Recent Progress in THC Polypropylene Catalysts

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TOHO TITANIUM

Outline

1. Introduction of Toho Titanium
2. Introduction of THC Catalyst
3. Today's Topics:
   New family of THC catalysts
   → Broadening the range of value-added PP

3.1 - for leading edge high performance ICP grade

3.2 - for super high flow Homo-PP/RCP

4. Summary

1. Introduction of Toho Titanium

JX Holdings Group

JX Holdings, Inc.

JX Nippon Oil & Energy Corp.	JX Nippon Oil & Gas Exploration Corp.	JX Nippon Mining & Metals Corp.	TOHO TITANIUM	Common Functions Companies
				Individual Operating Companies
Petroleum Refining & Marketing	Oil and Natural Gas Exploration	Metals	50.3% shares held by JX Holdings	

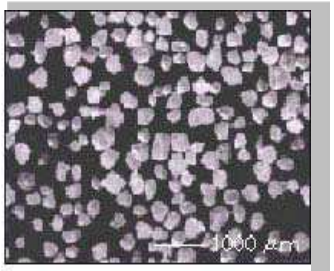
Business Domain and Major Products

Business development centered around titanium metal smelting technology

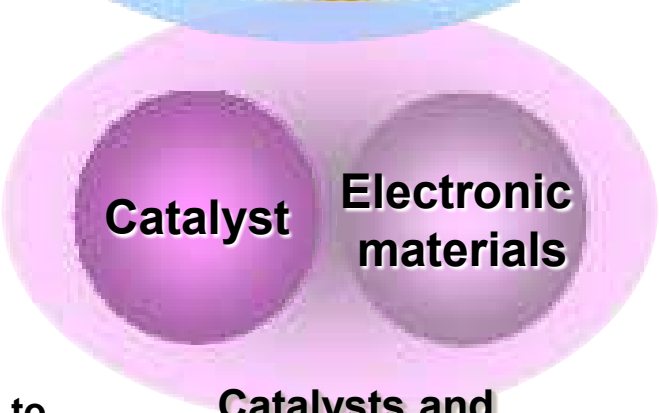
Sponge titanium

Titanium ingot

Fabricated titanium



Titanium catalysts used to produce polypropylene



Catalysts and Chemicals Business

Ultra-fine nickel powder

High-purity titanium dioxide

Product of TOHO for Polyolefin

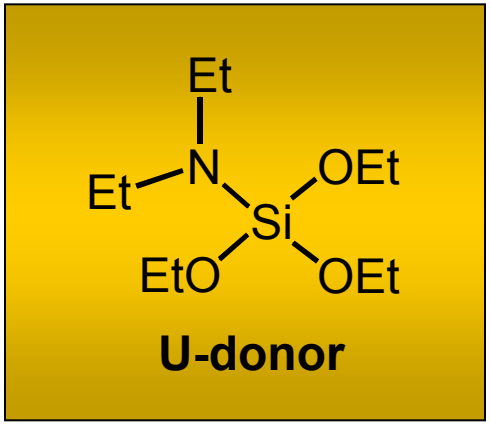
Catalyst:

- **THC catalyst series**

  (Mg-supported-type)

External donor:

- **U-donor** (for high melt flow PP grade)

