

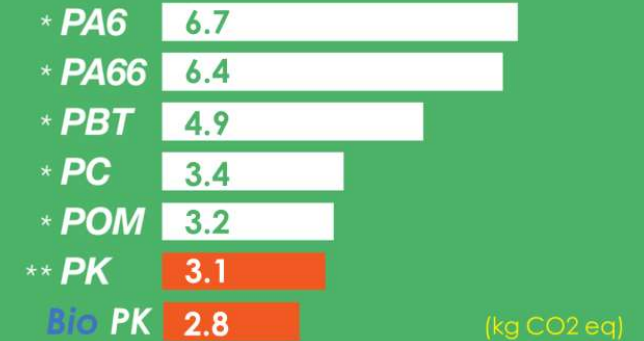
POKETONE™ Value Propositioning



Non Toxic High Efficiency

Acrylate Free
Melamine Free
Bisphenol A Free
Formaldehyde Free
Lead/ Chrome/ Free
Phthalate Free

Global Warming Potential



* Other ETP data is based upon the Eco-profiles data from www.plasticseurope.org

** PK data are based upon Ecovinvent database according to ISO Standard 14040 and 14044

Bio PK data are based on 46% bio-ethylene content

Contents

I . Market Trend & Challenges

II. POKETONE Sustainability

III. Understanding POKETONE

IV. Competitive Differentiation

V . Customer Testimonials/Case Studies

VI. Sales and Outlook

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II. POKETONE Sustainability

III. Understanding POKETONE

IV. Competitive Differentiation

V . Customer Testimonials/Case Studies

VI. Sales and Outlook

The industry demands **fresh solutions**



Despite their excellent overall properties and benefits, plastics are not a panacea. They occasionally can and do fail in their intended service environment. Unfortunately, some of these failures wind up in litigation.

Plastic failure is a common term used for any type of deformation that occurs in plastic during its lifetime. The main types of failures include wear, crack, degradation, distortion, and aesthetic alteration. These failures may affect the performance and service life of the application, where the specific plastic part is used. In order to avoid such problems, it is important to understand the types and causes of plastic failure.

Choosing the Right Plastic Material

REQUIREMENTS TO CONSIDER

- Physical properties
- Chemical properties
- Operational environment
- Cosmetic requirements
- Functional requirements
- Cost of the material
- Its ability to manufacture
- Environmental considerations

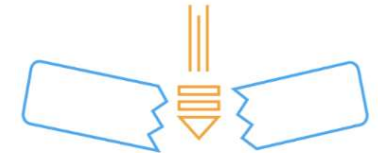
Will it stretch?



How stiff is it?



Can it absorb shock?



Is it Hard?



Heat resistance



Wear resistance



Water resistance



Chemical resistance

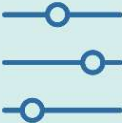


UV resistance



Market Trend & POKETONE™ Adaptation

Trend

	Sustainability and Environmental Responsibility Focus on eco-friendly materials with lower environmental impact.
	High-Performance Applications Demand for materials that withstand extreme conditions like chemicals, wear, and heat.
	Market Expansion in EV and Electrical Sectors Growth in EV and electrical sectors demanding high-performing, durable, and eco-friendly materials.
	Enhanced Safety and Compliance Increased focus on materials that meet stringent safety regulations.
	Customization and Versatility Growing demand for materials that can be adapted to various applications.

Why POKETONE



Potential for **Bio-based feedstock** use and low **Global Warming Potential**



High resistance to **chemicals**, **wear**, and **heat**, making it ideal for demanding environments.



Eco-friendliness, **chemical** resistance, electrical **insulation** properties, and meet these sector demands



Compliance with **safety standards**, making it ideal for sensitive applications like food contact and water contact parts.



Adaptability in a **wide range of applications**, from automotive to medical devices.

Challenges in Engineering Plastics

Challenges

	Chemical Resistance and Stability Essential for applications in aggressive environments, ensuring longevity and reliability.
	High Temperature Performance Crucial for applications exposed to high heat, maintaining properties under stress.
	Durability and Toughness Vital for heavy-duty applications where material strength is key to performance and safety.
	Bio-compatibility Critical for applications requiring non-toxic, safe materials for human contact.
	Low Moisture Absorption Key for applications where moisture could compromise performance or safety.
	Acoustic Damping Properties Important in automotive, consumer electronics, and construction for user comfort and product appeal.

POKETONE Solution



Superior resistance to chemicals and environments.



Exceptional short-term thermal stability(HDT) in high temperatures.



High resilience and toughness.



Suitable for medical and food contact applications.



Consistent performance in humid conditions.



Reduces noise, enhancing quality and comfort.

