General Information of SAKAI's Catalyst

Sakai Chemical Industry Co.,LTD.

29 Jan.,2020

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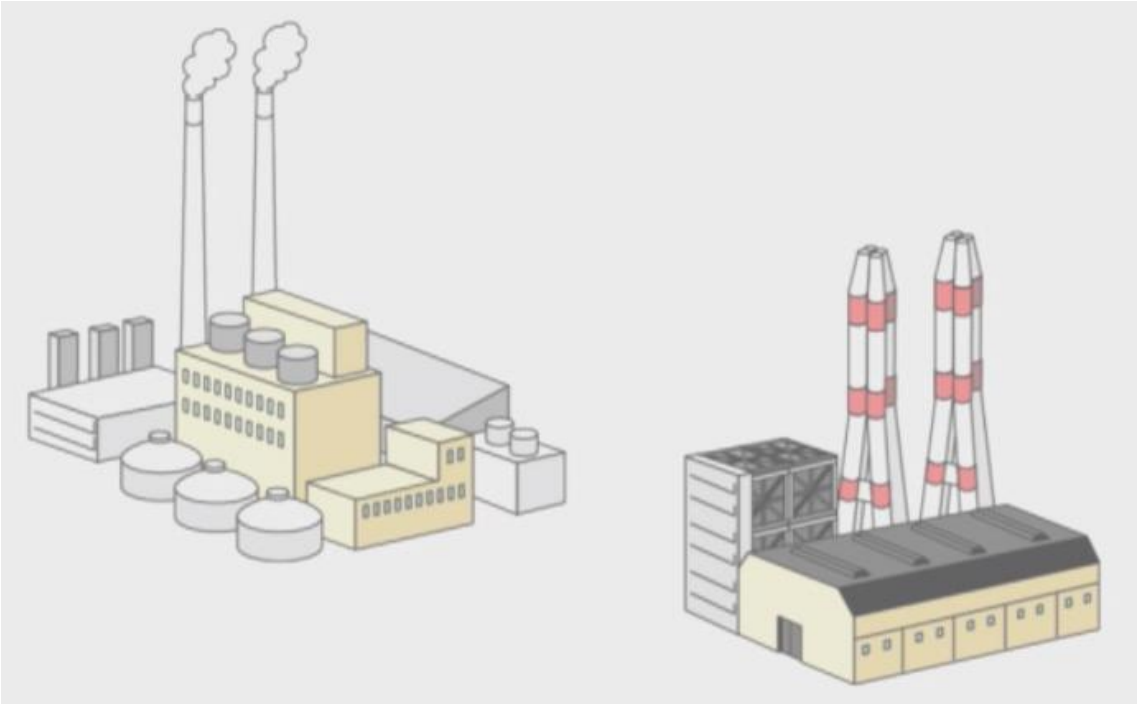

1. Corporate Profile

1-1. Profile

1-2. Certificate

1-3. Technology Prize

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1-5. Sakai Division

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SAKAI CHEMICAL

1-1. Profile

Foundation	1918
Capital	JPY21.8Billion
Head Office	Osaka
Branch	Tokyo
Works	Osaka(Sakai), Fukushima(Onahama)

Listed on 1st section of TOKYO STOCK EXCHAGE.

SAKAI CHEMICAL

1-2. Certificate
ISO 9001(2008)

JCQA

Quality Management System

CERTIFICATE OF CONFORMITY COPY

Certificate No. :	JCQA-0480	Registration Date :	1999. 4. 12
Renewal Date :	2011. 4. 12	Expiry Date :	2014. 4. 11

Name of Registered Organization: **Sakai Chemical Industry Co., Ltd. Electronic Materials Division et al.**

Address of Registered Organization: **5-2, Ebisujima-cho, Sakai-ku, Sakai-shi, Osaka, 590-8502, Japan et al.**

JAPAN CHEMICAL QUALITY ASSURANCE LTD. certifies that the Quality Management System of the above organization specified in the appendix, has been assessed and verified to be in accordance with the requirements of the quality management system standards as shown below:

Quality Management System Standards: **JIS Q 9001:2008**
ISO 9001:2008

The Date of Issue: **2012. 5. 7**

JAPAN CHEMICAL QUALITY ASSURANCE LTD. (JCQA)
Nittochi-Uchisaiwaicho BLDG. 7F, 1-2-1, Uchisaiwaicho, Chiyoda-ku, Tokyo, 100-0011, JAPAN

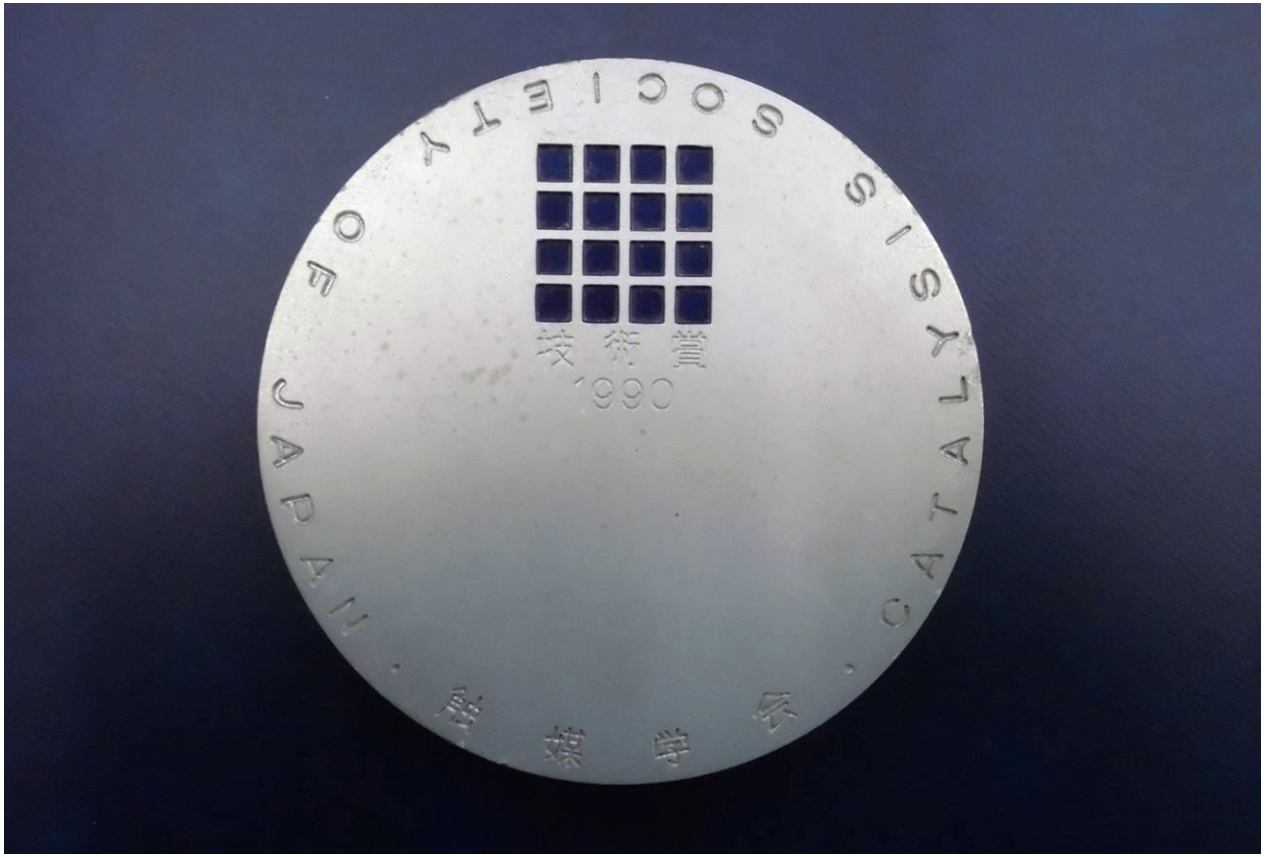
Hiromi Miyanishi
PRESIDENT REPRESENTATIVE DIRECTOR