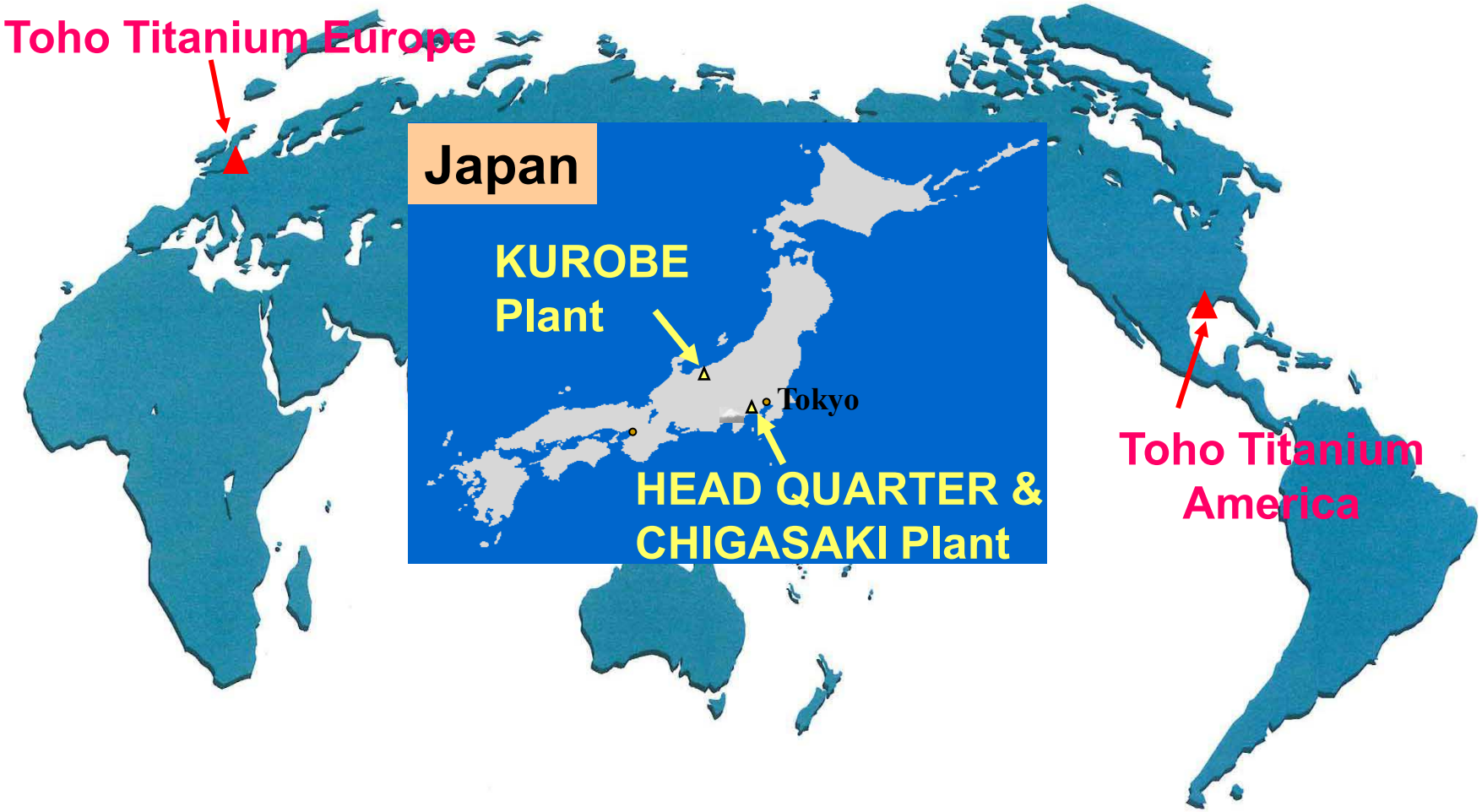


U-donor

Raw materials:

- **$TiCl_4$ (Highly Purified)**
- **$MgCl_2$ bulk & powder (Highly Purified)**
- **Pre-mixed powder of $MgCl_2/TiCl_3$**
- **Pre-mixed powder of $MgCl_2/TiCl_4$**

TOHO's Catalyst Production Sites and Worldwide Business



TOHO Catalyst History

1953: TOHO Titanium Co., Ltd. founded.
1954: Invention of Ziegler-Natta catalyst by Prof. Natta.
1957: TOHO initiated development of TiCl3-type Catalyst: TAC.
1965: TAC commercial production line started at Chigasaki.

TAC had been used globally for the following 40 years.

1986: THC commercial production line started at Chigasaki.
1999: Kurobe Plant started.
2000: TAC production ceased.
2011: TOHO acquired U-donor business from Ube Industries.

TOHO has been contributing to PP industry for more than 50 years.

