
GLOBAL EXCELLENCE
HYOSUNG
HYOSUNG
2013~2014


GLOBAL EXCELLENCE
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Hyosung has been setting the direction and building
solid foundations for various industries through countless challenges and
innovative technological breakthroughs
throughout its 50-year history.

History

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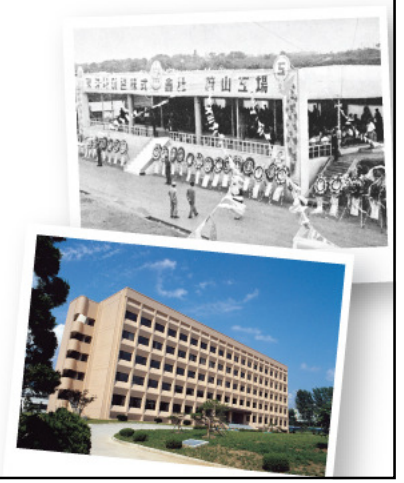
2013	Completed the carbon fiber plant in Korea, Started Commercialization of Polyketone
2010	Completed steel cord plant in Vietnam
2009	Completed the aramid fiber plant
1990	Started Spandex business
1989	Started PP and propylene business
1980	Established HYOSUNG BASF(50/50% JV)
1975	Acquired Hanyoung Industry (predecessor of Hyosung Heavy Industry)
1973	Dongyang Polyester and Dongyang Textile established
1971	R&D Center established
1966	Dongyang Nylon established
1957	Hyosung Industry established



GLOBAL EXCELLENCE
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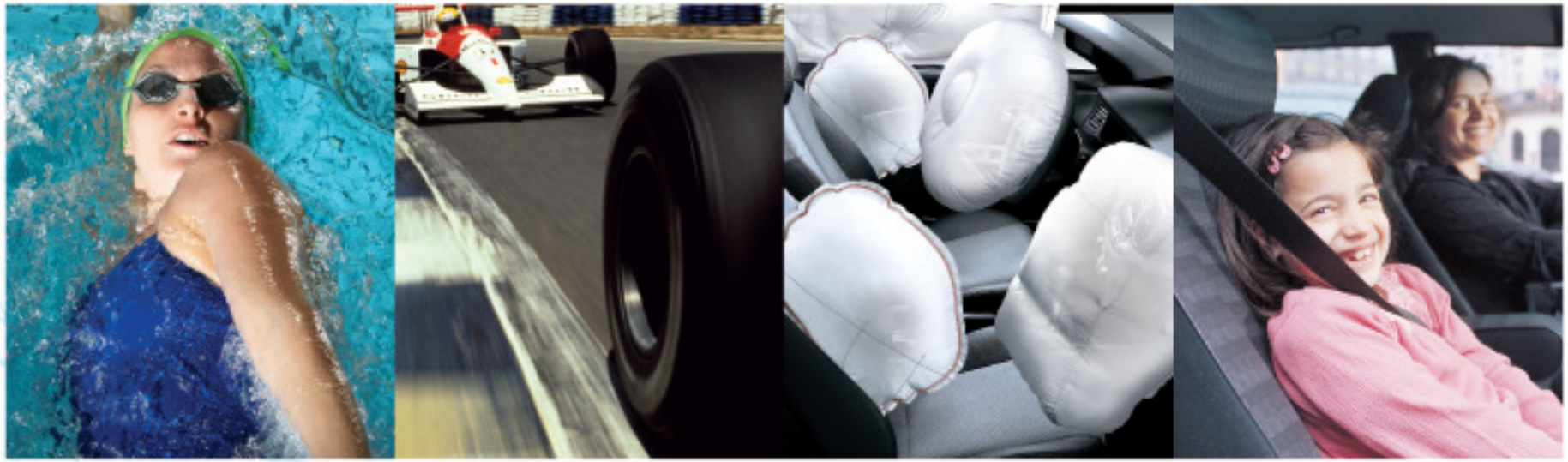
Leading & Responsibility

Hyosung has become a global leader in innovating textile, industrial materials, chemistry, heavy industry, construction and information communication.

GLOBAL NO.1

- Spandex
- Tirecode
- Airbag Fabrics
- Polyester Yarn For Seatbelts



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Leading & Responsibility

Hyosung is the living history and champion of Korea's economic development which has been overcoming difficulties and obstacles with indomitable spirit at frontlines.

KOREA NO.1

Transformer | Circuit Breaker | Motor | ATM | Pump | PET Bottles

Nylon Fiber | Polyester Fiber | Carpet | Food Packaging Film








Performances

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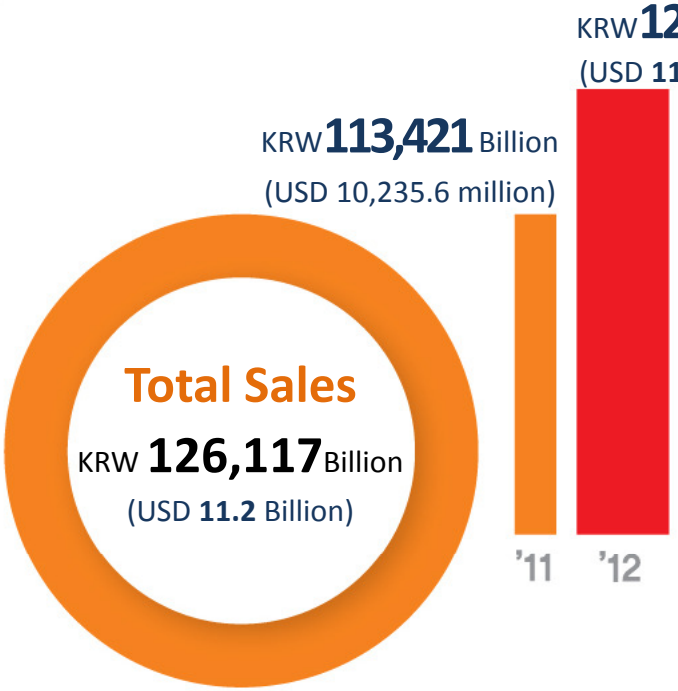

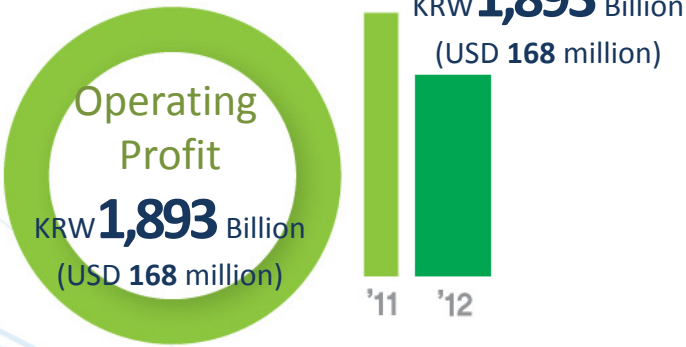

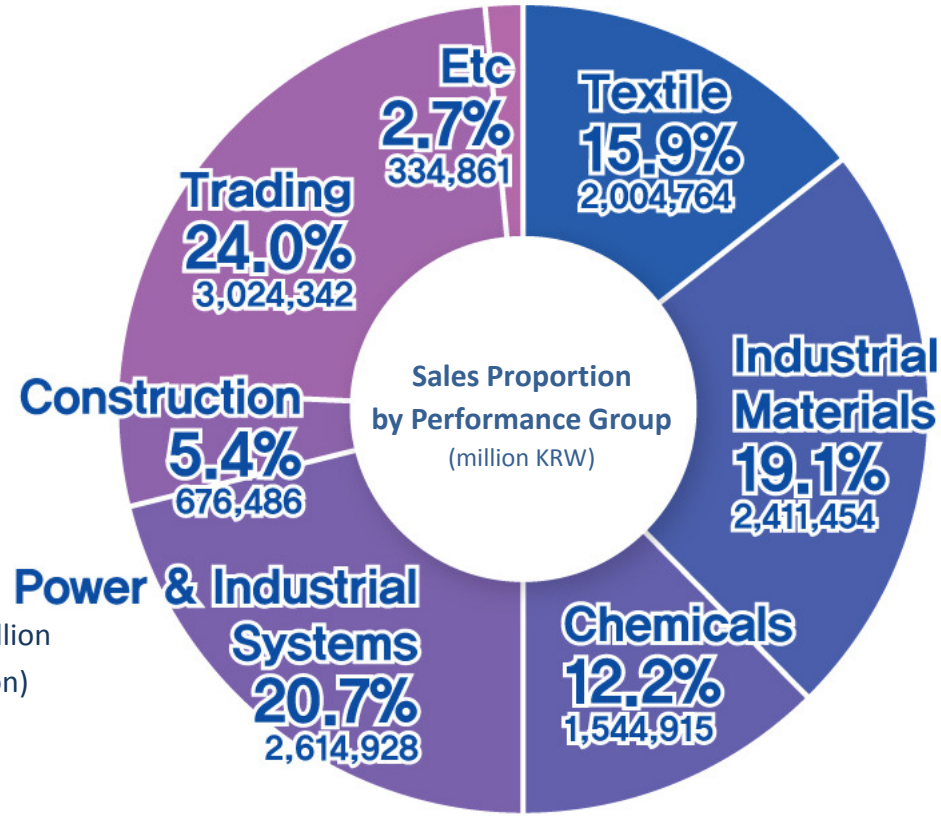

Business Areas

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With Customers, With the World