I . Market Trend & Challenges

II. POKETONE Sustainability

III. Understanding POKETONE

IV. Competitive Differentiation

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VI. Sales and Outlook

POKETONE™ Goes Green

Non-toxic

PK is a safe and sustainable thermoplastic material. It does not contain toxic substances like Acrylate, Melamine, Bisphenol A, Formaldehyde, Lead, Chrome Phthalate, and others. With low VOC emissions, polyketone promotes a healthier environment.



- ✓ Formaldehyde Free
- ✓ Phthalate Free
- ✓ Bisphenol A Free
- ✓ Acrylate Free
- ✓ Melamine Free
- ✓ Lead/ Chrome Free



Low Global Warming Effect

PK stands out as an environmentally conscious choice among engineering plastics. One of its notable advantages is its significantly lower Global Warming Potential (GWP) compared to other materials. By opting for polyketone, you contribute to reducing the impact on our planet's climate.

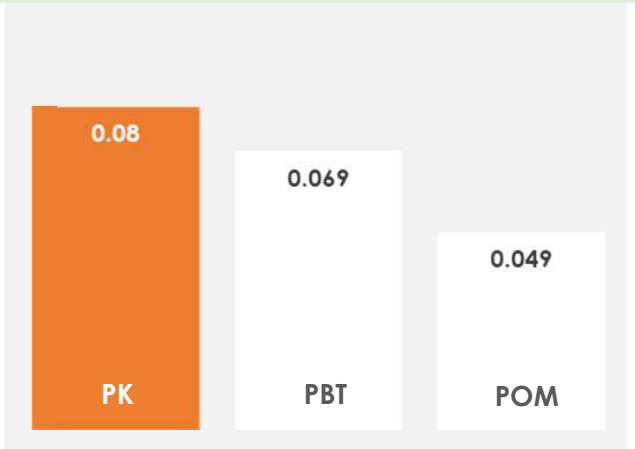
Global Warming Potential

PK	3.1
POM	3.2
PC	3.4
PBT	4.9
PA66	6.4
PA6	6.7

High Efficiency

PK offers a game-changing advantage in injection molding: shorter cycle times. This means customers can achieve higher efficiency, save energy, reduce production time, and enhance overall productivity. By choosing polyketone, you not only maximize efficiency but also contribute to sustainable manufacturing practices.

Cooling Speed comparison based on Thermal Diffusivity Coefficient(α)(m²/sec)



POKETONE™ Certificate

POKETONE polymers for food contact and medical applications are thoroughly tested for toxicity and biocompatibility. For all the base grades, POKETONE polymers are filed with the FDA and used in the development of food contact and medical devices



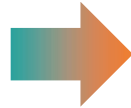
Sustainability Trends:

Where Does **POKETONE** Stand?

Sustainable Polymer Framework

FEEDSTOCK

- Renewable Feedstock
- Waste Feedstock
- Recycled Feedstock



PROCESS

- Non-hazardous
- Energy efficient
- Waste prevention



INTENDED USE

- Competitive properties
- Economically viable
- Safe-in-use



END-OF-USE

- Chemically recyclable
- Biodegradable
- Reprocessable



POKETONE Sustainability status

POKETONE Production Alternatives

- Exploring Blue CO and bio-based Ethylene for POKETONE.
- Goal: diversify inputs, boost sustainability, maintain quality.

POKETONE's Environmental Impact

- POKETONE is free from toxic substances, presenting a safer option
- Has lower Global Warming Potential than other materials.

POKETONE's Durability

- POKETONE is durable, extending product life cycle.
- Barrier properties lengthen shelf life of packaged food.

Recycling POKETONE

- Challenge: Limited market recognition hinders consumer recycling.
- Initiating post-industrial recycling to overcome these challenges

POKETONE

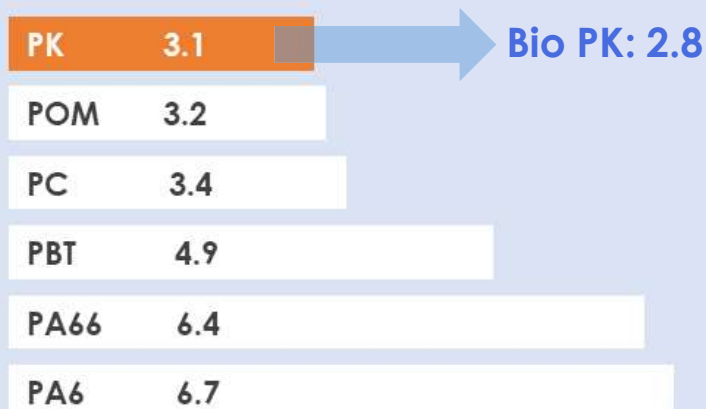
Global Warming Potential Reduction Strategy

- Current: Low LCA feedstocks and energy usage results in 3.08 kg CO₂/kg Peketone.
- Strategy A: Ready to produce Bio PK using Max 46% content of **Bio ethylene**.
- Strategy B: **Blue CO** usage will further reduce our GWP.