2. Introduction of THC Catalyst

Benefits by using THC Catalyst

THC Catalyst Business

- Independent of process licensors

Benefits for Customers

- Any PP producer can use THC Catalyst

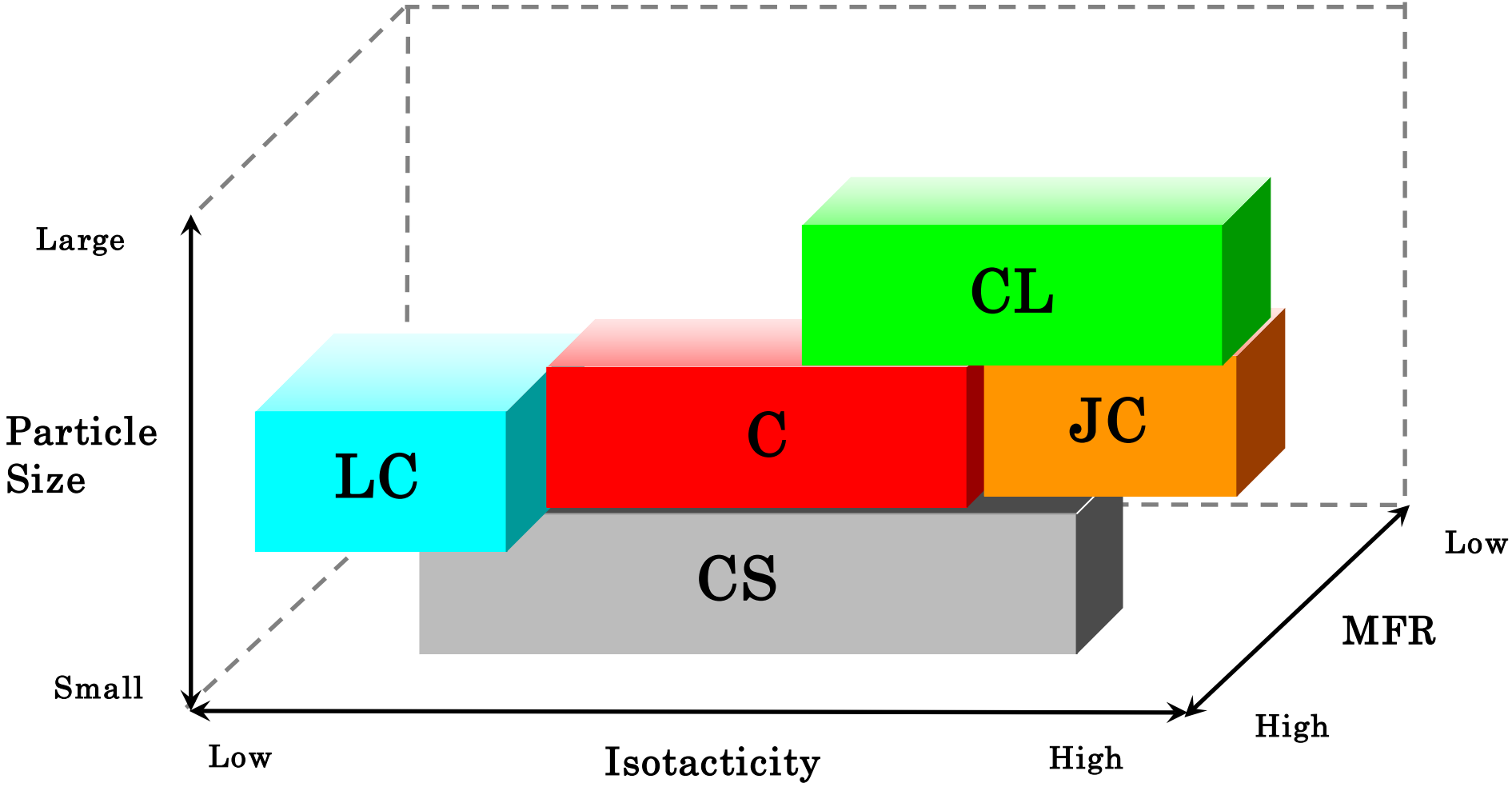
THC Catalyst Properties

- Wide range of catalyst line-up
  - isospecificity
  - particle size
- High porosity
- High activity
- Consistent quality

Benefits for Customers

- Various PP grades can be made in various PP processes
- High rubber content ICP can be made
- Clean polymer (low ash) can be made
- Stable production