SAKAI CHEMICAL

1-3. Technology Prize

Development of De-NOx catalyst by NH_3-SCR

the Catalysis Society of Japan in 1989



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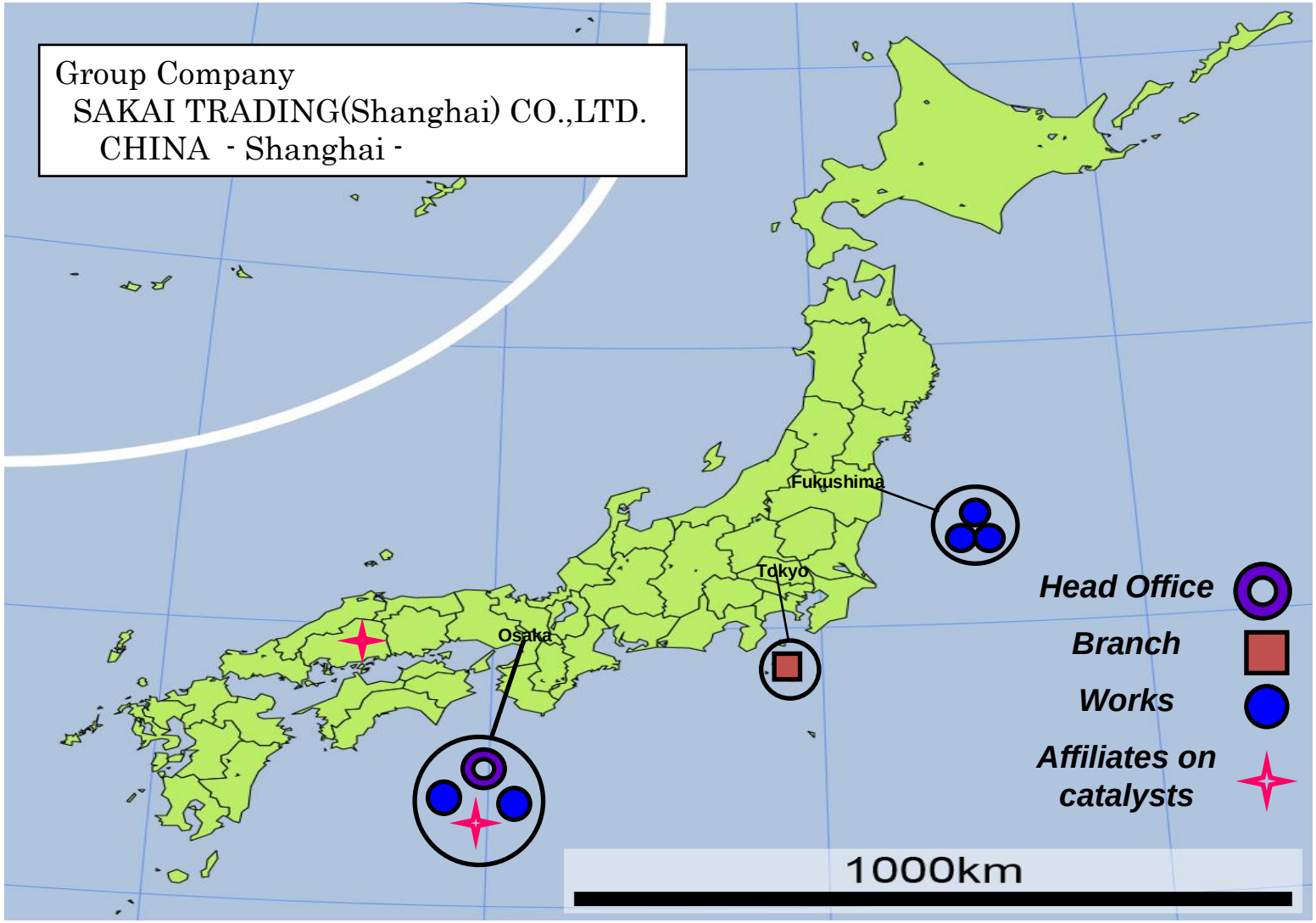
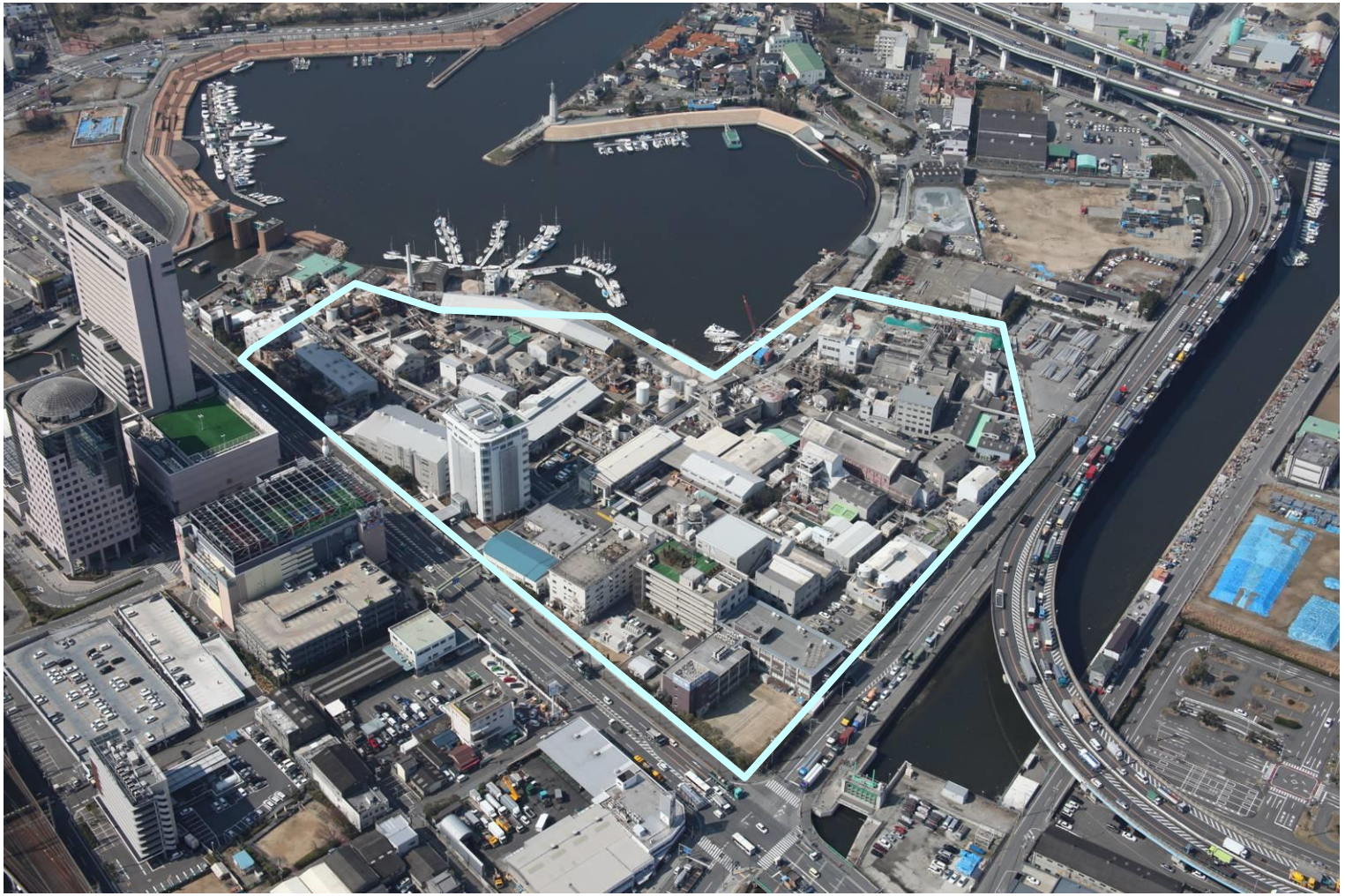
1-4. Network