[Current practices]

Utilizing feedstocks with low life-cycle assessments and minimizing energy consumption has led us to an emission rate of 3.08 kg of CO₂ for every kilogram of Peketone produced.

Global Warming Potential



[Future strategies]

Strategy A

We are ready to produce **Bio PK** using Max 46% content of **Bio ethylene**, which we anticipate will lower our Global Warming Potential to 2.8



Strategy B

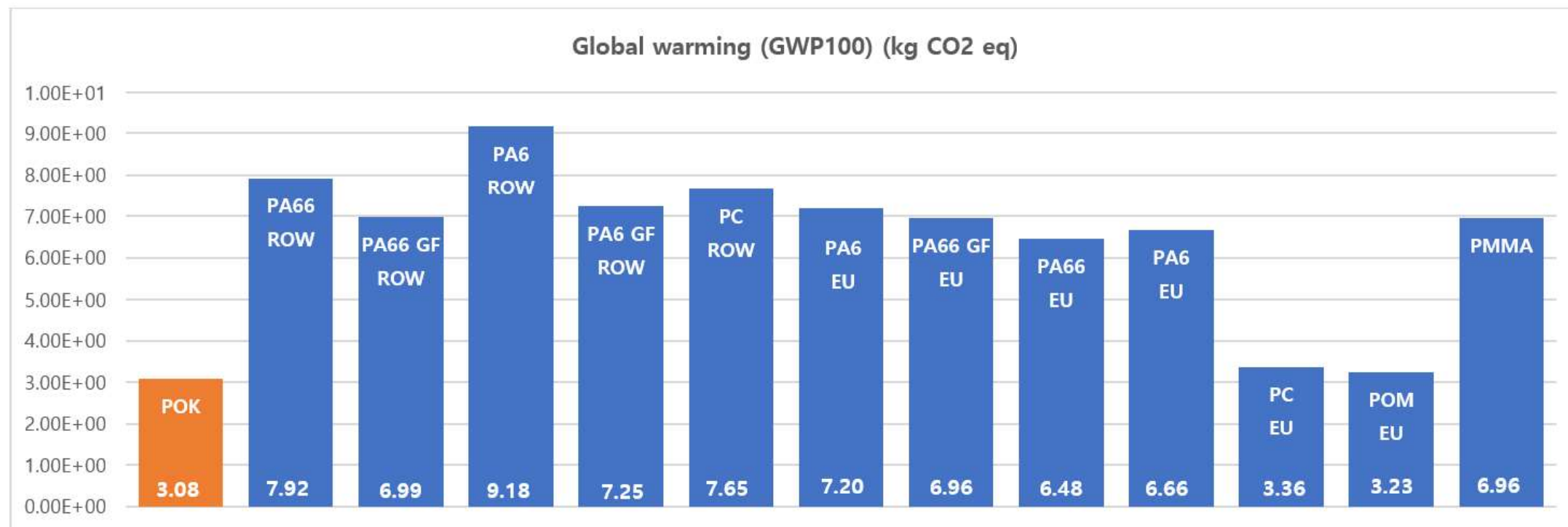
We're also exploring the use of **Blue CO** which could help us further decrease our GWP."

Environmental impact

POKETONE™ and other materials

The environmental impact calculated through the LCI database on the major plastic materials that POKETONE™ can replace were compared. This result can be used for internal decision making, but it cannot be used to claim the superiority of a specific product.

Climate change



VOC on **POKETONE** Sustainability



Products ▾ Resources ▾ Careers ▾ Investors ▾ Sustainability ▾



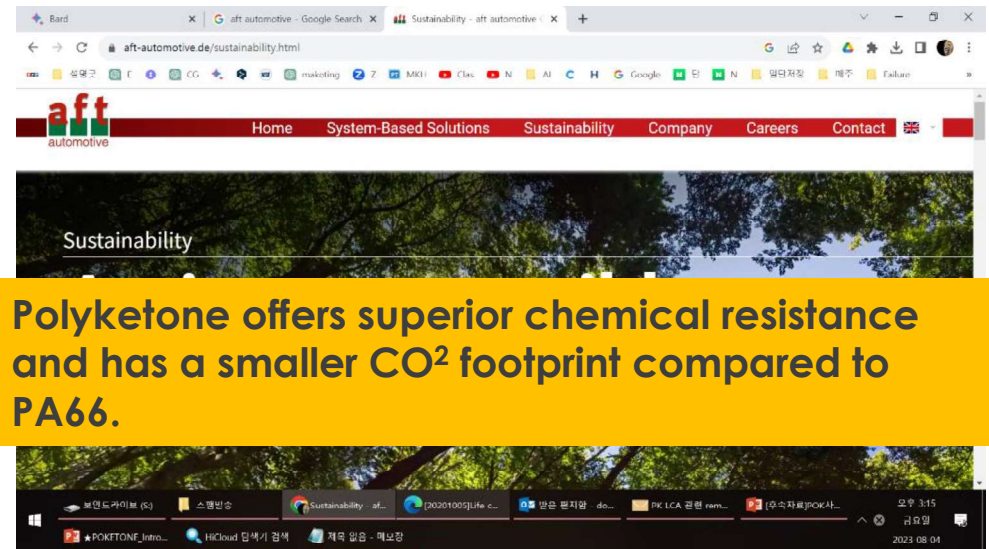
performance, these formulations provide excellent chemical resistance, low moisture uptake, excellent dimensional stability, and high impact and wear resistance. These properties offer manufacturers a high-performing, cost-competitive and more eco-conscious alternative to nylons (PA66 and PA6).