THC Catalysts Line-up

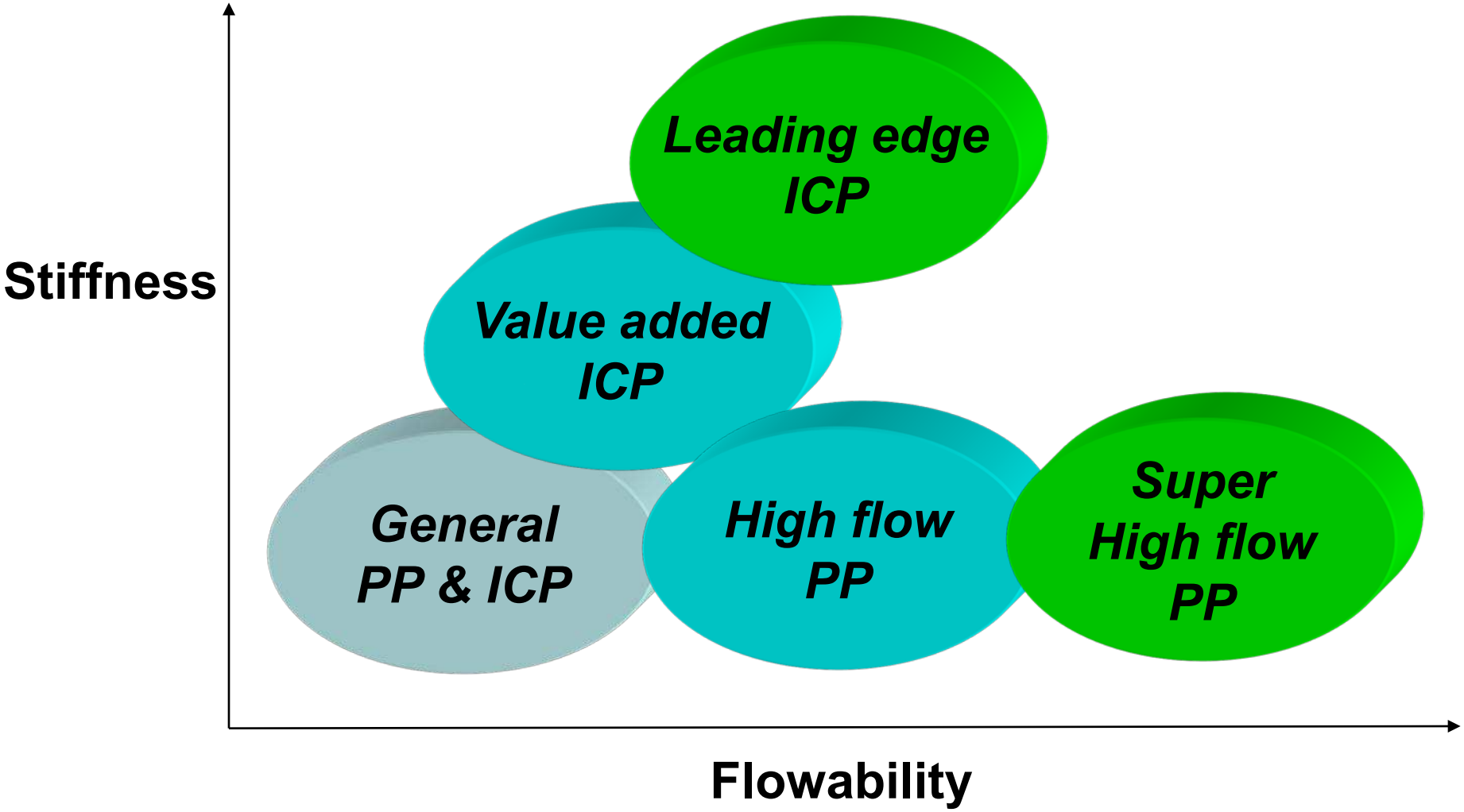


3. Today's Topics:

New family of THC catalysts
→ Broadening the range of value-added PP

3.1 - for leading edge high performance ICP grade
3.2 - for super high flow Homo-PP/RCP

Broadening the range of value-added PP



3.1 For leading edge high performance ICP

- Application: **Automotives, TWIM**
- PP properties: **high stiffness & high flow**
- Catalyst: advanced catalyst system

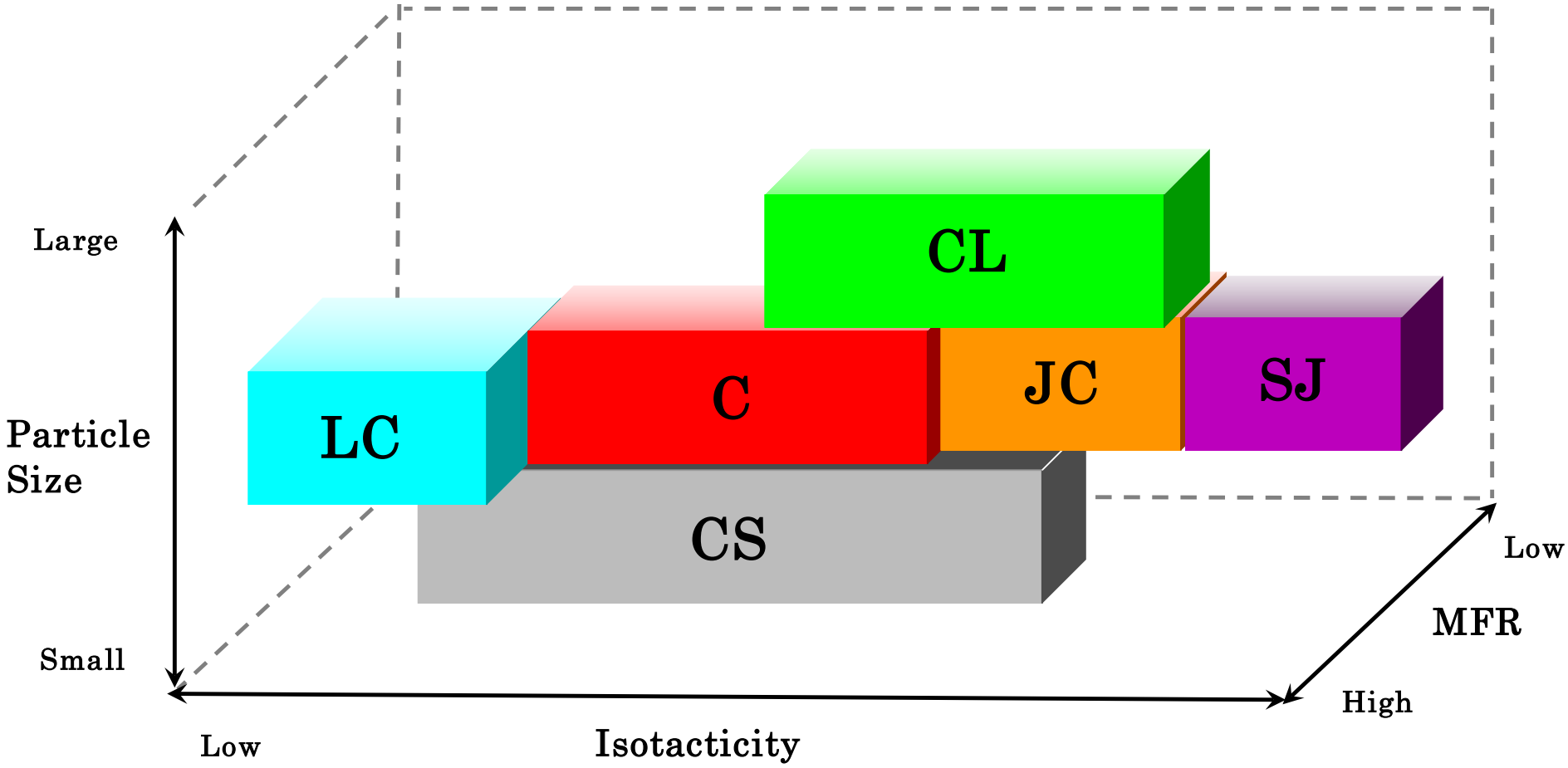
  having high iso-specificity and hydrogen response