Group Company
SAKAI TRADING(Shanghai) CO.,LTD.
CHINA - Shanghai -
Fukushima
Tokyo
Osaka
Head Office
Branch
Works
Affiliates on catalysts
1000km

1-5. Sakai works



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1-6. Onahama works

1-7. Semboku works

1-8. Products

- Titanium Dioxide

  for paints and catalysts
- Inorganic Chemical Products

  Barium, Strontium and Zinc Oxide
- Plastic Additives
- Electronic Materials
- Catalysts

  De-NOx/De-DXNs catalysts,
  photo catalysts and for chemical processing

  and others

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1-9. History of TiO_2 & Catalyst Division

Year	Event
1935	The first manufacturer to succeed in factory production of anatase type TiO_2.
1963	Onahama Works was completed in Fukushima for TiO_2 production.
1969	Semboku Works was completed in Osaka. Catalysts production was started.

2. De-NOx Catalyst

2-1. General Information
2-2. Manufacturing process of catalyst
2-3. Catalyst Shape
2-4. Applicable Range of Temperature
2-5. List of Honeycomb Shape & Size
2-6. De-NOx Reaction
2-7. De-DXNs Reaction
2-8. Characteristic Diagram on De-NOx Performance
2-9. Deactivation and Reactivation of Catalyst

2-1. General Information

- Sakai succeeded in developing and mass - producing of de-NOx catalysts before any other parties came into the the business.
- Sakai's De-NOx Catalysts now are regarded as the best among them.
- Sakai is the only De-NOx catalyst manufacturer who has TiO_2 production plant as well in the company.
- Sakai is a leading manufacturer of De-NOx Catalysts.