These grades meet the performance challenges of chemical, fuel contact, and high

The production of PK emits up to 61 percent less carbon dioxide (CO₂) than nylon (PA66 and PA6).

quickly, and have short cycle times.

Helping to improve sustainability over the end-product lifecycle, these formulations offer a reduced carbon footprint as a result of the PK base resin. The production of PK emits up to 61 percent less carbon dioxide (CO₂) than nylon (PA66 and PA6).



Polyketone offers superior chemical resistance and has a smaller CO₂ footprint compared to PA66.



The polyketone resin used to make PK 5000 is a low-carbon material made from carbon monoxide.

Carbon Sequestering Material – Polyketone (Pk)



Polyketone is a new green polymeric material composed of carbon monoxide and olefins. The CO₂ emissions of Polyketone are over 50% lower than those of PA66 and PA6.

- POM
- PBT
- Various GF, and MF- options available.



- High Chemical Resistance
- Good Wear & Abrasion Behavior
- Good Flame-Retardancy
- Lower Cycle Times With High Rate of Crystallization

Strength, Chemical Resistance



I . Market Trend & Challenges

II. POKETONE Sustainability

III. Understanding POKETONE

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What makes **PK** special?

Good Chemical resistance

PK Polymers are tough. With few known solvent, this new class aliphatic polyketones has good barrier properties and chemical resistance-even when exposed to extreme temperatures.



Outstanding Hydrolysis Stability

PK polymers are not susceptible to hydrolysis. They exhibit resistance to hydrolysis in a broad range of aqueous environment and absorb small amounts of water, resulting in almost no effect on strength



Friction and Wear resistance

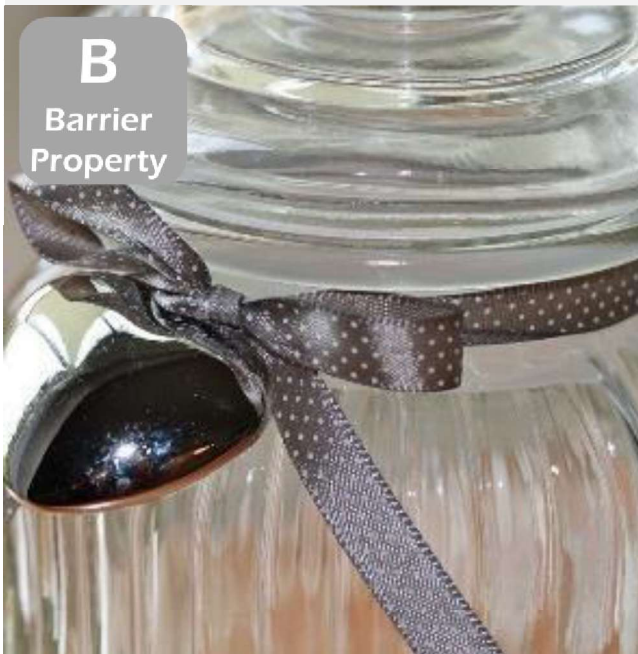
The tribological performance of gear assemblies and related mechanical systems can be improved if at least one of the wear-related components is made from PK



What makes **PK** special?

Good Barrier Performance

PK Polymers are resistance to a wide range of chemicals and exhibit good solvent and fuel barrier performance. This makes them attractive for use in pipe and barrier packaging.

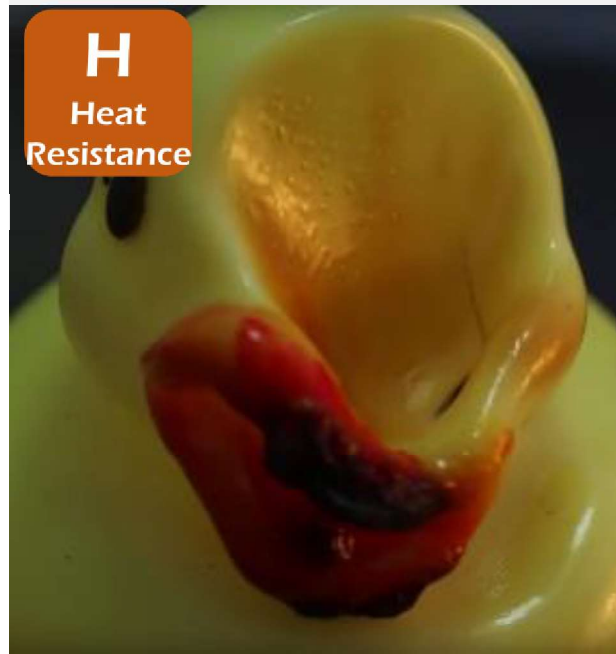


B

Barrier
Property

Heat resistance

PK have better thermal properties than many of the leading plastics with higher melt point at max 220°C,) heat deflection temp. (210°C, at 0.46 MPa). and VICAT softening point(195°C).