  - **THC-SJ catalyst**

  (new THC family with non-SVHC phthalate internal donor)

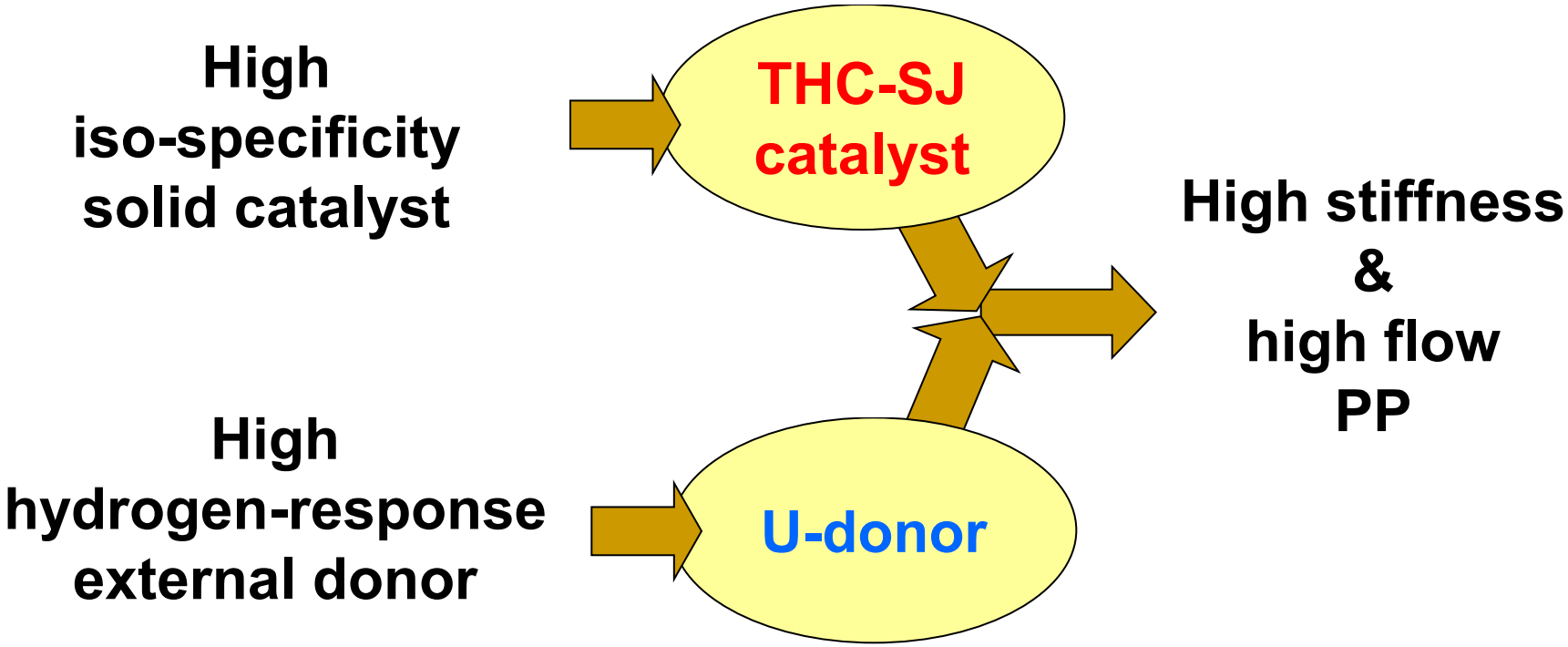
  - **U-donor**

THC Catalysts New Line-up "SJ"



