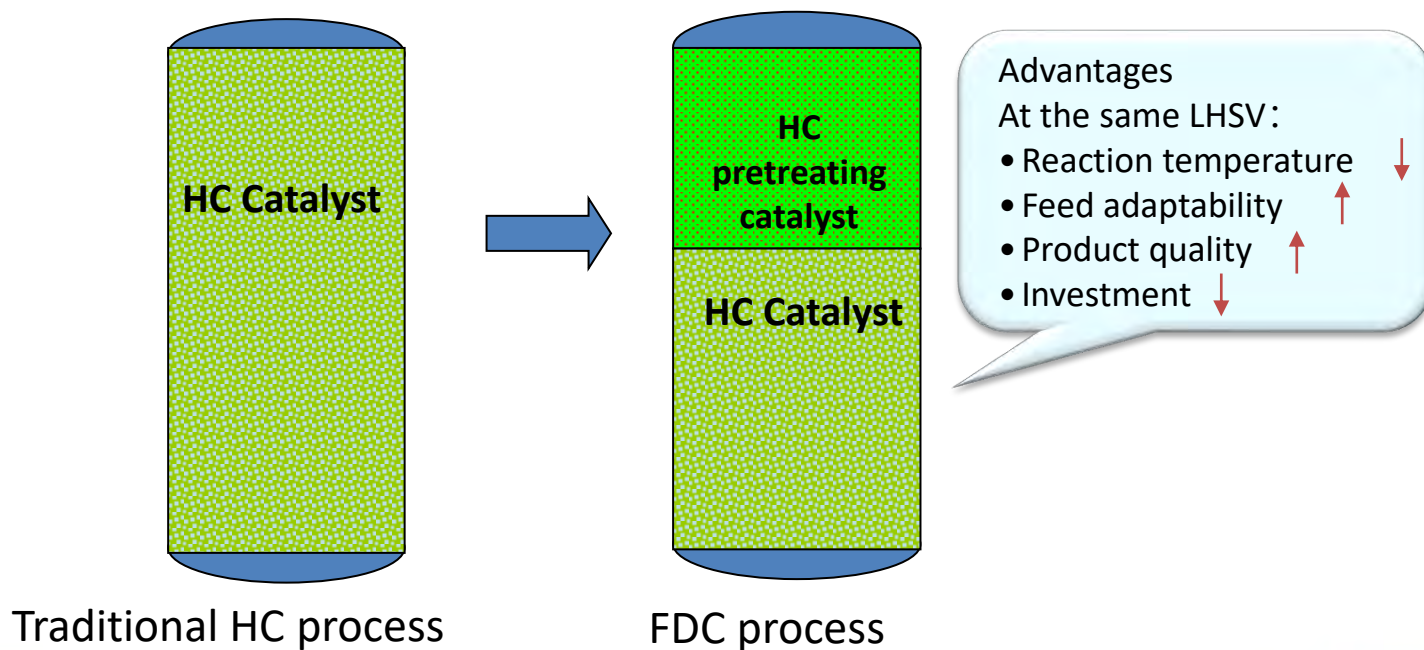
MCI(Maximally increasing cetane number)

FD2G(LCO to gasoline conversion)

FHI(hydro-isomerization to improve cold flow property of diesel)

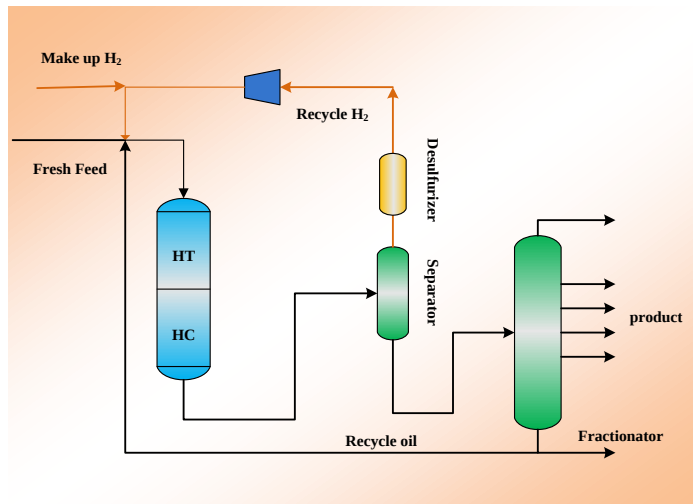
Hydrocracking Processes of Sinopec FRIPP

1. FDC process(single-stage double catalyst)



Hydrocracking Processes of Sinopec FRIPP—Middle distillate selective

1. FDC process (single-stage double catalyst)



1

FDC process was commercialized in 2005

2

It features high middle distillate yield, low hydrogen consumption, good product quality and low energy consumption

3

Applicable catalysts : FC-14, FC-28 and the latest generation of **FC-34** and **FC-38**