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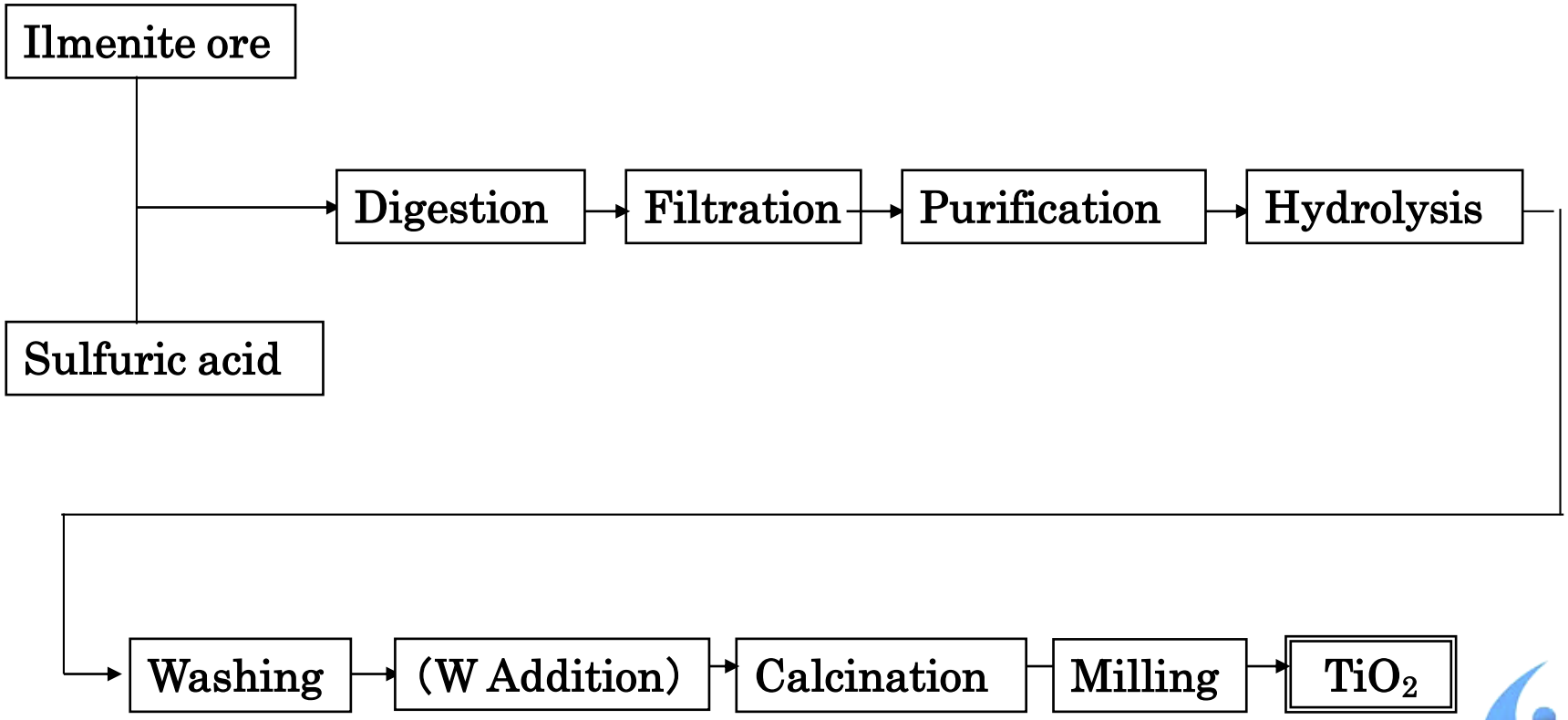
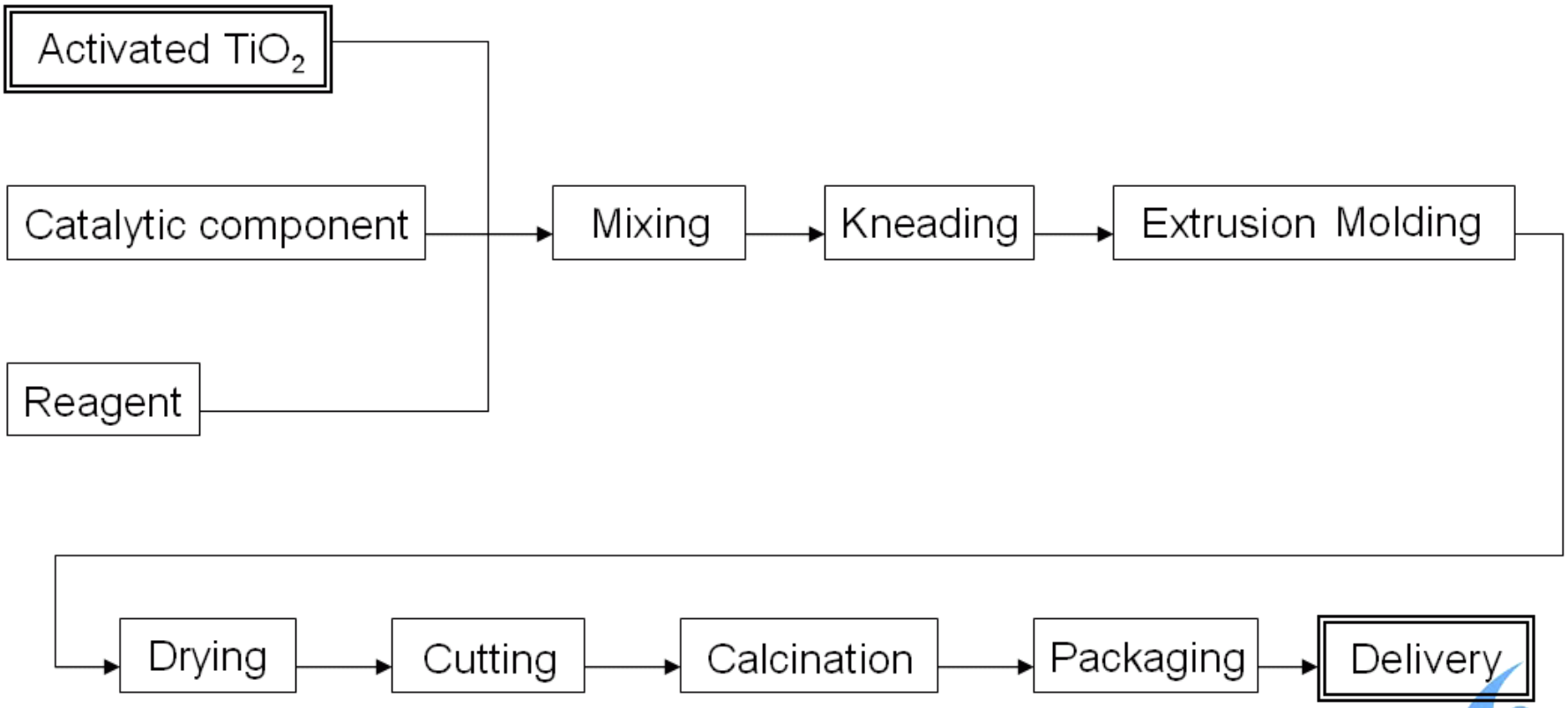
2-2. Manufacturing Process