Hyosung is your trusted partner

Textile	Spandex PU Nylon Polyester Fiber PU Fabric · Dyeing PU
Industrial Materials	Tire & Industrial Reinforcements PU Technical Yarn PU Global Safety Textiles Interior PU Aramid Business Division Carbon Business Division
Chemicals	PP/DH PU Film PU Packaging PU TPA PU Neochem PU Optical Film PU
Power & Industrial Systems	Power Systems PU Industrial Machinery PU HYOSUNG GOODSPRINGS PU Wind Energy Business Division
Construction	Construction PU Hyosung EBARA Engineering PU Chinhung International, Inc.
Trading	Steel & Metal Products PU Ⅰ, Ⅱ Chemical Products PU LED Business Division Hyosung Trans-World PU
Information & Communication	Nautilus Hyosung PU Hyosung Information Systems PU Hyosung ITX Co., Ltd. Galaxia Electronics Co., Ltd. Galaxia Communications Co., Ltd. Galaxia Device Co., Ltd.
Financing & Other Affiliated Companies	Hyosung Capital PU The Class Hyosung Co., Ltd. Hyosung Toyota Corporation The Premium Hyosung Co., Ltd

Domestic Business Premises

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15 Plants

20 Offices and Sales

5 R&DB Labs

Seoul : Mapo(HQ), Cheongdam/Bangbae/Suseo/Banpo Office,
Environment R&D Center, Electronic R&D Center

Gwangju Frozen Storage

Anyang Plant
R&DB Labs
Power & Industrial Systems R&D Center

Jincheon Plant
Gwanghyewon Plant

Oksan Plant

Sejong Plant

Daejeon Plant

Gumi Plant

Jeonju Plant

Daegu Plant

Eonyang Plant
Steel Wire Technical Center

Ulsan Plant

Yongyeon Plant

Yangsan Plant

Changwon Plant

Mapo (HQ) Office


Anyang Plant


Gumi Plant


Jeonju Plant


Ulsan Plant


Yongyeon Plant


Eonyang Plant


Changwon Plant

Overseas Business Premises

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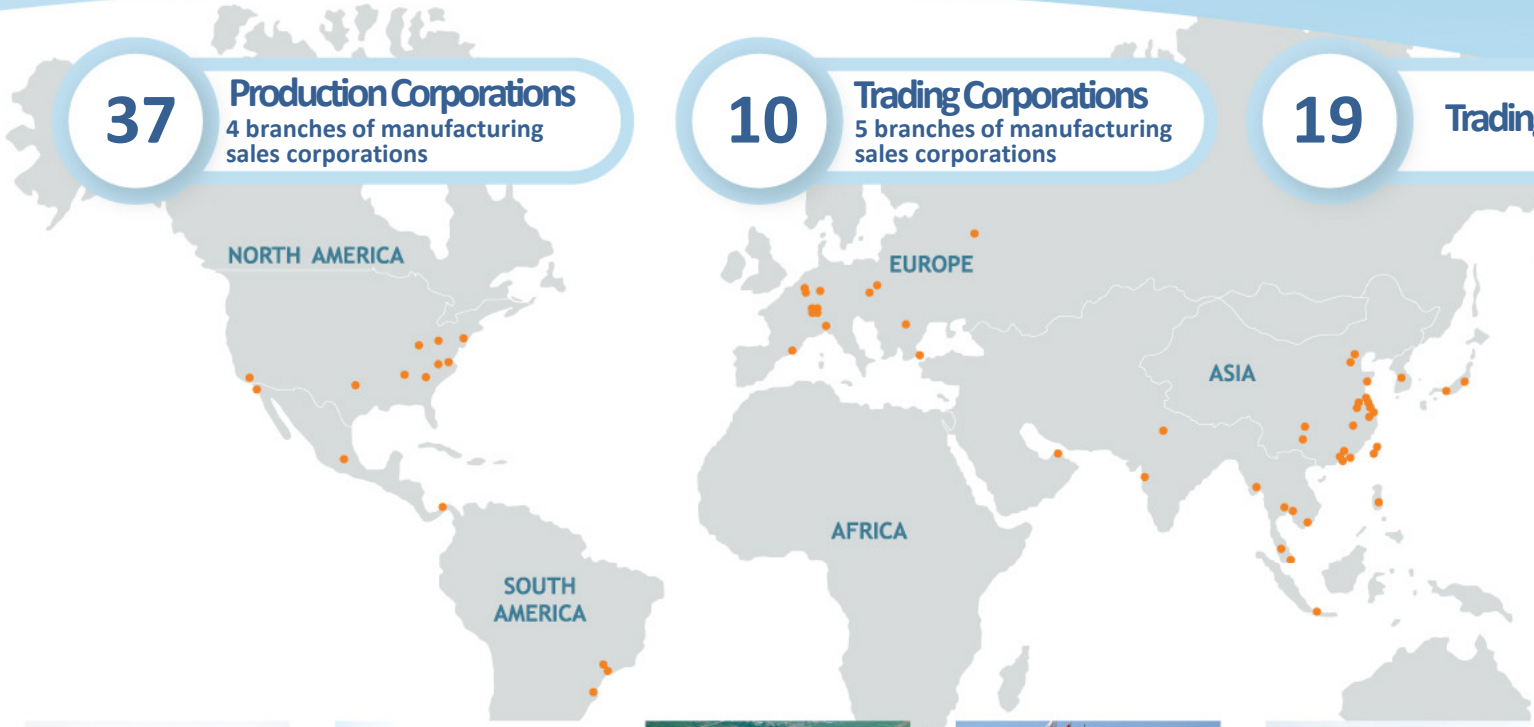
37 Production Corporations
4 branches of manufacturing sales corporations

10 Trading Corporations
5 branches of manufacturing sales corporations

19 Trading Offices



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Introduction to POLYKETONE

Hyosung R&DB Labs.

【 Contents 】

Ⅰ. Introduction

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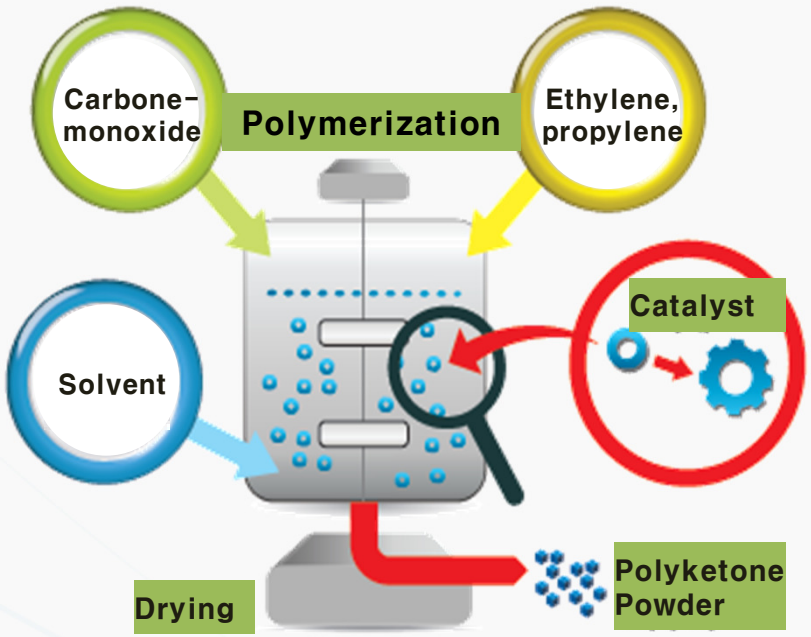
Polyketone

- New Green polymeric material composed of carbon-monoxide and olefin (ethylene, propylene).
- Composition
  - ENPLA Ter-Polymer (carbon-monoxide + ethylene + propylene)
  - Super Fiber Co-Polymer (carbon-monoxide + ethylene)



$$n\,CO + (n\text{-}m)CH_2 = CH_2 + m\,CH_2 = CH(CH_3)$$

Carbone-monoxide | Ethylene | Propylene

$$-(CH_2CH_2C(=O))_{n-m}-(CH_2CH(CH_3)C(=O))_m-$$

Polyketone

Ⅰ. Introduction

Ⅱ. Characteristics

Ⅲ. Applications

Ⅳ. Present & Future

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1

Characteristics – "New Green Polymeric Material"

- **New green polymeric material made of CO, one of major air-pollution source.**

* Major 6 Air Pollution Source : CO, NOx, SOx, NH3, VOC, PM

Polyketone 50,000MT

CO Consumption 25,000MT.