4

Industrial unit result : Middle distillate (Jet fuel +diesel) yield **78.85%**, Comprehensive energy consumption ~ 30Kg standard oil /t feed

Hydrocracking Processes of Sinopec FRIPP—Middle distillate selective

1. FDC process (single-stage double catalyst)—commercialization cases

No.	Site	Unit type	Unit scale, MMt/a
1	Jiangsu	HPHC	1.5
2	Hainan	HPHC	1.2
3	Shandong	HPHC	0.56
4	Liaoning	HPHC	1.3
5	Liaoning	HPHC	1.0
6	Liaoning	HPHC	1.5

a: high pressure hydrocracking($P>10\text{MPa}$)

Hydrocracking Processes of Sinopec FRIPP—Middle distillate selective

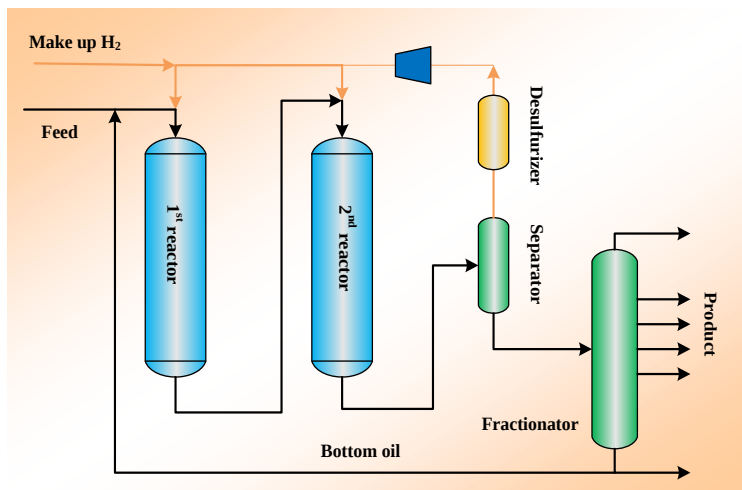
1. FDC process (single-stage double catalyst)

Industrial unit operation result of FDC process

Operation condition	Result				
process	single-stage in series(full recycle)				
Pressure, MPa	15.2				
Result	VGO	Light Naphtha	Heavy Naphtha	Jet Fuel	Diesel
Yield, %	100	3.86	13.77	36.73	42.12
Density(20°C), g/cm ³	0.9140	<0.65	0.7228	0.7990	0.8441
Distillation range, °C	331~524	30~79	76~142	145~261	280~362
Sulfur, mg/kg	19700		<0.5	1.9	1.0
Nitrogen, mg/kg	1322		<0.5		
Smoke point, mm				24	
Solidification point, °C					-12
Cetane number					59.5

Hydrocracking Processes of Sinopec FRIPP—Middle distillate selective

2. FMD₁ process(single-stage in series)



1

A hydrocracking technology employing middle-distillate selective catalyst and once through or full recycle operation mode

2

With UCO full recycle operation mode, middle distillate yield is ~75%, among which jet fuel yield is ~45%

3

It features good feed adaptability, flexible operation scheme, long operation period

4

Applicable catalysts : FC-26, FC-50 and the latest generation of FC-60 and FC-80

Hydrocracking Processes of Sinopec FRIPP—Middle distillate selective

2. FMD₁ process(single-stage in series)—commercialization cases

No.	Site	Unit type	Unit scale, MMT/a
1	Jiangsu	HPHC	1.0
2	Guangdong	HPHC	1.1
3	Zhejiang	HPHC	1.2
4	Guangdong	HPHC	1.2
5	Jiangxi	HPHC	2.4
6	Hebei	HPHC	1.5

a: high pressure hydrocracking(P>10MPa)

Hydrocracking Processes of Sinopec FRIPP—Middle distillate selective

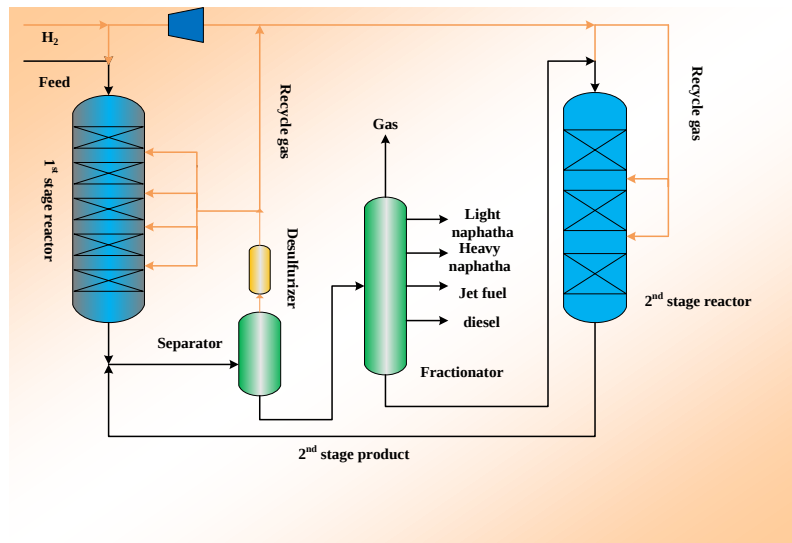
2. FMD₁ process(single-stage in series)