2-2-1. Manufacturing Process of TiO_2



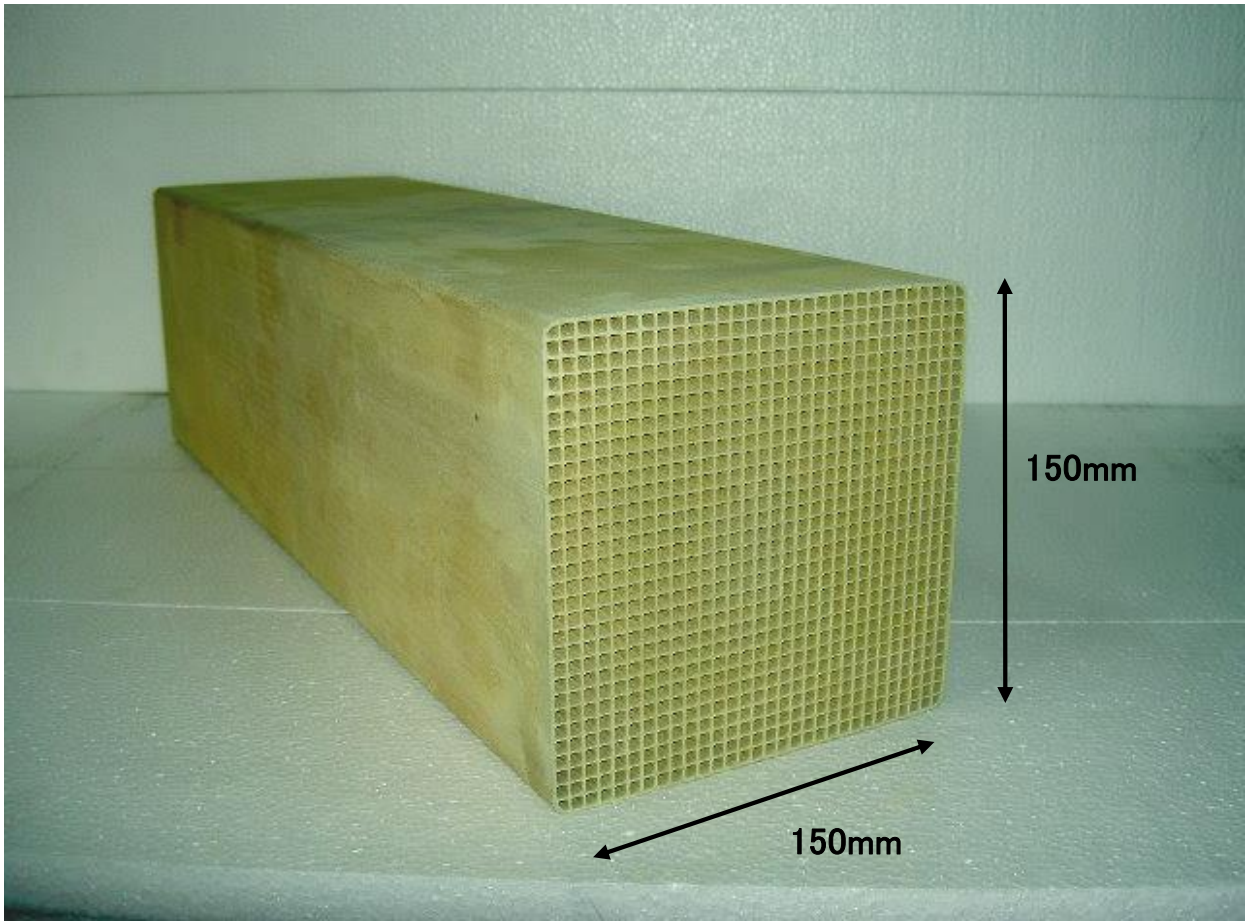
2-2-2. Catalyst



Capacity of production(catalyst): 3000 m^3/y

2-3. Catalyst Shape

2-3-1. Honeycomb type



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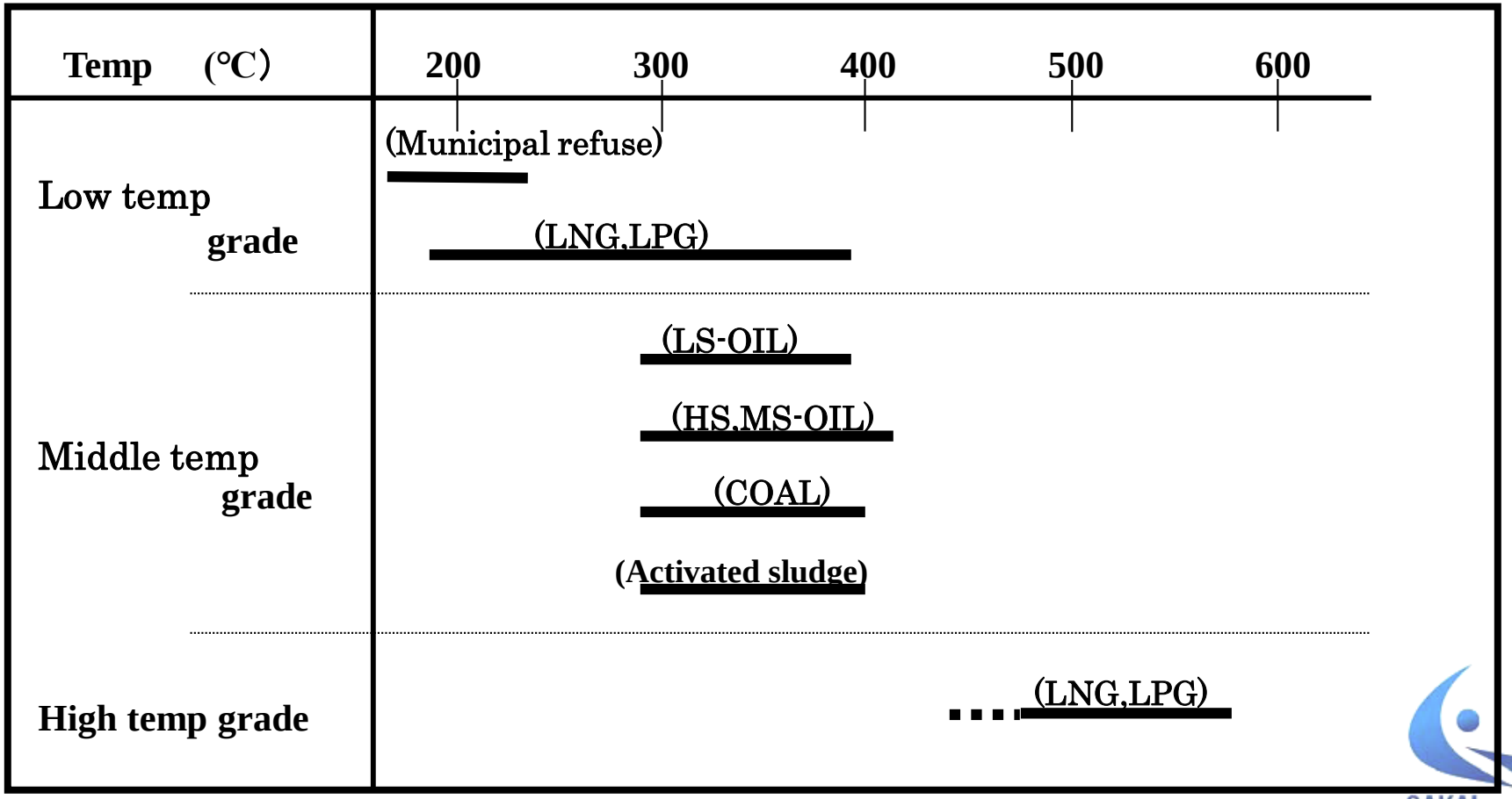
2-3-2.TREFOIL-CAT

2-4. Applicable Range of Temperature



2-5. List of Honeycomb Shape & Size

Shape	150mm□					
Pitch (mm)	7.4	6.0	5.0	4.2	3.7	3.3
Cell (n × n)	20 × 20	25 × 25	30 × 30	35 × 35	40 × 40	45 × 45
Opening (%)	68.9	69.0	68.1	72.7	72.5	69.7
Surface Area per Volume (m2/m3)	442	553	660	795	908	1001