Total Emission of Air pollution source in Korea : 3.68 mil. MT

- **NOx 28.8%** *Nitrogen Oxide*
- **VOC 23.5%** *Volatile Organic Compounds*
- **CO 20.9%** *Carbon Monoxide*
- **SOx 10.9%** *Sulfur Oxide*
- **NH_3 7.9%** *Ammonia Emission*
- **TSP 4.8%** *Total Suspended Particulate*
- **PM_{10} 3.2%** *Particle Matter in Diameter 10㎛*

Same as 3.80 mil. Pine Tree

(30yr. Pine tree purify 6.6 Kg/yr CO_2)

Source : National Institute of Environmental Research (Korea)

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2

Characteristic– "High Impact Strength"

- More than 230% higher impact strength compared to Nylon, PBT.
- No deterioration due to good hydrolysis resistance.

Items		Unit	POK	PA6	PA66	PBT	POM
Density		g/cm³	1.24	1.14	1.14	1.30	1.41
Melting Temperature		℃	220	220	260	220	160
Impact Strength		KJ/m²	12	5.2	4.1	5.0	6.5
Tensile Strength	Dry Conditioned Wet	MPa	70 70 60	80 55 35	80 70 50	55 - -	65 - -
Elongation at Break	Dry Conditioned Wet	%	270 270 390	17 40 360	19 60 370	16 - -	35 - -
Flexural Modulus	Dry Conditioned Wet	MPa	1,800 1,800 1,450	2,600 1,200 600	2,900 2,200 1,100	2,400 - -	2,500 - -

* Dry: 23℃, 50% RH, 24hrs Conditioned: 23℃, 50% RH, 60days Wet: 23℃, 90% RH, 60days
** POK : Hyosung M330A properties.

Ⅱ. Characteristics

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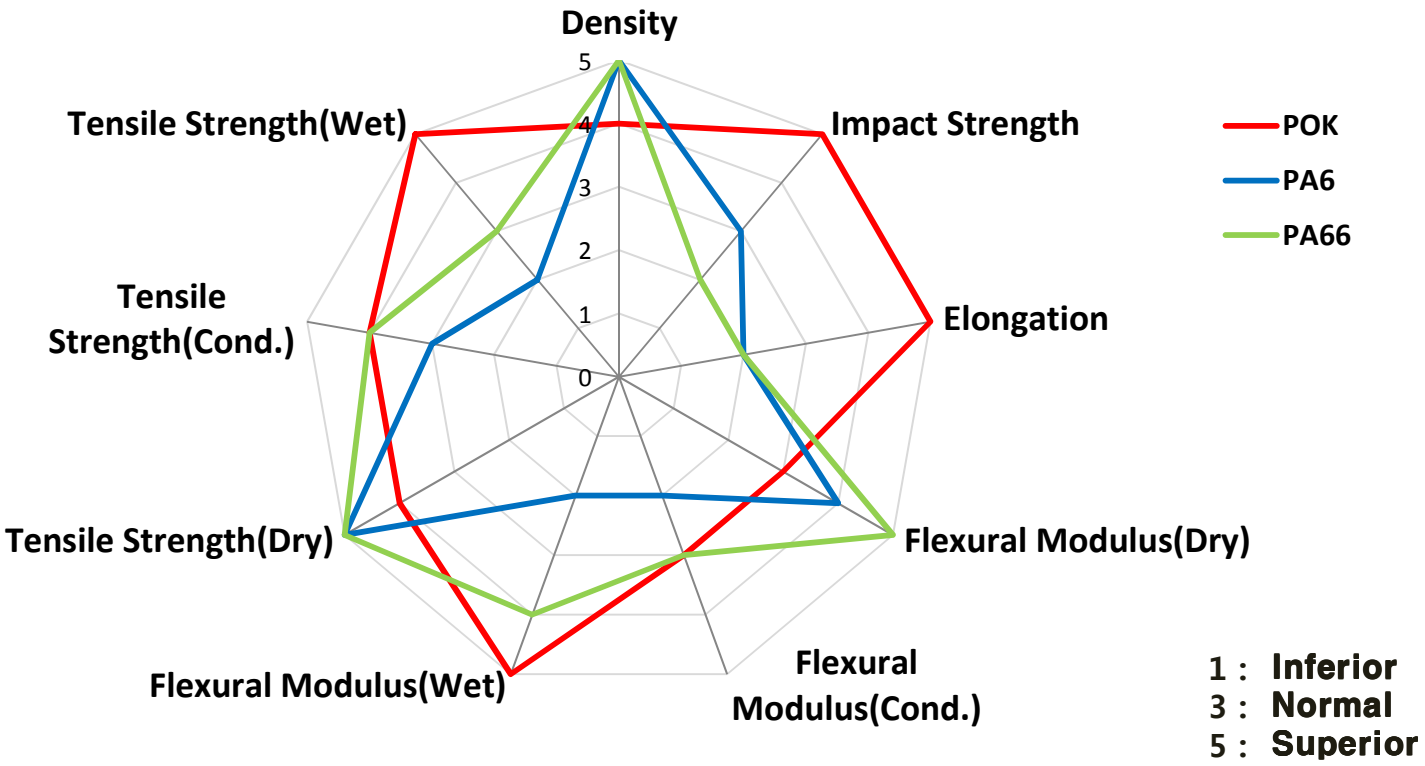
- **Generally PA6, P66 has high tensile property but impact strength and elongation is low. Polyketone have good impact strength and elongation with enough tensile property.**



* Dry: 23℃, 50% RH, 24hrs Conditioned: 23℃, 50% RH, 60days Wet: 23℃, 90% RH, 60days
** POK : Hyosung M330A properties.

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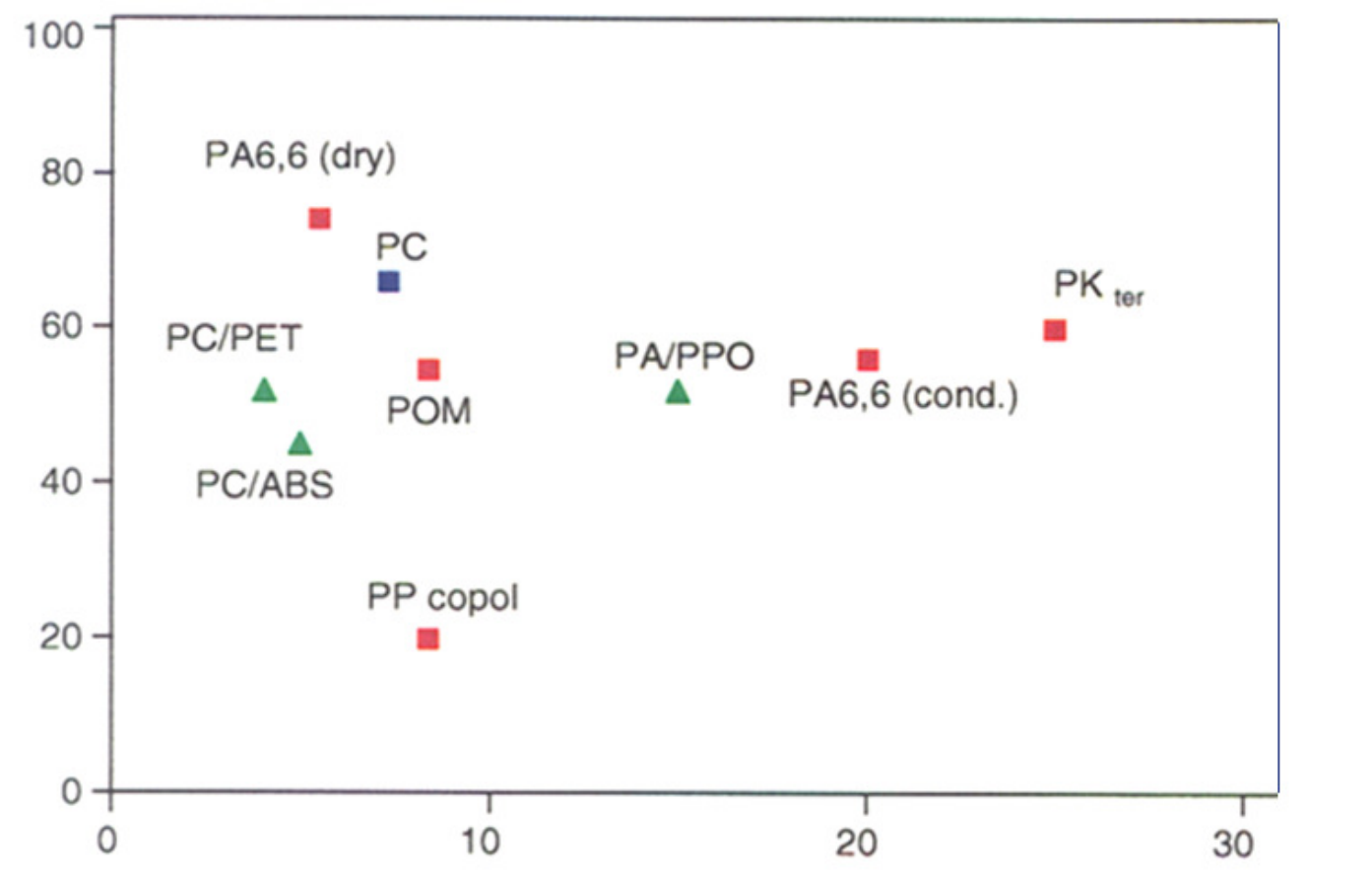
Tensile Properties