Industrial unit operation result of FDM₁ process

Item	Result				
Process	single-stage in series(full recycle)				
Pressure, MPa	13.4				
Industrial application result	VGO	Light Naphtha	Heavy Naphtha	Jet Fuel	Diesel
Yield, %	100	11.34	13.74	29.30	38.53
Density(20°C), g/cm ³	0.9106	0.6689	0.7438	0.7891	0.8187
Distillation range, °C	305~572	28~106	98~143	150~226	210~369
S, mg/kg	17000	<0.5	<0.5	<1	<1
N, mg/kg	1260	0.2	<0.5	<1	<1
N+A, %			52+6		
Smoke point, mm				29.0	
Cetane index					69.0

Hydrocracking Processes of Sinopec FRIPP—Middle distillate selective

3. FMD₂ process(two stages)



1

A new HC process especially developed to meet the customers' need for maximizing middle distillate yield and to respond to the scaling up of HC units

2

The first stage deals with fresh feed and the second stage deals with the UCO

3

Pilot test: middle distillate yield can be as high as 79.35m% when Middle East VGO is processed

Hydrocracking Processes of Sinopec FRIPP—Middle distillate selective

3. FMD₂ process(two stages)

Pilot test result of FMD₂ process

Item					
Process	Two stages (full recycle)				
Pressure, MPa	13.7				
Pilot test result	VGO	Light Naphtha	Heavy Naphtha	Jet Fuel	Diesel
Yield, %	100	5.96	11.32	28.75	50.60
Density(20°C), g/cm ³	0.9121	0.6489	0.7214	0.7774	0.8387
Distillation range, °C	335~532	32~82	85~130	139~228	243~358
Sulfur, mg/kg	12800	<0.5	<0.5	<1.0	<1.0
Nitrogen, mg/kg	1328	<0.5	<0.5	<1.0	<1.0
Aromatic potential, %			45.1		
Smoke point, mm				30	
Cetane number					58.2

Hydrocracking Processes of Sinopec FRIPP—Middle distillate selective

4. FHC(flexible hydrocracking process)

UCO full recycle mode

Middle distillate scheme:

middle distillate (jet fuel + diesel)yield: 60%~65%

Chemical material scheme:

heavy naphtha yield: 30%~ 40%

total yield of chemical material: 60%~ 65%

1

Product scheme can be flexibly adjusted by changing catalysts, processing mode and product cutting point

2

Applicable catalysts: FC-12, FC-32 and the latest generation of **FC-76** and **FC-86**

Hydrocracking Processes of Sinopec FRIPP—Middle distillate selective

4. FHC(flexible hydrocracking process)—commercialization cases

No.	Site	Unit type	Unit scale, MMt/a
1	Tianjin	HPHC ^a	1.2
2	Tianjin	HPHC	1.8
3	Shanghai	HPHC	1.4
4	Shanghai	HPHC	1.5
5	Fuzhou	HPHC	2.1
6	Shandong	HPHC	2.0
7	Liaoning	HPHC	1.6
8	Xinjiang	HPHC	1.0
9	Jilin	MPHC ^b	0.9
10	Guangdong	HPHC	2.4
11	Hubei	HPHC	1.8
12	Taizhou	HPHC	1.5
13	Shandong	HPHC	1.5

a: high pressure hydrocracking(P>10MPa) b: moderate pressure hydrocracking(P<10MPa)

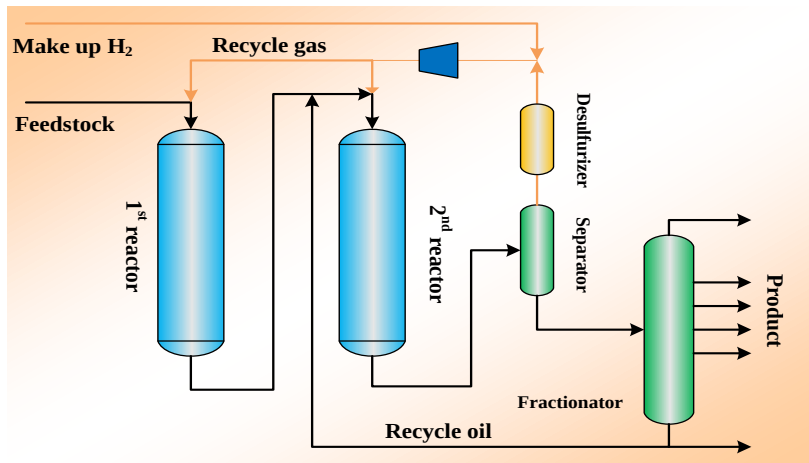
Hydrocracking Processes of Sinopec FRIPP—Middle distillate selective