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2-6. De-NOx Reaction

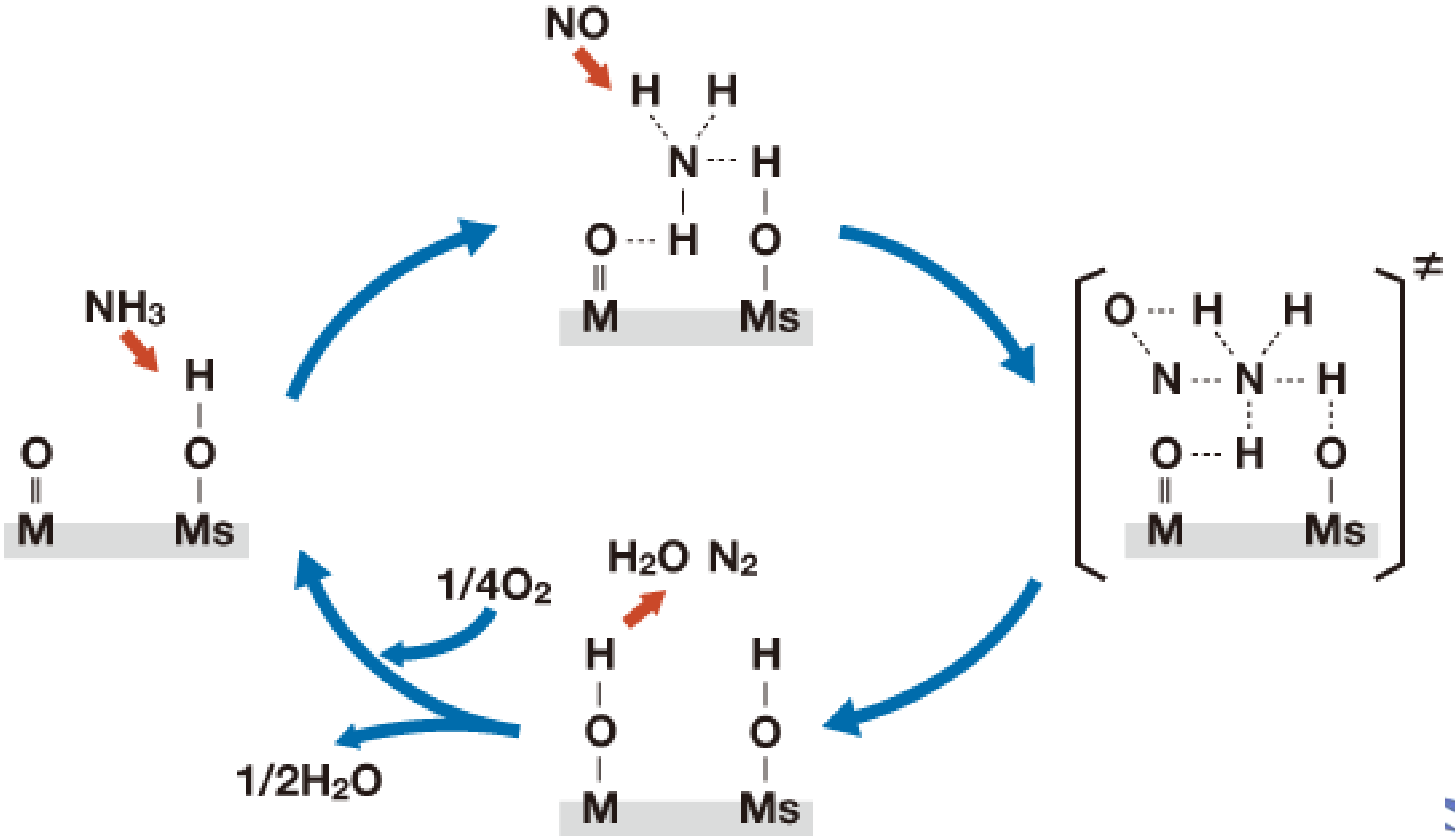
2-6-1. NOx and NH_3 Mole Ratio

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

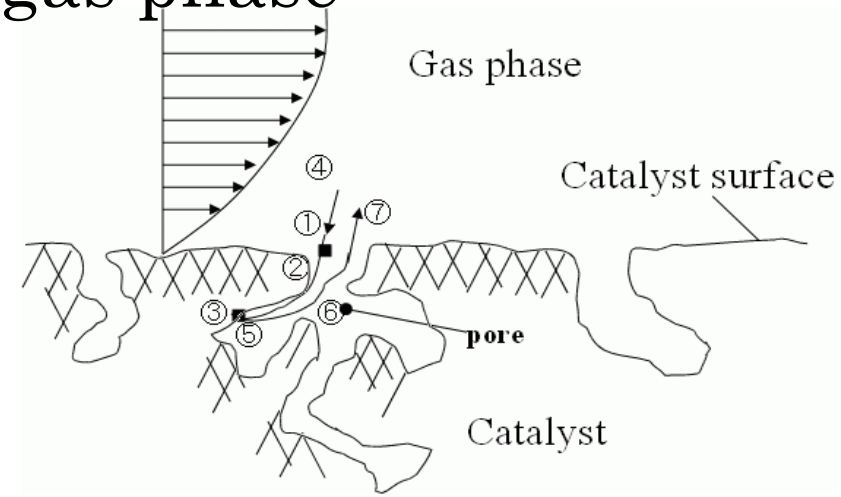
$$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$$

$$6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$$

2-6-2. Mechanism of reaction(De-NOx)