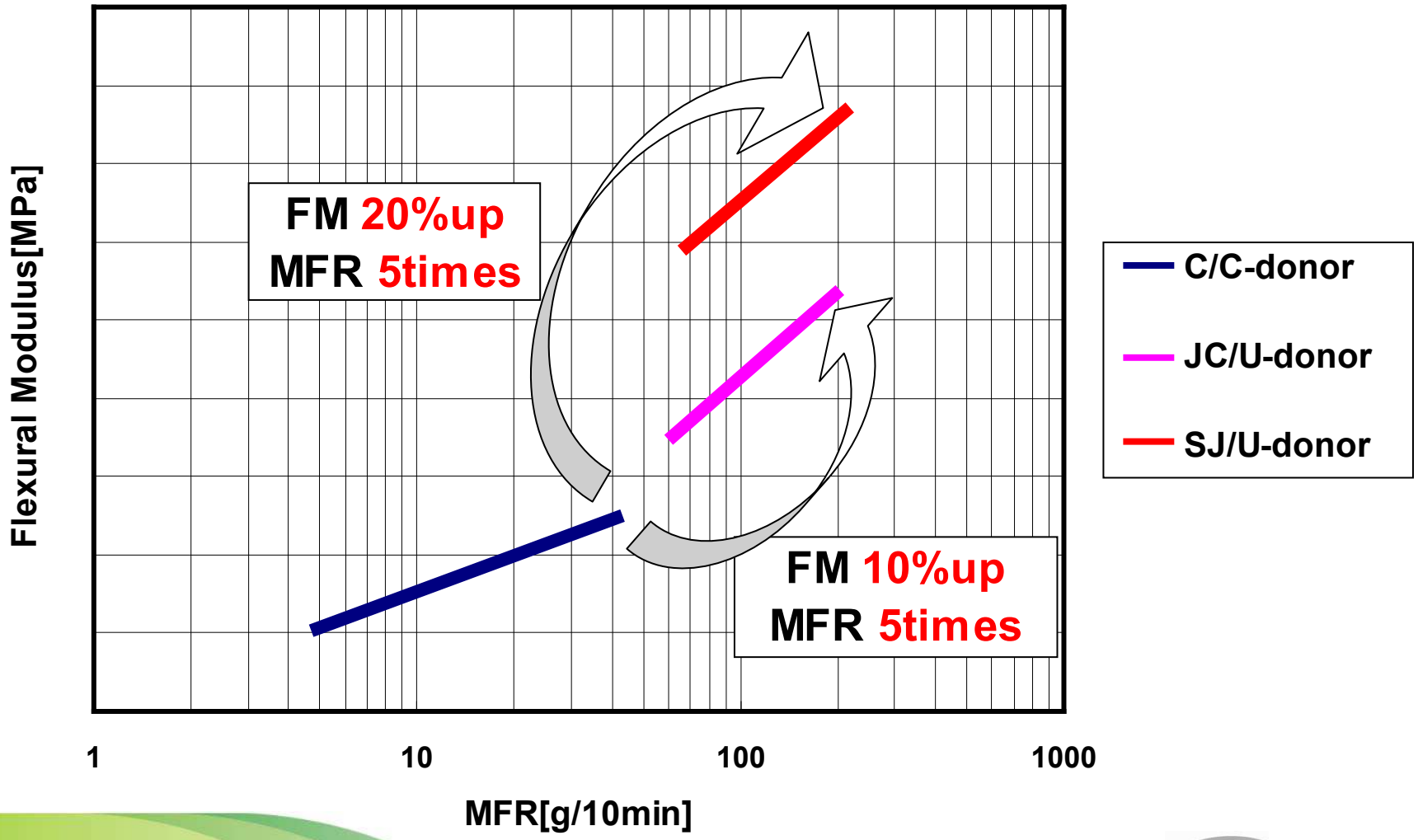
Catalyst system for leading edge high performance ICP

Combination of high iso-specificity solid catalyst and high hydrogen-response external donor