4. FHC(flexible hydrocracking process)

Item	Result					
Process	single-stage in series/ once through					
Pressure/MPa	14.2					
Industrial results	VGO	Light Naphtha	Heavy Naphtha	Jet Fuel	Diesel	UCO
Yield, %	100	11.53	14.42	30.76	15.38	26.91
Density(20°C)/g·cm ⁻³	0.9076	0.6812	0.7504	0.8040	0.8204	0.8325
Distillation range/°C	264~491	30~114	89~158	152~291	186~353	251~479
Sulfur, mg/kg	19600	<0.5	<0.5	<2	<2	<5
Nitrogen, mg/kg	5	<0.5	<0.5	<1	<1	<1
Smoke point, mm				25.0		
Cetane index					66.8	
BMC1						10.7

Hydrocracking Processes of Sinopec FRIPP—Chemical material selective

1. FMN (maximally producing heavy naphtha)



1

Employing proprietary highly active HC catalysts, single-stage in series mode and full recycle of distillate with boiling point beyond 177°C to maximally produce CCR feed

2

Applicable catalysts: FC-24, FC-46 and the latest generation of FC-52 and FC-82

3

Pilot test result: CCR feed yield can be ~70%

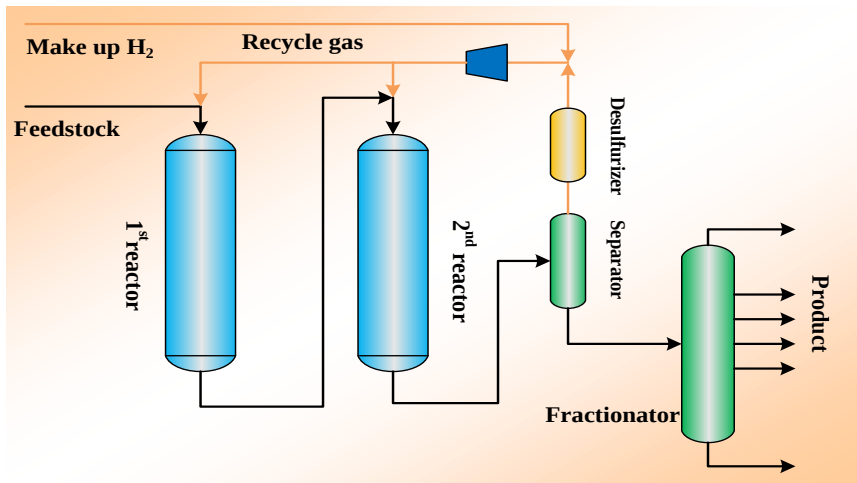
Hydrocracking Processes of Sinopec FRIPP—Chemical material selective

1. FMN process industrial result

Item	Result		
Process	Two-stage(full recycle)		
Pressure/MPa	13.0		
Industrial result	Feed	Light naphtha	Heavy naphtha
Yield, %	100	20.75	71.85
Density(20°C)/g·cm ⁻³	0.8906	0.6474	0.7400
Distillation/°C	153~545	31~77	72~177
Sulfur, mg/kg	13200	<0.5	<0.5
Nitrogen, mg/kg	1253	<0.3	<0.3
Paraffin, %		91.2	
N+A, %			41+9

Hydrocracking Processes of Sinopec FRIPP—Chemical material selective

2. FMC₁ process (single-stage in series)



1

It produce both CCR feed and ethylene feed with high quality

2

Industrial application result: **chemical material (L/H naphtha +UCO)** yield can be ~85%

Hydrocracking Processes of Sinopec FRIPP—Chemical material selective

2. FMC₁ process (single-stage in series)—commercialization cases

No.	Site	Unit type	Unit scale, MMt/a
1	Jiangsu	HPHC	2.0
2	Zhejiang	HPHC	1.5
3	Liaoning	HPHC	1.3
4	Liaoning	HPHC	1.1

a: high pressure hydrocracking(P>10MPa)

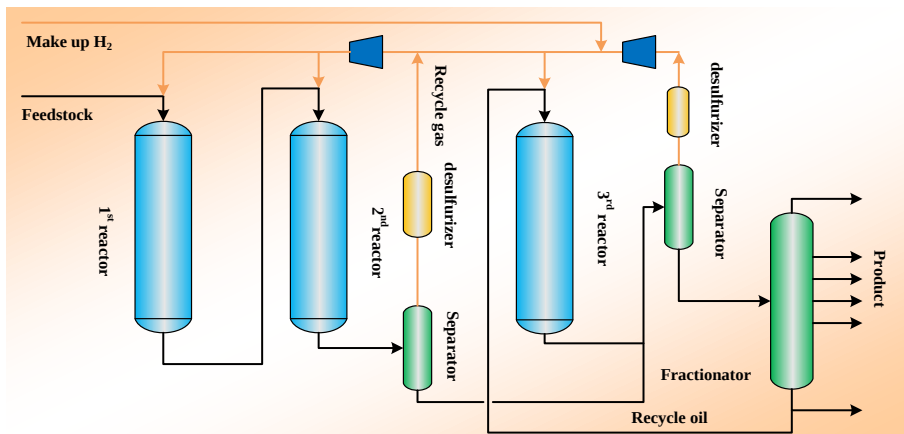
Hydrocracking Processes of Sinopec FRIPP—Chemical material selective