Semi Crystalline
Amorphous
Alloy

Tensile Strength at Yield (MPa)



Elongation at Yield (%)

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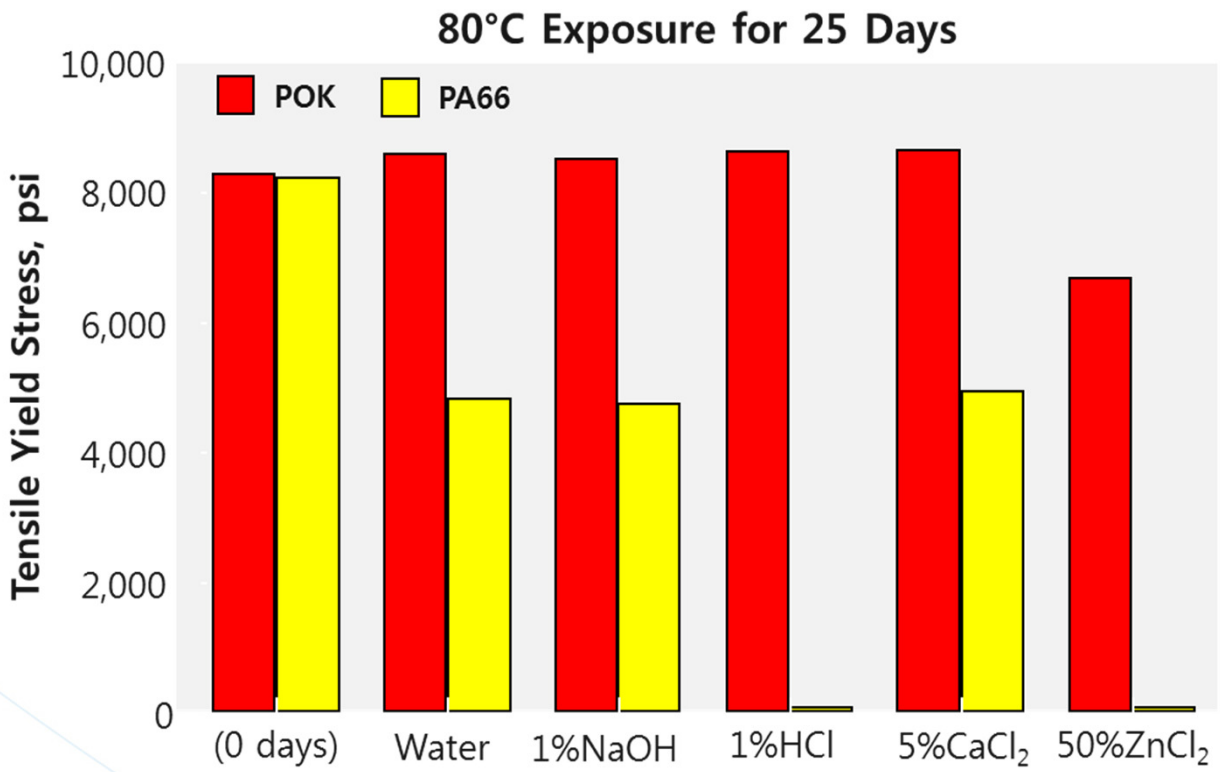
3

Characteristic – "Excellent Chemical Resistance"

- **PK's chemical resistance is the top level among the plastics.**
- **No drops in properties due to the resistance to acidic/basic solutions.**



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Chemical Resistance

	Semi-crystalline							Amorphous		
	PK	PA66	PA12	POM	PBT	PPS	PVDF	PPO	PSU	PC
Hydrocarbons										
aliphatic	+	+	+	+	+	+	+	●	●	●
aromatic	+	+	+	+	+	+	+	●	●	●
halogenated	+	+	●	+	●	+	+	●	●	●
Ketones	+	+	+	+	+	+	●	●	●	●
Esters/ethers	+	+	+	+	+	+	+	●	●	●
Aldehydes	+	●	●	+	+	+	+	●	●	●
Aqueous										
water	+	●	+	+	●	+	+	+	+	+
weak acids	+	●	●	●	●	+	+	+	+	+
weak bases	+	●	●	+	●	+	●	+	●	+
strong acids	●	●	●	●	●	●	+	+	●	+
strong bases	●	●	●	+	●	●	●	●	●	●

+ Resistant ● Not Resistant

Note: Relative ranking including temperature effects

Ⅱ. Characteristics

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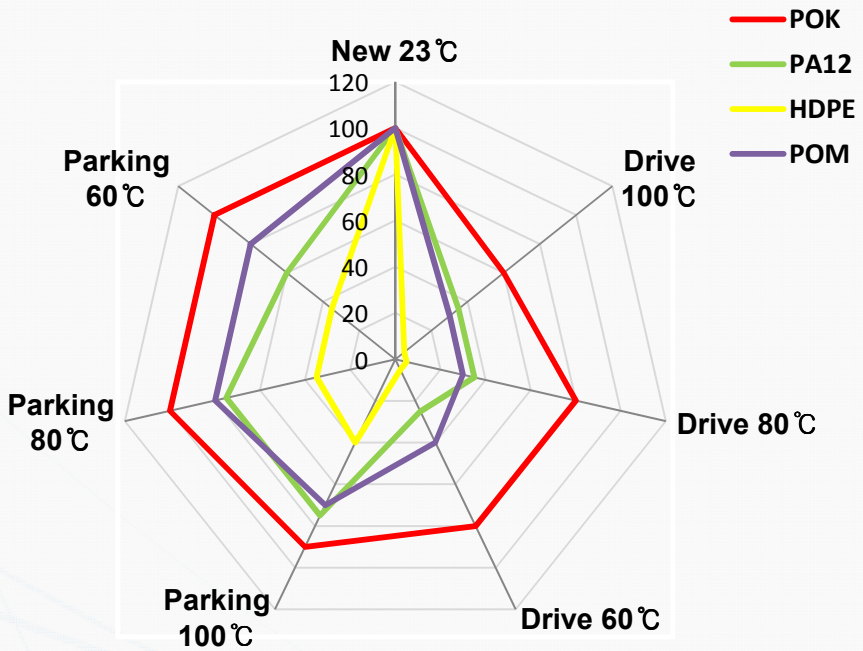
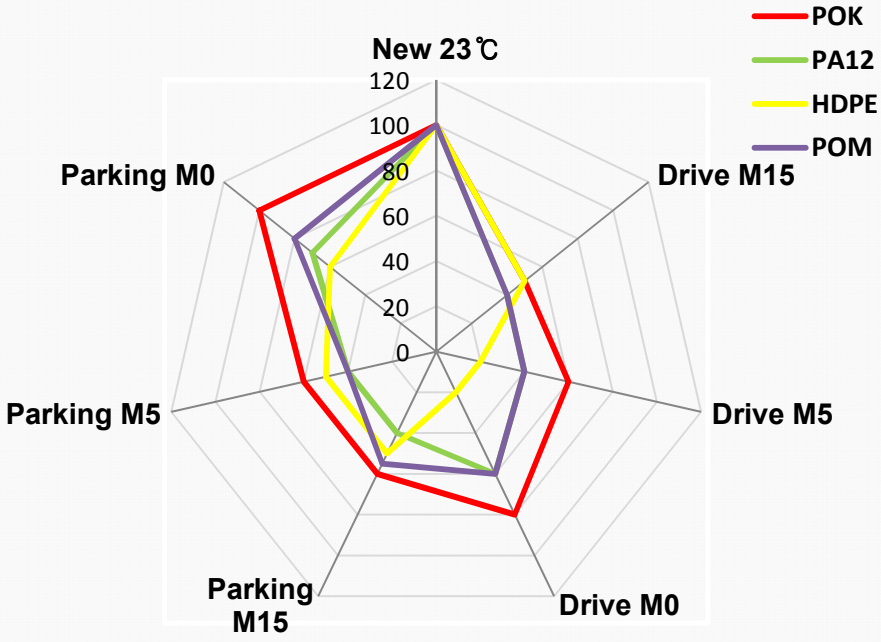
- ***Excellent fuel resistance, small change after 3,000 hrs test .***
- ***2 times superior to the PA12, current material for automotive tube.***