2-6-3. Reaction Kinetics for NH_3 dispersing into gas phase



①Diffusion of NH_3 from gas phase to catalyst surface

⇩

②Diffusion of NH_3 into catalyst pore

⇩

③NH_3 adsorption on active site

⇩

④NO diffusion from gas phase to adsorbed NH_3

⇩

⑤Reaction of NO-NH_3 toN_2 + H_2O

⇩

⑥Desorption of N_2 and H_2O to catalyst surface

⇩

⑦Diffusion of N_2 and H_2O into gas phase

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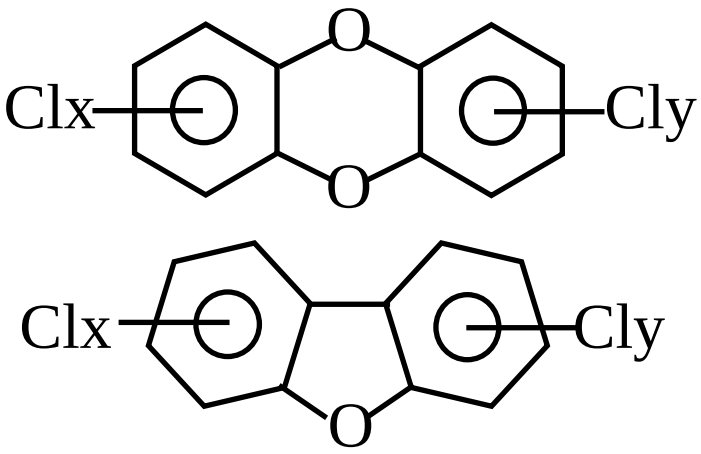
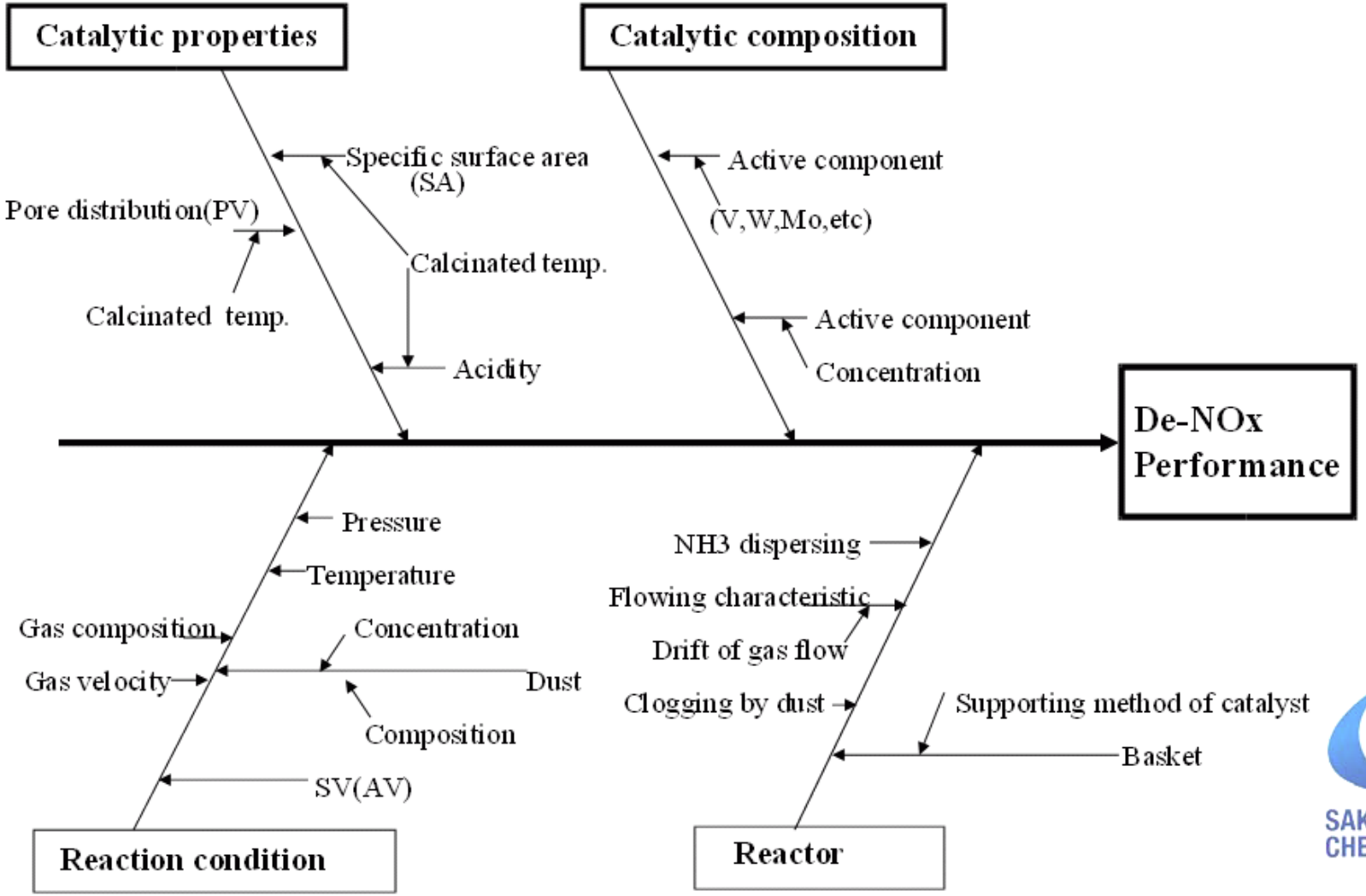
2-7. De-DXNs Reaction



$+O_2$ ⇨ $CO2+H2O+HCl$

2-8. Characteristic Diagramon De-NOx Performance



2-9. Deactivation and Reactivation of Catalyst

No.	Items	Washing with water	Heating
1	$CaSO_4$,$Ca(OH)_2$,SiO_2	×	×
2	NH_4HSO_4 ※	◎	△
3	Dust	○	×
4	Alkalis	○	×
5	Heavy Metals	×	×
6	Sintering	×	×