2. FMC₁ process (single-stage in series)—industrial application result

Item	HC unit				
Process	Single-stage in series/once through				
Pressure/MPa	14.2				
Industrial results	Feed	Light naphtha	Heavy naphtha	Jet Fuel	UCO
Yield, %	100	9.15	46.52	10.35	28.26
Density(20°C)/g·cm ⁻³	0.8878	0.6543	0.7441	0.7923	0.8051
Distillation/°C	237~496	33~65	83~174	159~242	210~428
Sulfur, mg/kg	2600	<0.5	<0.5	<0.5	7.3
Nitrogen, mg/kg	1705	<0.5	<0.5	<0.5	<0.5
Aromatic potential, %			55.3		
Smoke point, mm				27	
BMCI					11.2

Hydrocracking Processes of Sinopec FRIPP—Chemical material selective

3. FMC₂ process (two stages)



1

Heavy and inferior hydrocracking feedstock can be totally transformed into high-quality chemical light oil with FMC₂ process

2

The process is similar to FMD2, the difference is that second stage of FMC₂ deals with 177 °C ~ 350 °C distillates instead of tail oil from the first stage

3

Pilot test result: **chemical material (L/H naphtha + UCO)** yield can reach ~95%

Hydrocracking Processes of Sinopec FRIPP—Chemical material selective

3. FMC₂ process (two stages)

Item	Result			
Process	Two stage/full recycle			
Pressure/MPa	12.4			
Pilot test result	Feed	Light naphtha	Heavy Naphtha	UCO
Yield, %	100	10.86	50.37	32.46
Density(20°C)/g·cm ⁻³	0.9164	0.6482	0.7516	0.8385
Distillation/°C	328~531	33~81	74~174	379~530
Sulfur, mg/kg	16000	<0.5	<0.5	<5
Nitrogen, mg/kg	1475	<0.5	<0.5	<2
Paraffin, %		>95		
Aromatic potential, %			61.3	
BMCI				11.5

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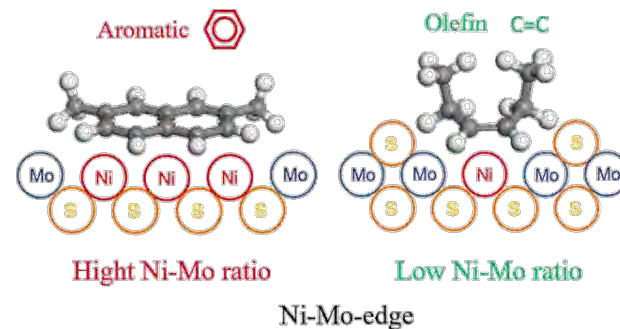
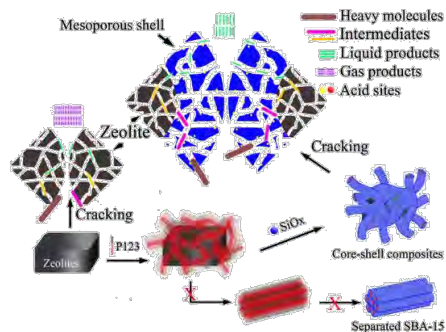
Hydrocracking Catalysts of Sinopec FRIPP



Based on the deep understanding of molecule behavior during hydrocracking process, FRIPP has developed a series of hydrocracking catalysts with high conversion efficiency and high selectivity which are commercialized for more than **220** times.



We have a full range of hydrocracking technologies and catalysts and are able to provide **“tailor-made”** catalysts for the clients.