Property (Flexural Modulus) after treated 3,000 hrs in Diesel



Property (Flexural Modulus) after treated 3,000 hrs in Gasoline (60℃)

M0 : gasoline
M5 : gasoline 95%+ methanol 5%
M15 : gasoline 85%+ methanol 15%



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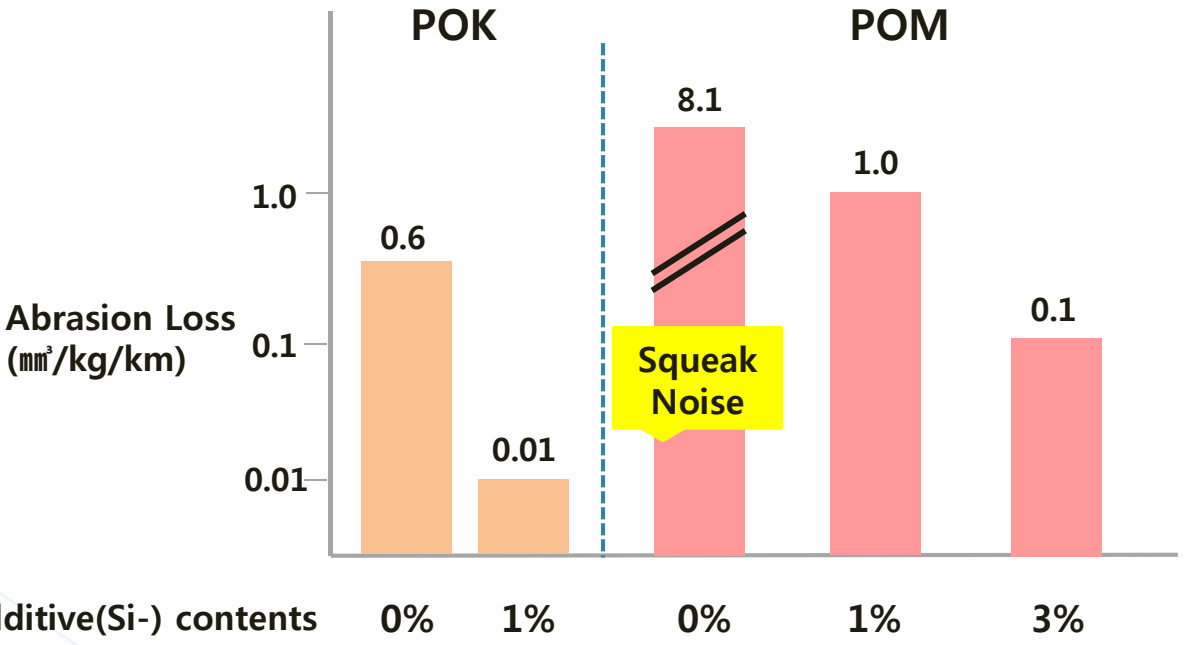
4

Characteristic– "Excellent Tribological Property"

- **Polyketone has 14 times higher anti-abrasion property than that of POM, currently most stiff material. It helps almost permanent use without change.**

*** POK base resin > POM base resin → 14 times higher.**
*** POK base resin > POM with 1% additive → 1.7 times higher.**
*** POK with 1% additive > POM with 3% additive → 10 times higher.**



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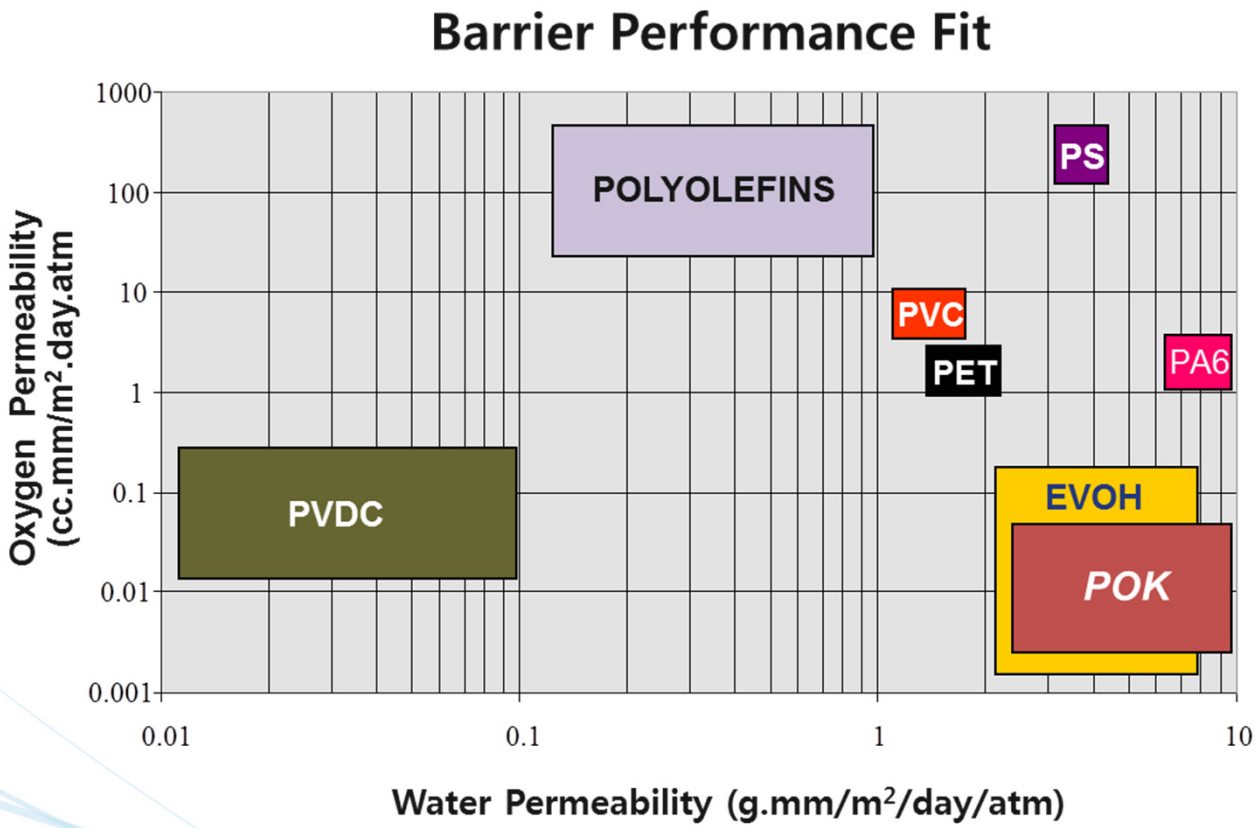
5

Characteristic– "High Barrier Property" : Gas Barrier

- **Same level of EVOH, top class of food packaging material due to the gas barrier property.**
  (EVOH : multi-layer, Polyketone : mono-layer)



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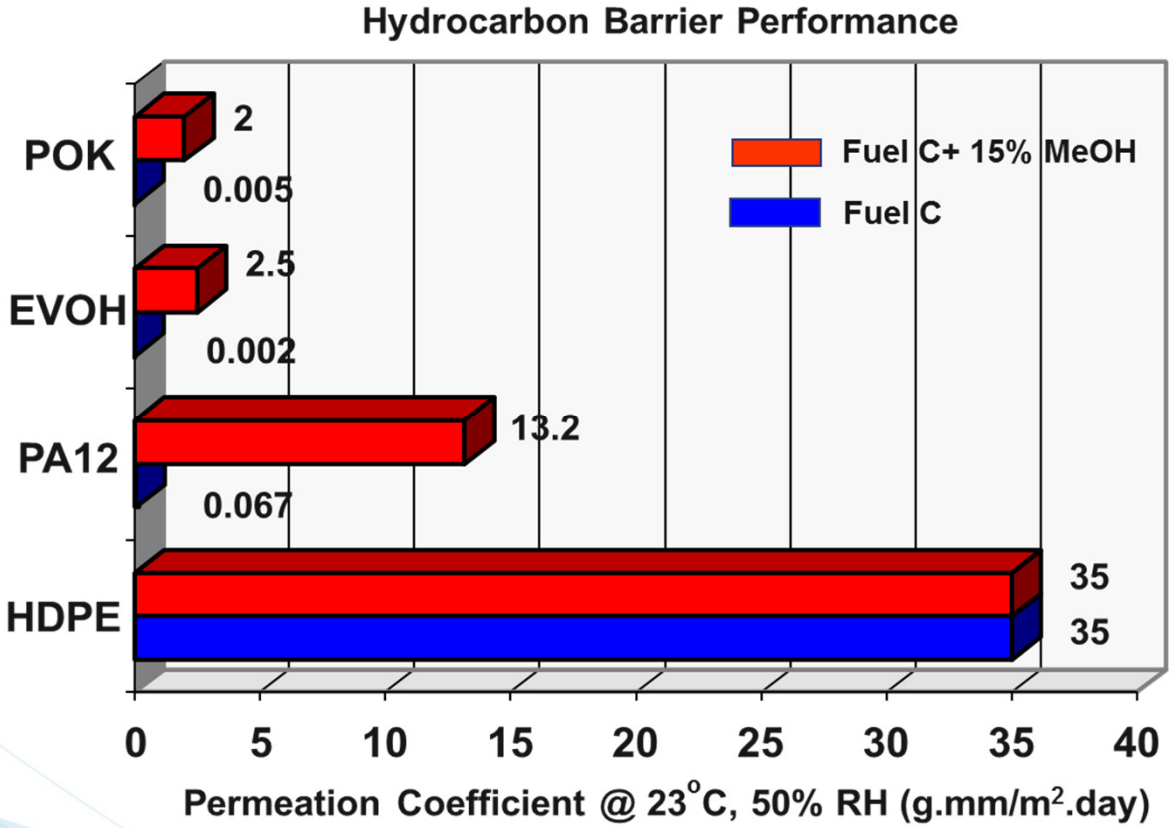
Characteristic – "High Barrier Property" : Hydrocarbon