THC-SJ Catalyst
for leading edge high performance ICP

Toho's Homo polymerization results



3. Today's Topics:

New family of THC catalysts
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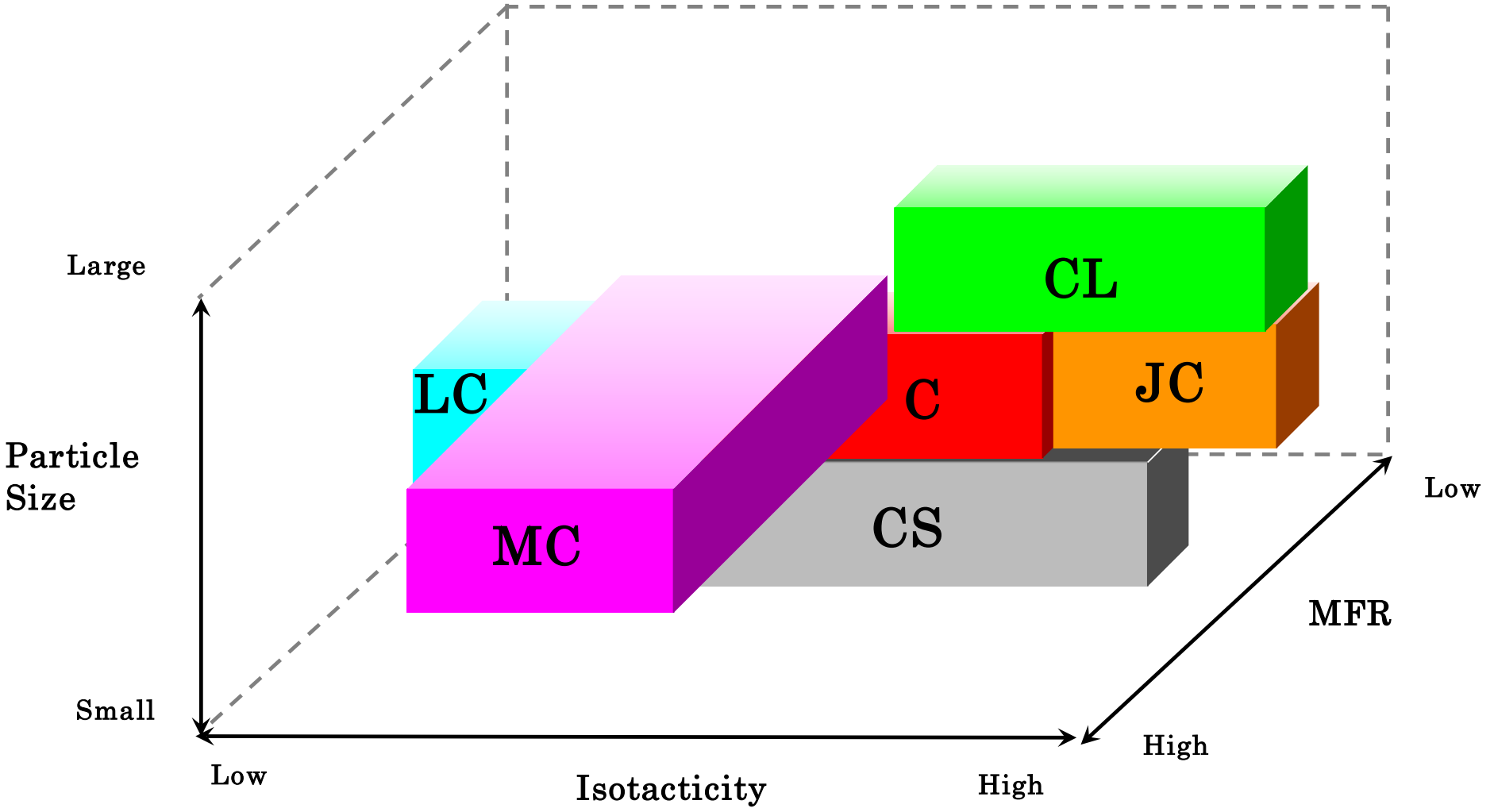
3.2 For super high flow Homo-PP/RCP

- Application: **non-woven, spunbond**
- PP properties: **Super high flow (MFR=1000~2000)**
- Catalyst: innovative catalyst system having high hydrogen-response
  - **THC-MC catalyst**
  (new THC family with non-phthalate internal donor)
  - **U-donor**

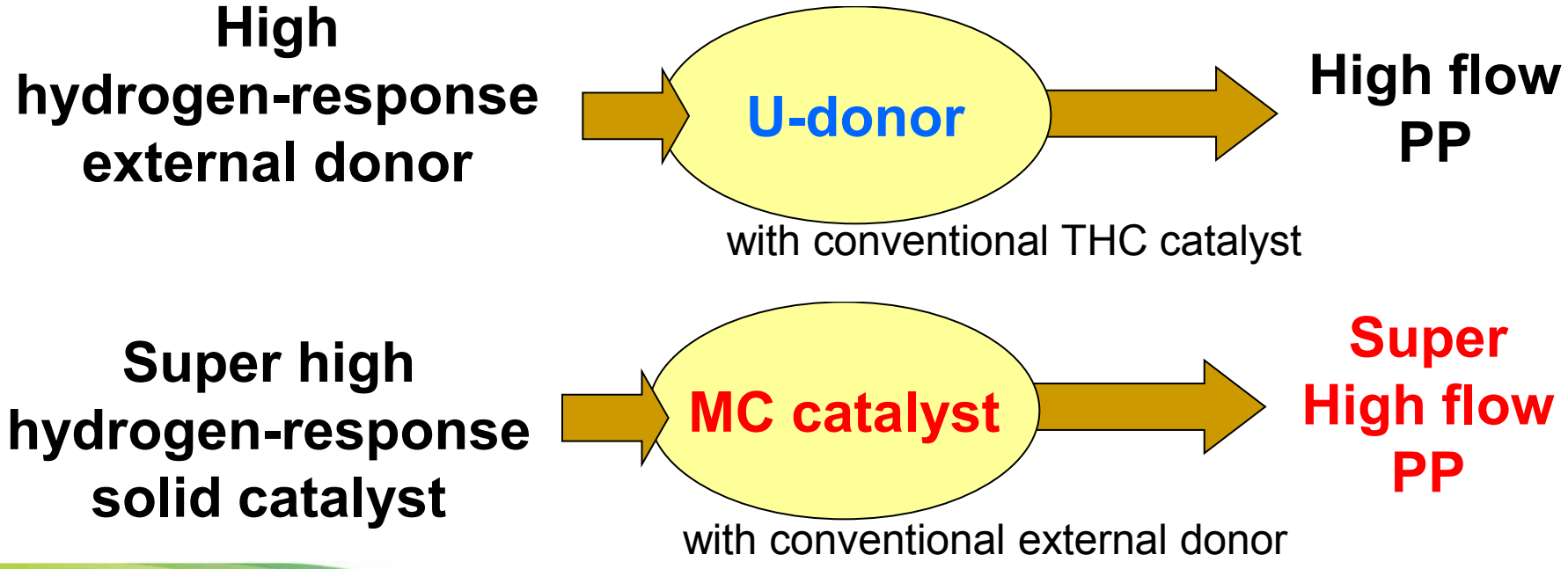
THC Catalysts New Line-up "MC"