Hydrocracking Catalysts of Sinopec FRIPP

Hydrocracking catalysts developed by FRIPP include:



Naphtha selective catalysts



Flexible catalysts



Middle distillate selective catalyst



Catalysts especially suitable for single-stage process



Guard catalysts and pretreating catalysts



Inferior diesel upgrading catalysts



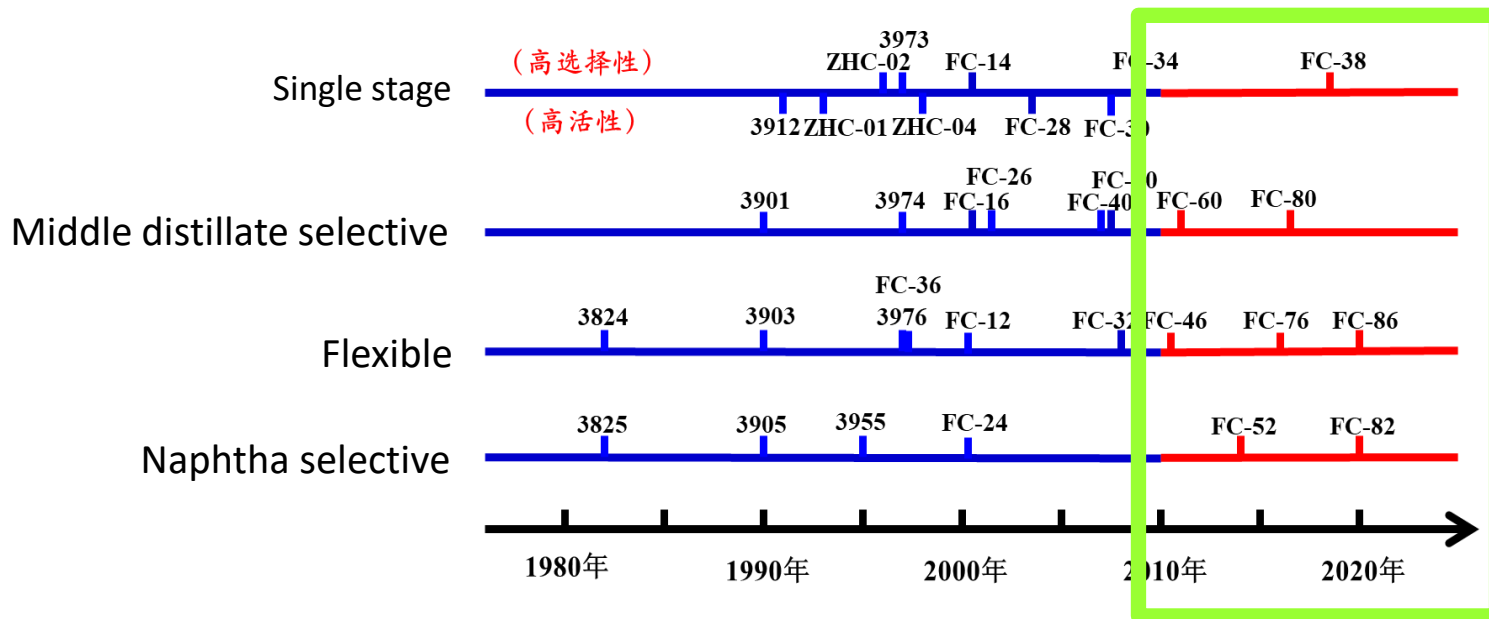
Cold flow property improving catalysts



Lube oil hydrotreating catalysts

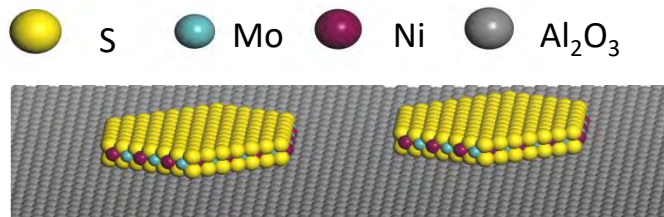


Hydrocracking Catalysts of Sinopec FRIPP

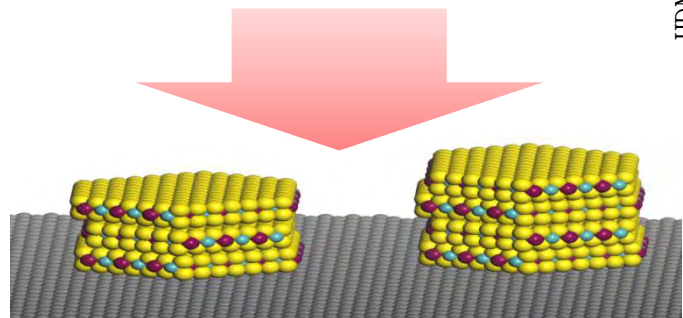


- ❑ The catalysts are tested by AVANTIUM and are identified as “first class product”
- ❑ We are Invited to form a strategic alliance with Albemarle Co. to jointly explore the international market