- **Polyketone has excellent barrier property to the hydrocarbon, with good chemical resistance.**



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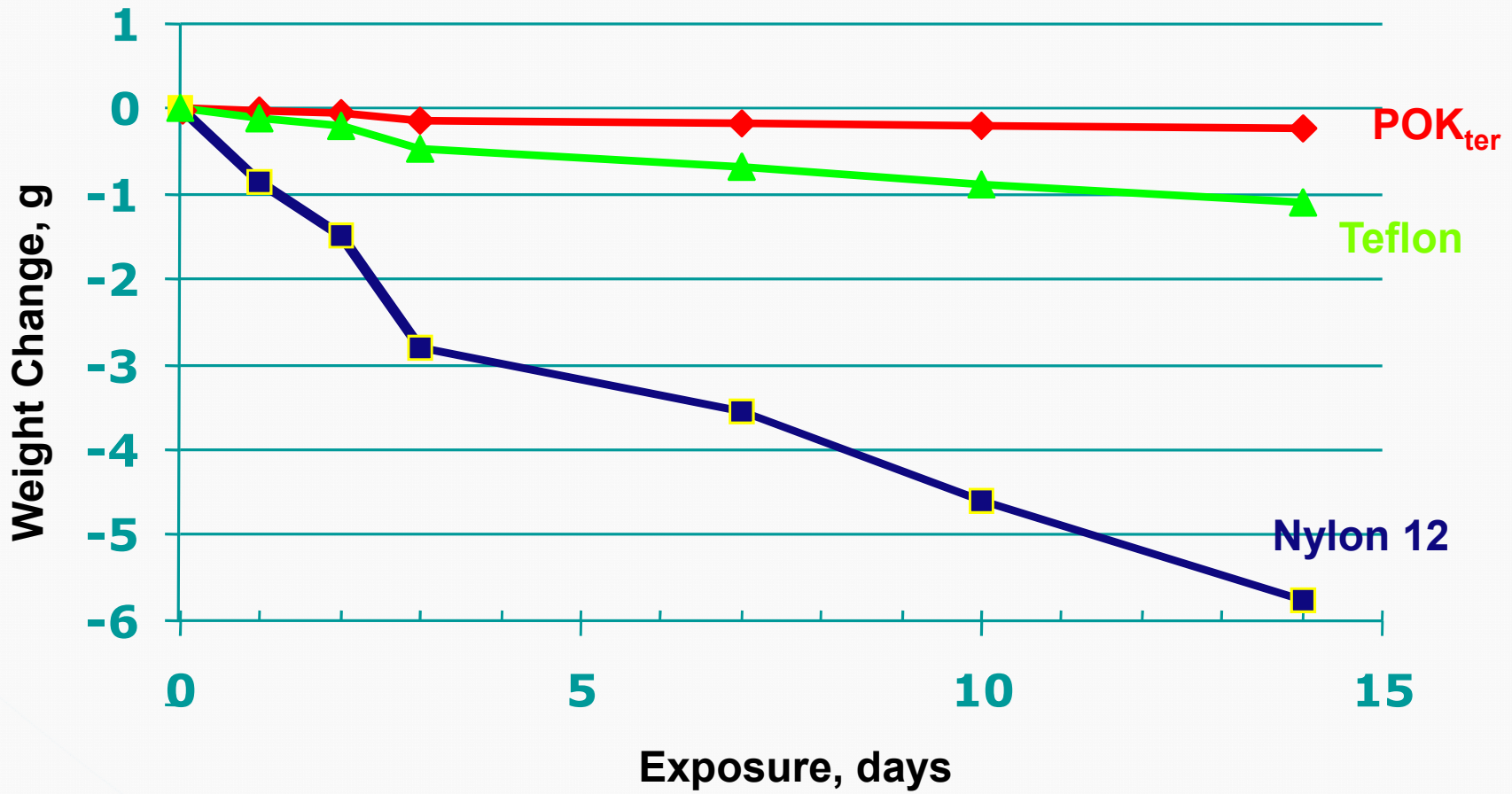
Permeability to unleaded Gasoline at 93℃



* Measured according to GM SPEC 9061-P

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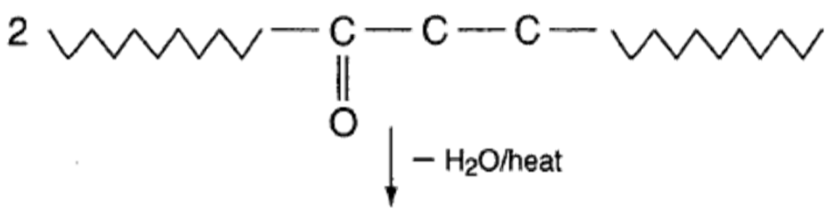
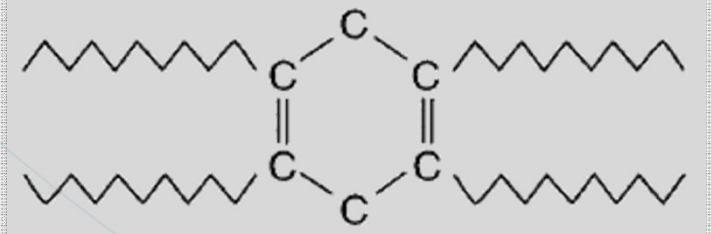
6

Characteristic – "Excellent Flame Retardant"

- **Polyketone makes water, reacted ketone(C=O) group with hydrogen during burning and Char layer covered surface not to contact to oxygen and heat.**
  ⇒ 50% dose of flame retardant additive compared to Nylon (UL-V0 rate).



Char 형성 : *"Carbon Rich Aromatic Polymer"*



*** Phosphorous flame retardant (Metal Phosphinate) test result for UL-V0 rate**

	PK	NY66
Contents(%)	8	17

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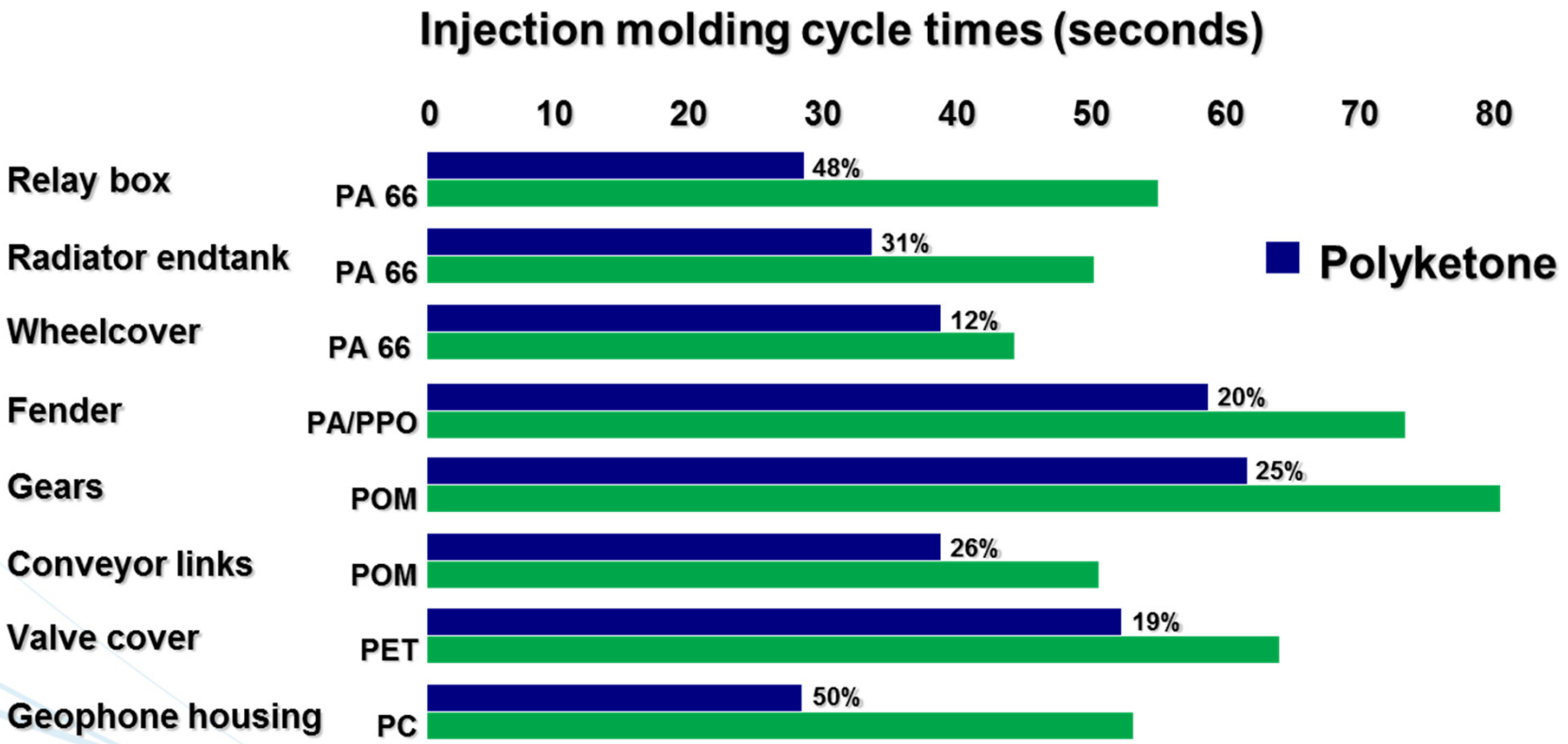
7