H

Heat
Resistance

Non-toxic

For all the base grades, PK are filed with the FDA and used in the development of food contact and medical devices. They also safe with low to zero volatile organic compounds emission,.(VOCs)



S

Safety
Non-Toxic

What makes **PK** special?

Impact resistace

PK boasts 2-3 times higher impact strength than standard engineering plastics, ensuring resilience against sudden forces. This makes it ideal for components in operational parts.



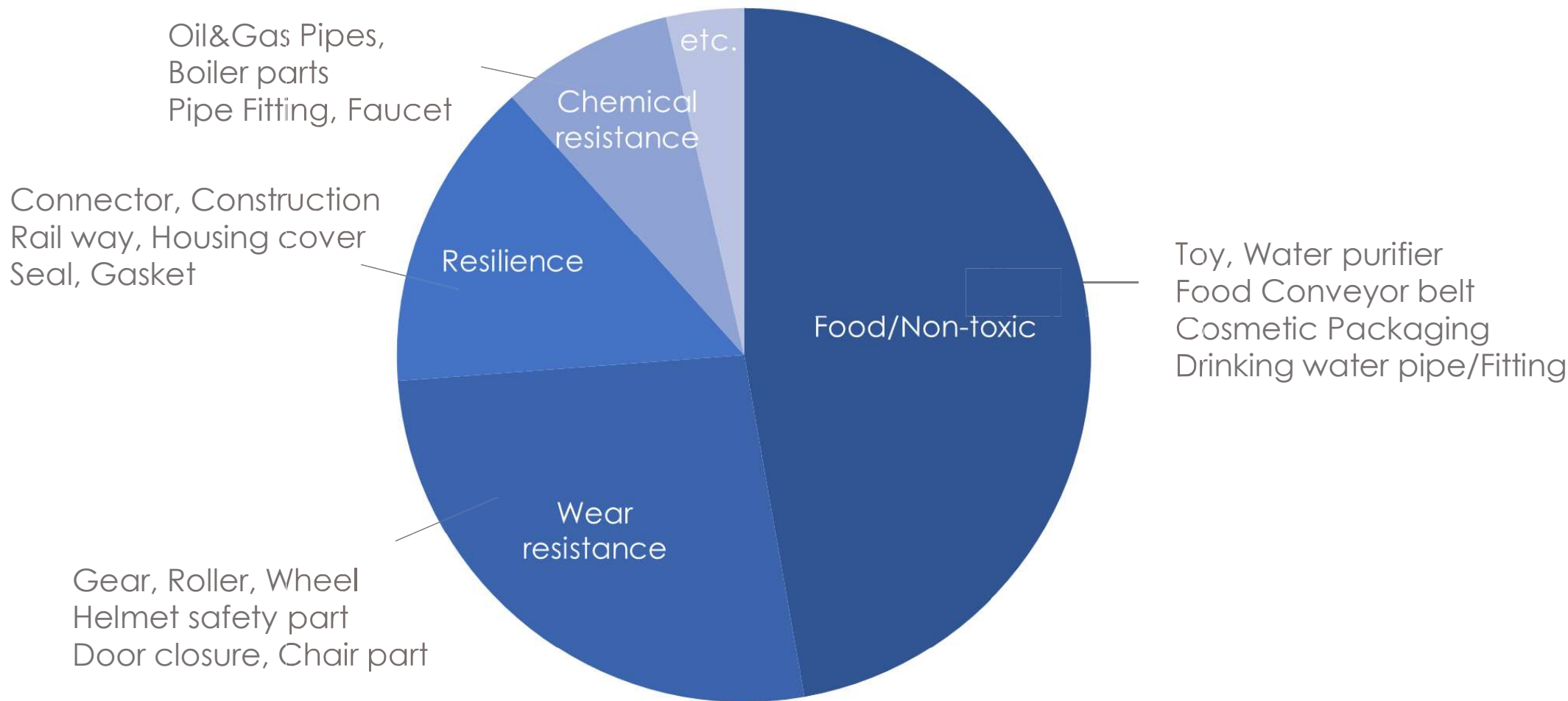
Resilience

PK demonstrates excellent resilience to deformations and resistance to repetitive loads. Leveraging these advantages, it is being sold as a substitute for metals in spring applications, gears and seals.