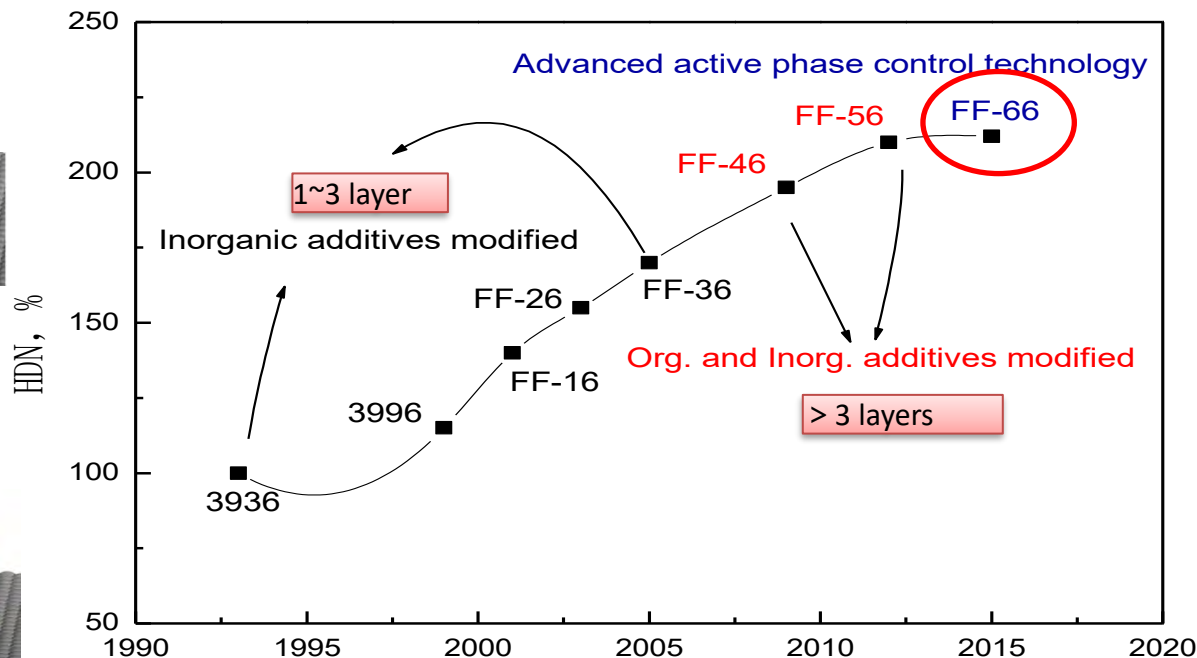
Hydrocracking pretreating Catalysts of Sinopec FRIPP



I 型Co (Ni) -Mo-S



II 型Co (Ni) -Mo-S



Hydrocracking Catalysts of Sinopec FRIPP

Naphtha selective catalysts



1

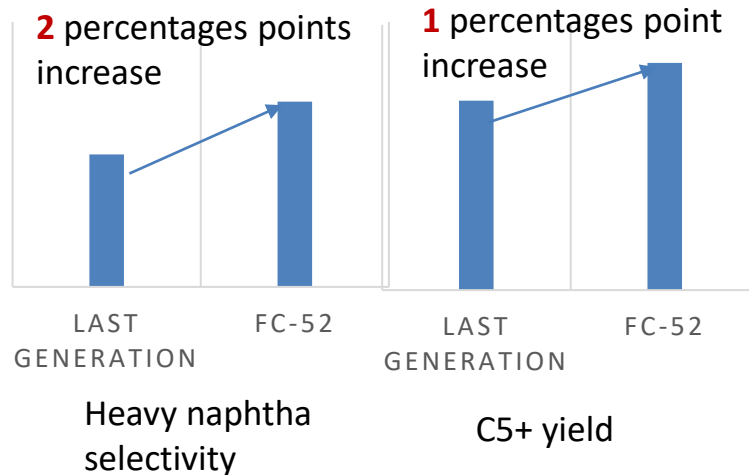
Suitable for single stage in series and two stages processes

2

Good at maximizing naphtha and UCO

3

Decreasing BMCI and final boiling point of UCO to produce better ethylene feed



Hydrocracking Catalysts of Sinopec FRIPP

Flexible hydrocracking catalysts



1

Suitable for single stage in series and two stages processes

2

Flexibly producing naphtha, middle distillates and UCO

3

The UCO can be ethylene feed with nice quality

Compared to last generation FC-76 provides

- ✓ 0.5-1.1 percentage point higher C5+ yield
- ✓ 0.09-0.18 percentage point lower H₂ consumption
- ✓ 1.8-2.7 percentage point higher Heavy naphtha selectivity
- ✓ 1.8-2.1 percentage point lower UCO BMCI

Hydrocracking Catalysts of Sinopec FRIPP

Middle distillate selective catalyst



FC-16 features:

- ✓ High middle distillate selectivity
- ✓ UCO with low pour point as the feed of lube base oil

Characteristics of FC-80:

- ✓ Capable of getting tail oil as ideal feed for lube base oil with high viscosity index;
- ✓ Successful application in Russia

Hydrocracking Catalysts of Sinopec FRIPP

Catalysts especially suitable for single-stage process



FC-14 provides:

- ✓ High middle distillate selectivity
- ✓ Better cold flow property of middle distillate and UCO
- ✓ More isomerized products