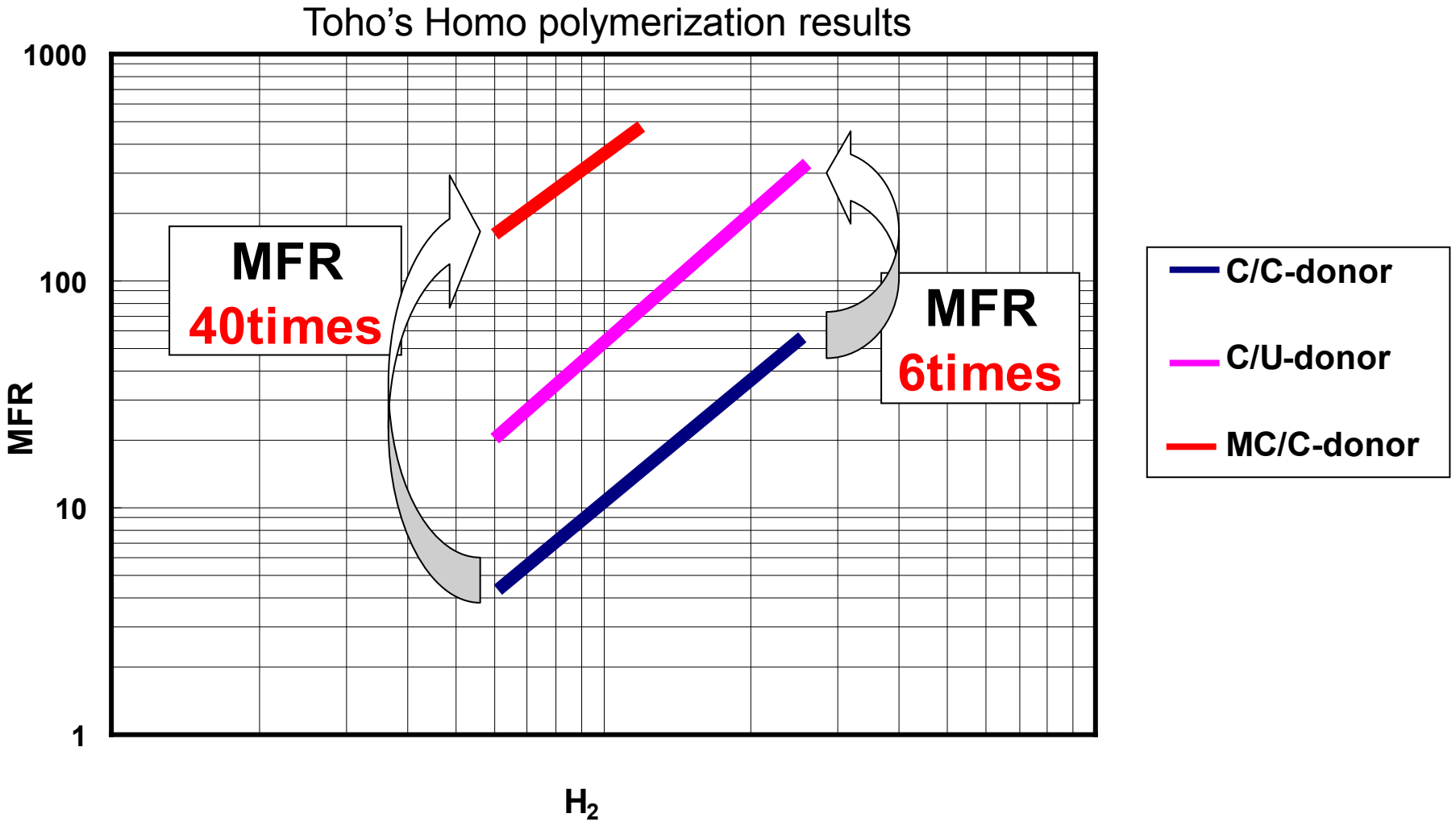
Catalyst system for super high flow PP

Combination of conventional solid catalyst and high hydrogen-response external donor

Combination of high hydrogen-response solid catalyst and conventional external donor



THC-MC catalyst
for super high flow Homo-PP/RCP



4. Summary

(1) TOHO has been supplying Ziegler-Natta PP Catalysts for half a century.

(2) TOHO's THC catalyst are globally used for production of all PP grades in various PP processes.

(3) TOHO's THC-SJ catalyst produces extremely high crystallinity and high modulus PP.
Combination of THC-SJ catalyst and U-donor is good for high modulus and high flow ICP.

(4) TOHO's THC-MC catalyst produces super high flowability PP.