POKETONE™ Applications

POKETONE Key Value & Applications



Polyketone(PK) Chemical Structure

Polyketone

a family of
Semi-crystalline aliphatic Polyketone,
made of **CO** and Olefins

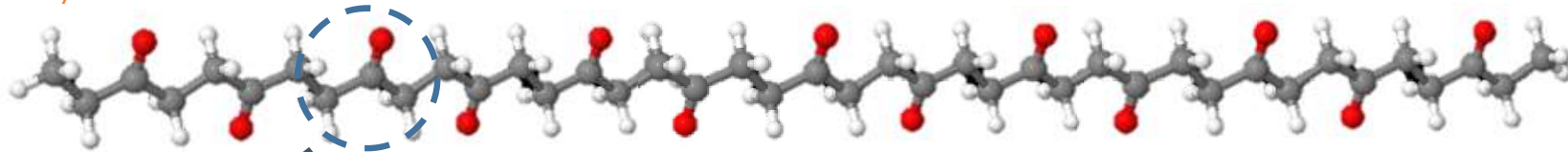
Made of

Carbon
Monoxide

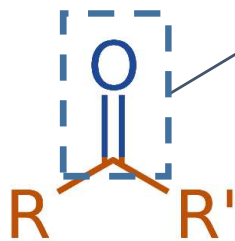


Olefins

Polyketone



a Ketone



Carbonyl Group: Polar

The Oxygen sucks electrons from the carbon

Creating a strong attraction
between polymer chains.

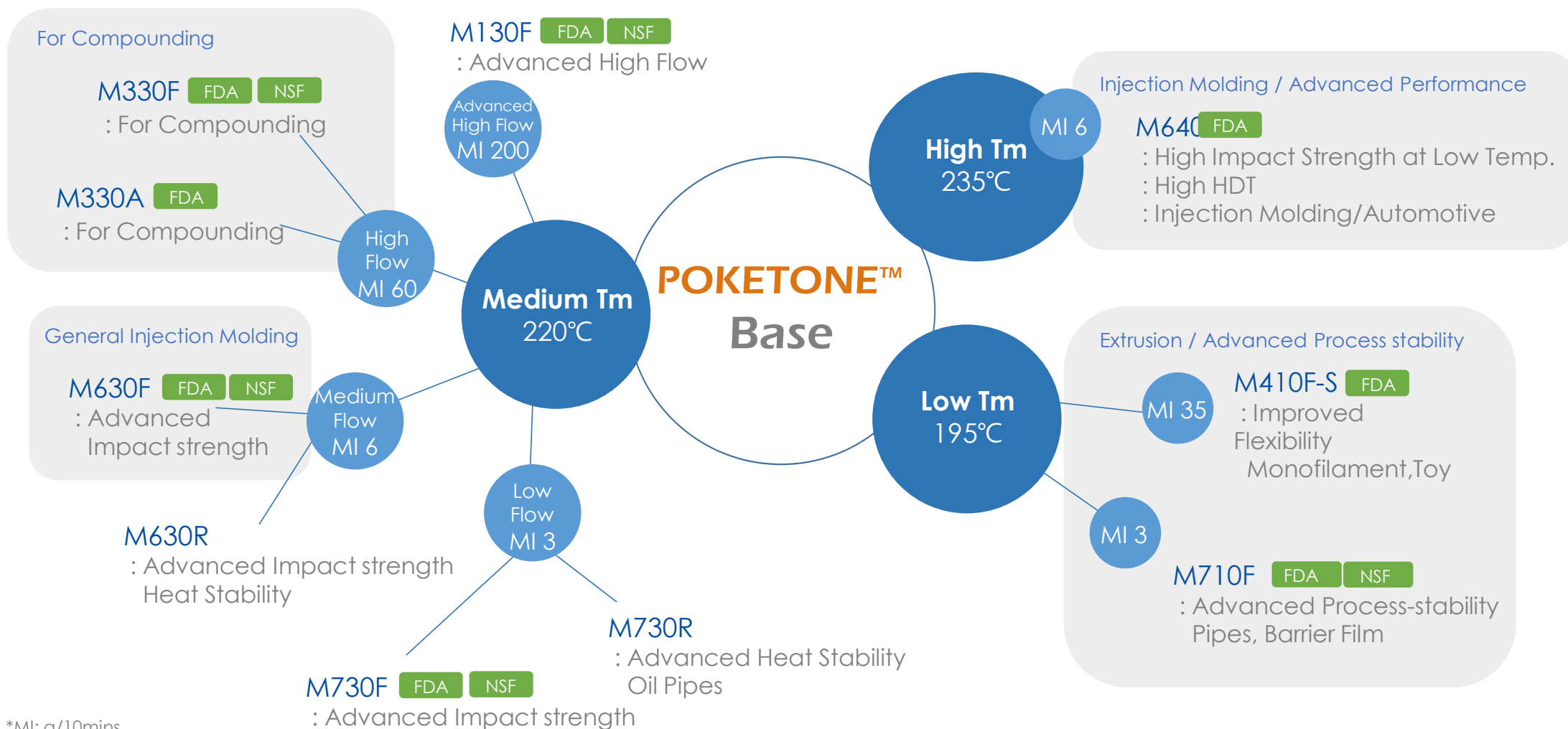


High
Melting Point
Strong
interaction

POKETONE material Selection(Base)