Hydrocracking Catalysts of Sinopec FRIPP

Hydrocracking catalyst of FRIPP has been exported to Europe

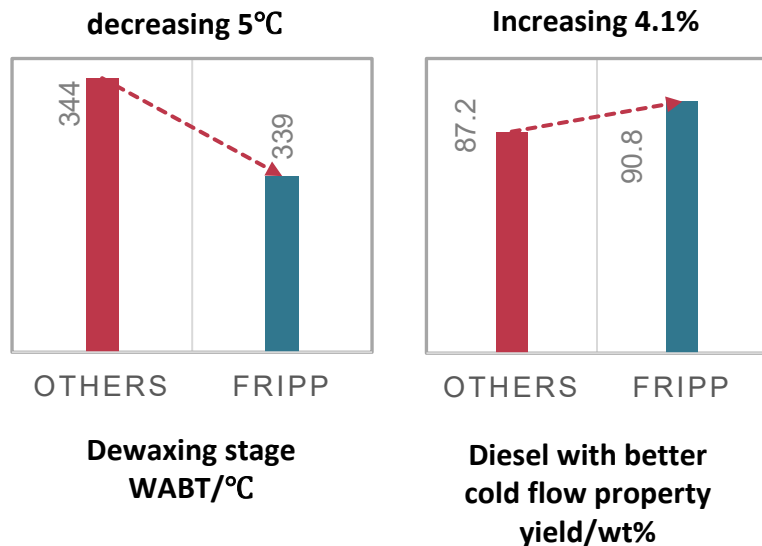


Products	Light naphtha	Heavy naphtha	Jet fuel	Diesel	UCO
Yield, %	3.12	14.59	11.26	41.57	35.38
Density/g·cm ⁻³	0.6690	0.742	0.801	0.835	0.841
Mercaptan sulfur/μg·g ⁻¹			2		
Copper corrosion			Pass		
Solidification point/°C					37
Smoke point/mm			>25		
Cetane number				55	
S/μg·g ⁻¹		<0.5			3
N/μg·g ⁻¹					0.8
Viscosity index					141

All the parameters of key indexes meet the requirements, especially the UCO viscosity index is stable above 140, which has been fully approved by the Client

Hydrocracking Catalysts of Sinopec FRIPP

Diesel hydro-dewaxing catalyst of FRIPP has been exported to Kazakhstan refinery



All the parameters of key indexes are better than the catalyst installed last period, and catalyst from FRIPP has been fully approved by the Client

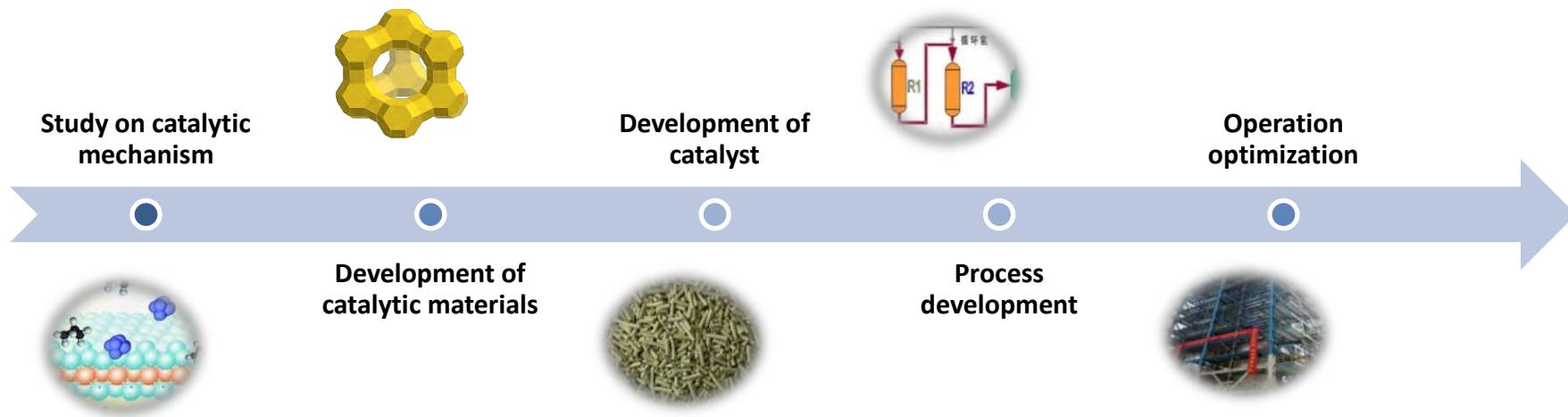
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Conclusion



- Sinopec FRIPP developed a series of hydrocracking technologies and laid solid foundation for producing clean oil.
- FRIPP hydrocracking technologies have been successfully applied in many industrial enterprises.
- Clients can choose appropriate technologies according to their needs.

Thanks

www.sinopec.com

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