Characteristic– "High Productivity"

- High crystallinity of Polyketone helps to shorten cycle time.
  → Improve productivity



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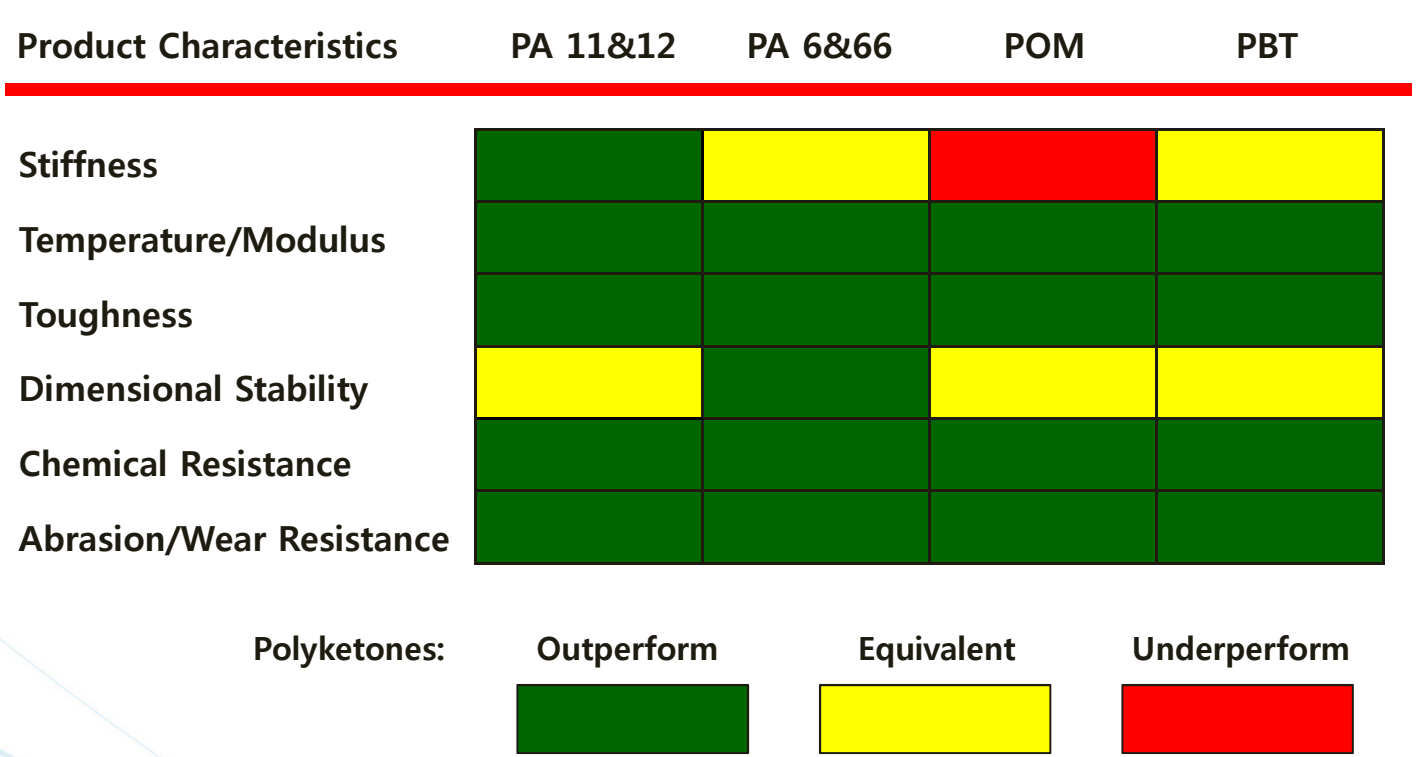
Summary

- Polyketone is new green polymeric material, made of carbon-monoxide. It has excellent *"Impact strength", "Chemical Resistance", "Anti-abrasion", "Gas barrier", "Flame retardant"*, superior to current engineering plastic.



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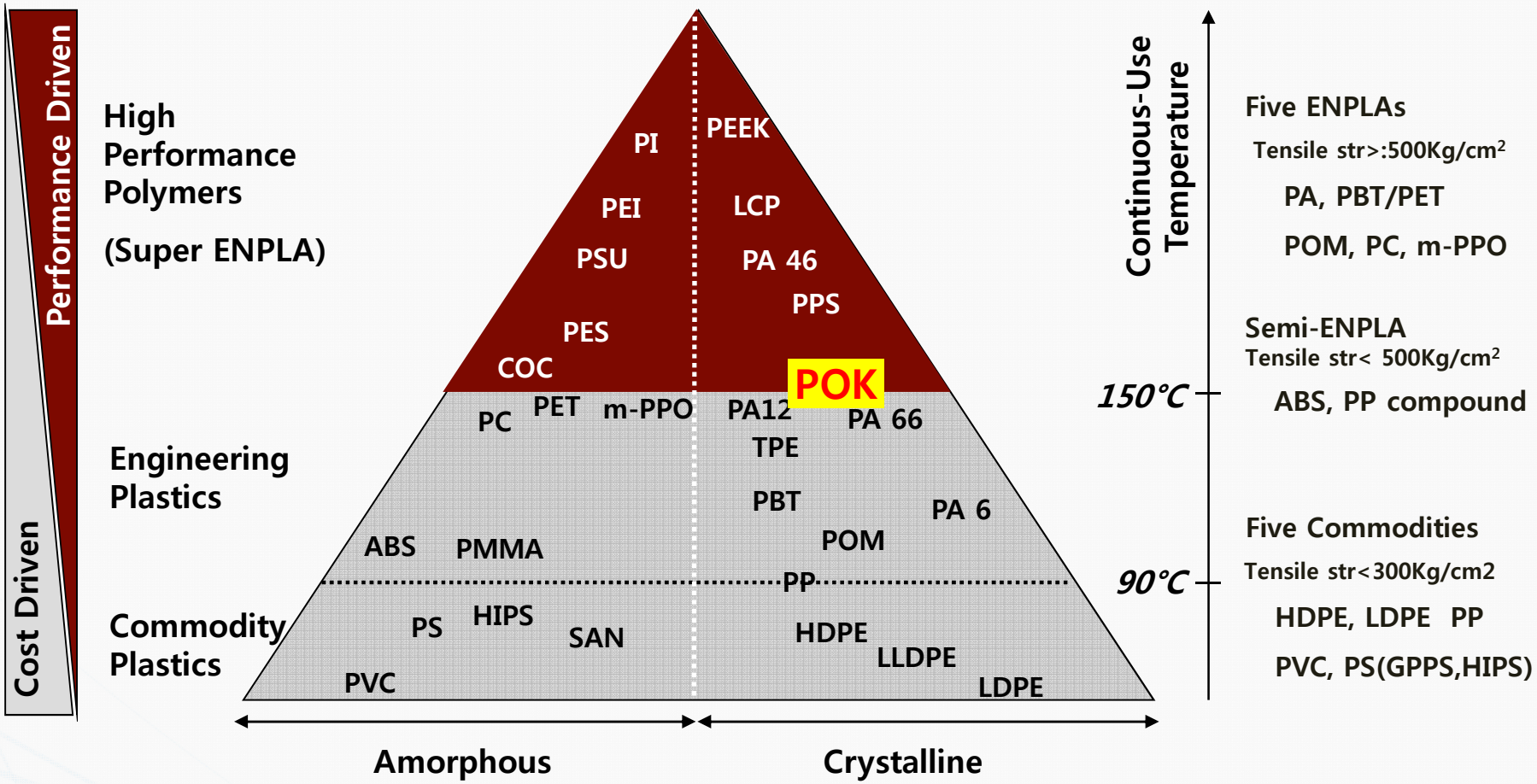
Polyketone Positioning



Ⅰ. What is Polyketone

Ⅱ. Characteristic

Ⅲ. Applications

Ⅳ. Present & Future

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1 *Automotive Fuel Systems and under the Hood Applications*

Characteristics

- Very Good Chemical Resistance
- High Permeation Resistance
- Superior Impact Strength
- Good High Temperature Performance

* Under Developing with Hyosung's Polyketone.