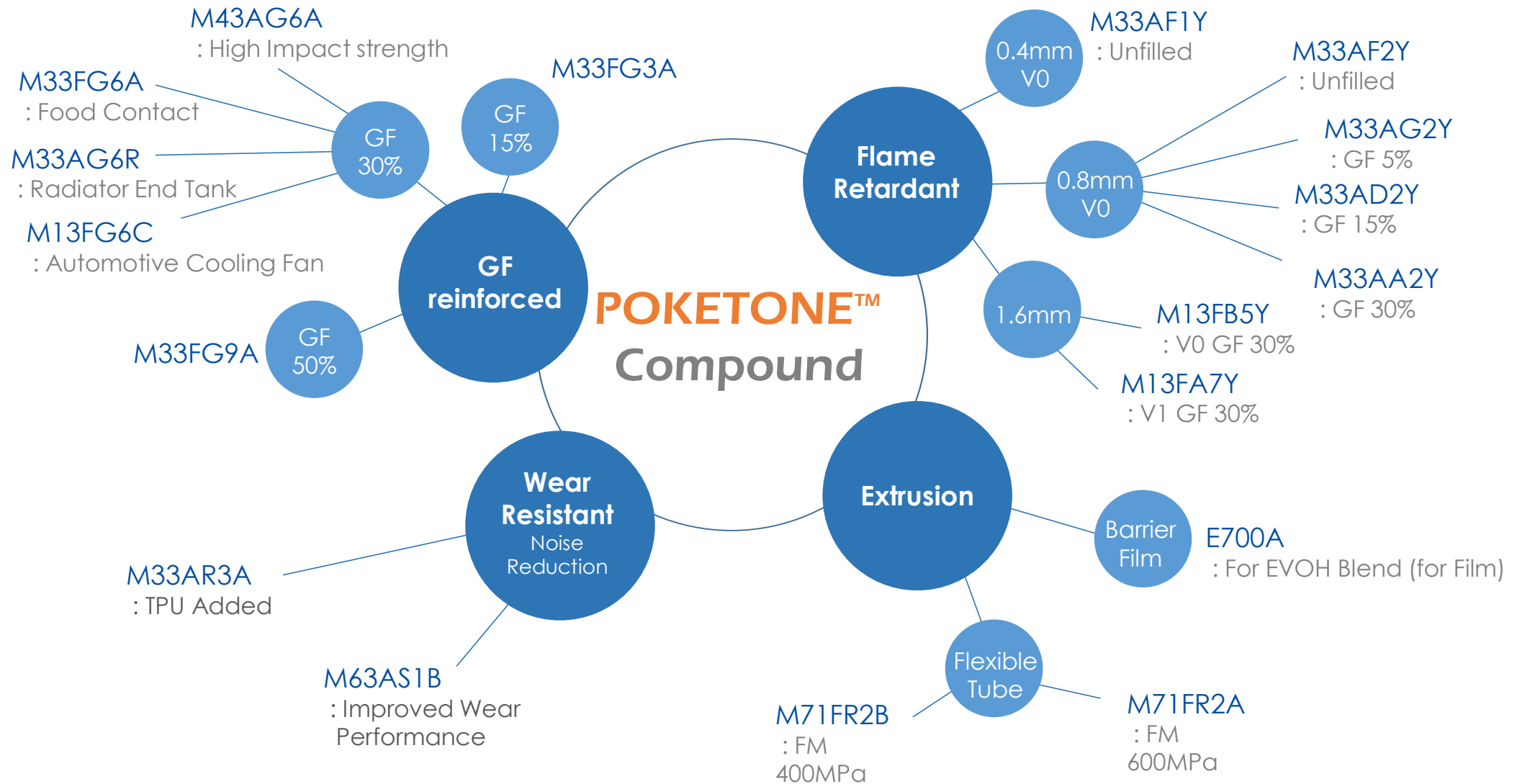


POKETONE™ material Selection(Base)



*MI: g/10mins

POKETONE™ material Selection(Compound)



PK vs Engineering plastics

Density



Heat distortion resistance(HDT,0.46MPa)



Tensile Strength(Yield)



Toughness



Elongation(Yield)