※ $NH_3 + SO_3 + H_2O \rightarrow NH_4HSO_4$

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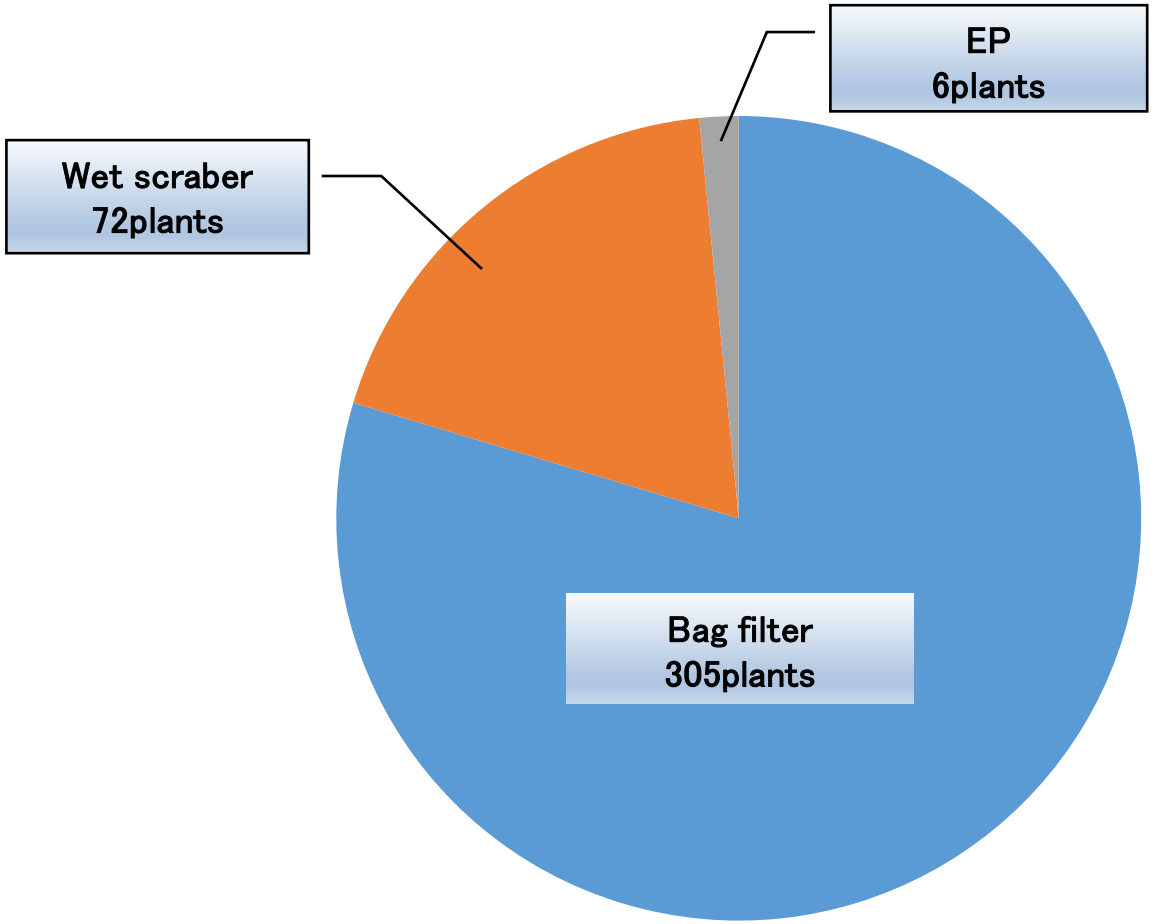
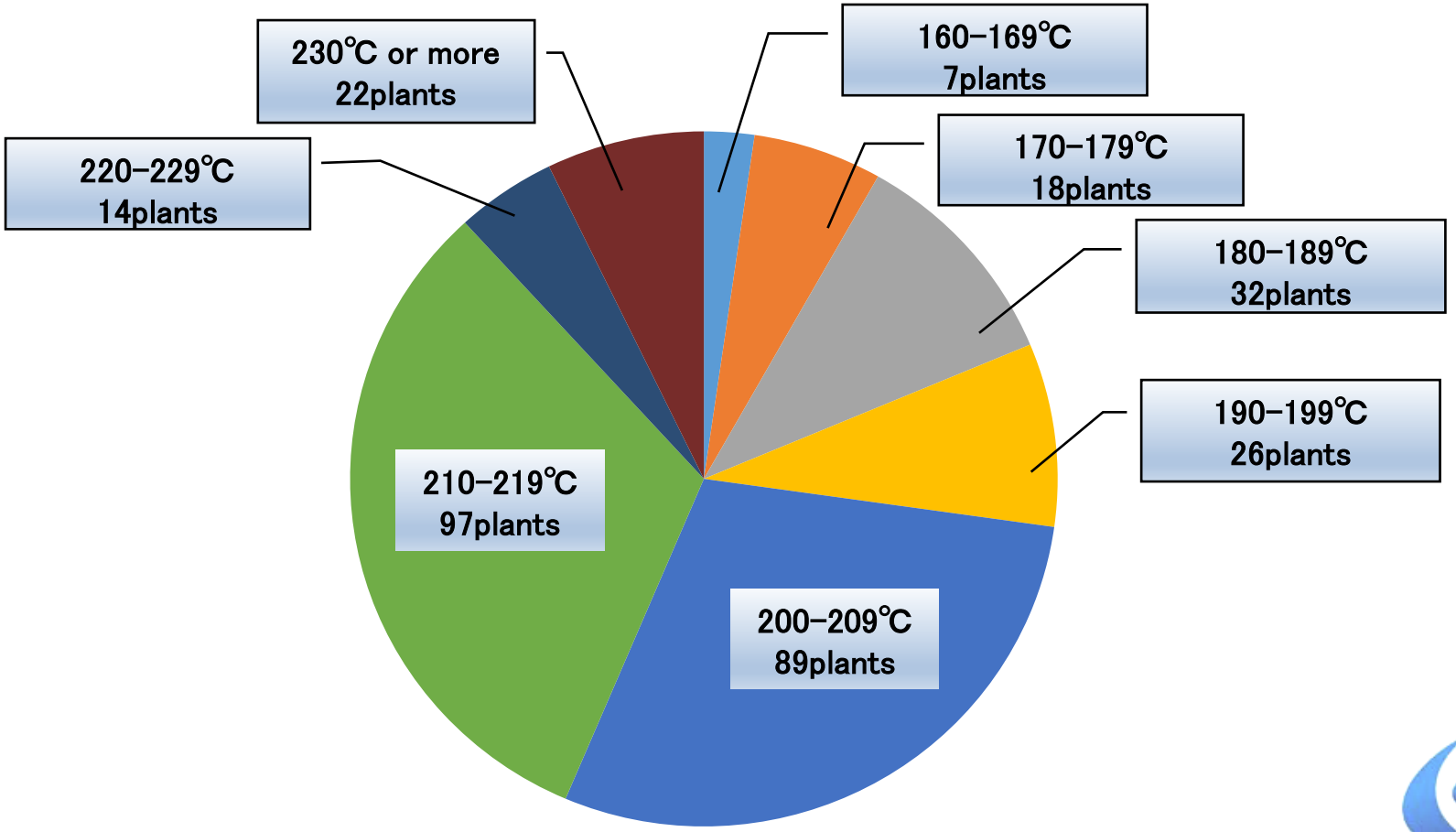
3. Delivery Record

Classification by Pretreatment



Until March 2016

Classification by Tempareture（After Bag Filter）



Until March 2016

De-NOx,De-DXNs Catalyst（After Bag Filter）

No.	Place	Capacity（t/day）	Gas Volume（Nm3/h）	Catalyst Volume（m3）	Temp.（℃）	SOx（ppm）	Intlet NOx (ppm)	Outlet NOx (ppm)	Intlet DXNs (ng-TEQ)	Outlet DXNs (ng-TEQ)	Delivery	Replacement
1	Toyama	85	21000	3.0	170	25	70	40	---	---	2014	None(1year)
2	Niigata	110	34000	1.1	171	10	70	60	0.13	0.05	2014	None(1year)
3	Tokyo	144	38000	11.3	175	10	70	50	0.1	0.025	2012	None(3years)
4	Chiba	60	23000	7.3	175	5	127	60	1	0.1	2002	None(13years)
5	Saitama	53	21000	4.7	178	5	100	20	10	1	2007	None(8years)
6	Nagano	47	16000	9.6	180	10	250	50	1	0.01	2007	After 4years(1layer)
7	Gifu	56	20000	17.3	180	20	200	50	2.5	0.05	2013	None(2years)
8	Saitama	100	28000	13.0	185	15	150	115	0.3	0.02	2002	After 8years(1layer)
9	Yamagata	98	30000	9.1	190	20	180	100	1	0.1	2001	After 11years(2layers)
10	Aichi	97	30000	13.8	190	25	125	70	1	0.05	2008	After 1year(1layer)
11	Kanagawa	400	178000	29.7	200	35	100	50	---	---	1993	After 9year(2layer) Washing in water

De-DXNs Catalyst（After Bag Filter）

No.	Place	Capacity（t/day）	Gas Volume（Nm3/h）	Catalyst Volume（m3）	Temp.（℃）	SOx（ppm）	Inlet DXNs (ng-TEQ)	Outlet DXNs (ng-TEQ)	Delivery	Replacement
12	Mie	150	81000	8.6	171	26	1	0.1	2012	None(3years)
13	Wakayama	30	12000	2.3	175	7	0.23	0.05	2010	After 4years(1layer)
14	Osaka	95	53000	21.0	188	55	1	0.1	2007	None(8years)
15	Nagano	50	33000	10.4	189	5	10	1	2007	None(8years)
16	Fukuoka	61	15000	9.5	190	10	0.5	0.05	2004	None(11years)
17	Fukushima	70	31000	3.6	190	50	0.23	0.1	2006	None(9years)
18	Hiroshima	30	11000	2.7	195	20	1	0.05	2001	None(11years)

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