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2 *Automotive Outer Component Applications*

Characteristics

- Superior Impact Strength
- Very Good Chemical Resistance
- Very Good Hydrolytic Stability
- Outstanding Stiffness/Toughness Balance

Door Checker

Fuel Filler Door

Snow Chain

Wheel Cover

* Under Developing with Hyosung's Polyketone.

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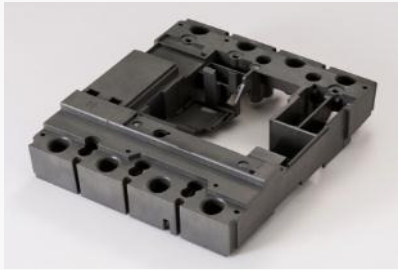
3 *Electrical Applications : Connector & Plug, Switch, Socket, etc.*

Characteristics

- Halogen and Red Phosphorus Free Fire Retardant
- Good Toughness
- Good Tracking Resistance
- High Resilience
- Good Processability

Connector & Plug



Switch

Power Line Bus

* Under Developing with Hyosung's Polyketone.

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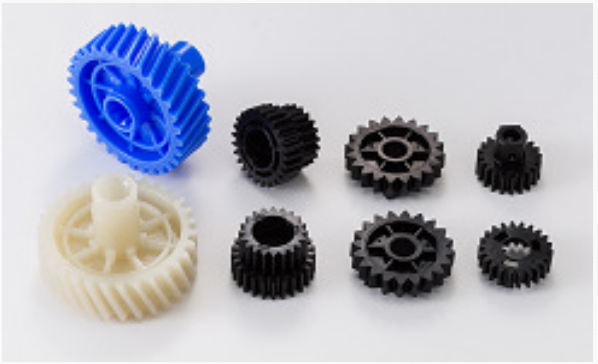
4 *Gears : ATM, Office Automation(OA), Automotive, etc.*

Characteristics

- Superior Wear & Abrasion Resistance
- High Creep Resistance
- Very Good Hydrolytic Stability
- Outstanding Stiffness/Toughness Balance



Gears of ATM, OA Machines

Power Steering
Warm Gear

* Under Developing with Hyosung's Polyketone.

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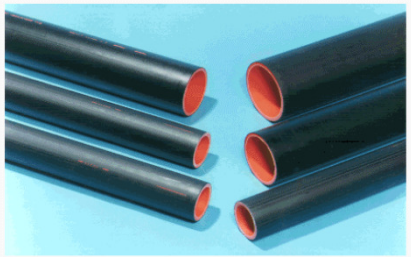
5

Barrier Pipe & Packaging Applications

Characteristics

- Chemicals & Hydrocarbons Barrier
- Oxygen Barrier : Food
- Aroma/Flavor Barrier : Personal Care Products



Pipe & Tube

Pipe Cap

Packaging Bottles

Personal Care Products

Food Packaging

* Under Developing with Hyosung's Polyketone.

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Ⅰ. Introduction

Ⅱ. Characteristic

Ⅲ. Application

Ⅳ. Present & Future

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Development History

- 2004 **Start Lab. Scale Development.**
- 2006 Bench scale Polymerization Equipment set-up
  (Capa. : 10 MT/Y, Anyang R&DB Labs.)
- 2008 Start ENPLA development.
- 2011 Start Fiber Development.
- 2012 **Pilot Polymerization Plant set-up.**
  (Capa. : 1,000 MT/Y, Ulsan Plant)
- 2013 Finish engineering for Commercial Plant.
- 2015 **Commercial Plant start .**
  (Capa. : 50,000 MT/Y, Ulsan Plant)

Hyosung developed basic material technology and engineering design was finished.

" June `2015, Commercial plant will be started"

▪ **Patent : Total 160**
(Domestic 133, World-wide 27)

[Pilot Plant]
· 1,000 MT/Y

IV. Present & Future

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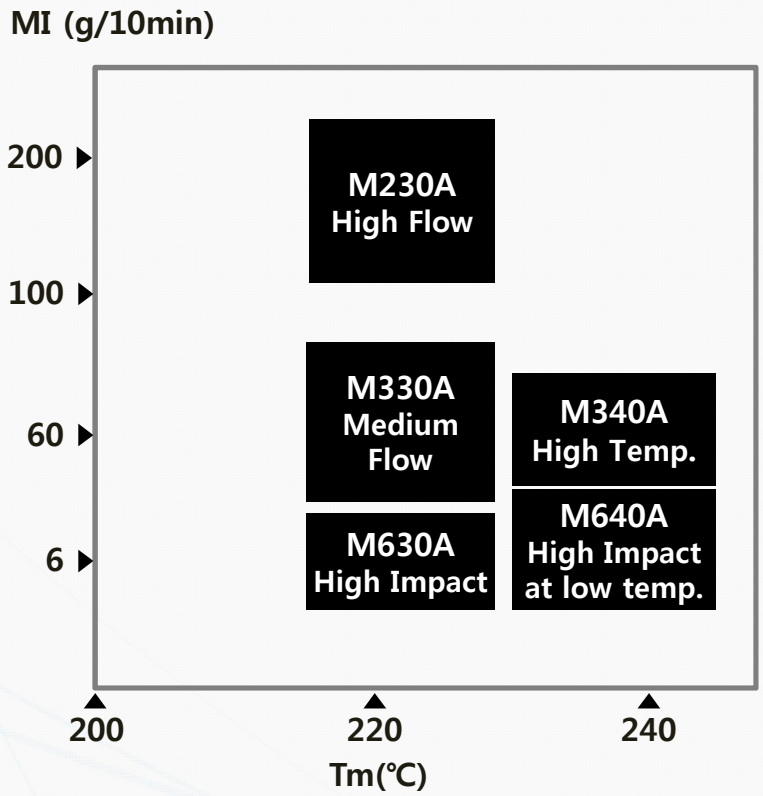
Portfolio

- 5 Base resin (M230A~M640A) and 27 compounding recipes
- Melt Index 6~200, Melting Temp. 220~240℃ for Injection Molding and Extrusion.



POK Grade		Characteristic	
Name			
M230A	High Flow	Injection Molding	For High Filling
M330A	Medium Flow		For general/thin wall injection
M340A	High Temp.		For high temperature use
M630A	High Impact	Extrusion/ Injection	For Pipe Extrusion For high impact injection molding
M640A	High Impact at low temp		For high impact at low temperature

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Base Resin Grade : High Flow M230A, Medium Flow M330A, High Impact M630A.

Item	Method	Unit	M230A	M330A	M630A
Physical					
Density	ASTM D792	g/cm³	**1.24**	**1.24**	**1.24**
Water Content (23°C, 60% RH, Eq.)	ASTM D570	%	**0.45**	**0.5**	**0.5**
Thermal					
Melting Temperature	ASTM D1525	°C	**220**	**220**	**220**
Melt Flow Rate (240°C, 2.16kg)	ASTM D1238	g/10min	**150**	**60**	**6**
Deflection Temperature	ASTM D648				
: HDT 0.45MPa(4.6 kg/cm²)		°C	**205**	**210**	**210**
Mechanical					
Tensile Strength	ASTM D638	Kg/cm²	**500**	**600**	**620**
Nominal Strain at Break	ASTM D638	%	**>25**	**>250**	**>300**
Flexural Strength	ASTM D790	Kg/cm²	**500**	**600**	**620**
Flexural Modulus	ASTM D790	Kg/cm²	**13,000**	**18,000**	**18,000**
Charpy Notched Impact Strength	ASTM D256	Kg · cm/cm	**5**	**12**	**18**
Electrical					
Volume Resistivity	ASTM D257	Ω·cm	**10^{15}**	**10^{15}**	**10^{15}**
Dielectric Strength	ASTM D149	KV/mm	**20**	**17**	**17**

Thank you very much.