Hardness



Flexibiliy



Young's Modulus

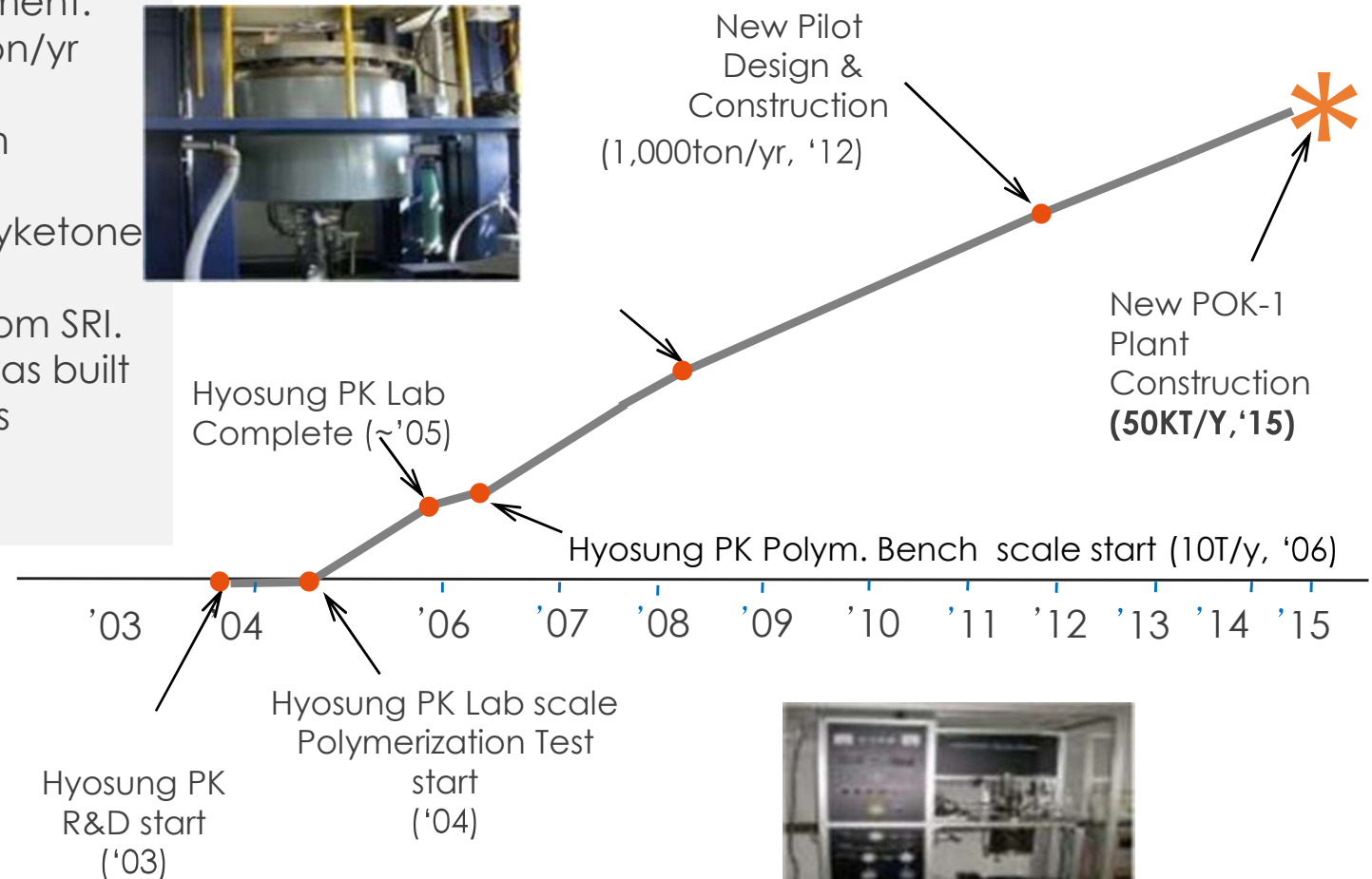


Overcoming the Challenges:

Solutions to Approach **PK's** Limitations

	 Black Specks	 UV Degradation	 Discoloration
Typical Root Causes	✓ Contamination during processing ✓ Thermal degradation	✓ Exposure to UV rays	✓ Exposure to UV or chemicals ✓ Exposure to heat or high humidity
Preventive Solutions	► Purging: Purge thoroughly using high viscosity PE, PP or GranaClean™ before and after processing to prevent cross-linking with other polymers ► Operating condition: Keep the melt temperature as low as possible, aiming for 20°C above its T_m and the maintain the residence time less than 5 mins to minimize the thermal damage. ► M/B Carrier and Pigment: Use PK or LLDPE carriers and appropriate pigments in master batches.	► Indoor use: Keep PK products indoor ► Outdoor use: Add UV 1164(0.5%), TiO₂(2-3%), Carbon Black(1%) or Glass fiber as extra protective agents against UV degradation	► Storage Conditions: Keep PK products indoor avoiding direct contact with light, heat, and humidity. ► Color Choice: Consider using black, brown and green color in the PK formulation to minimize visible color changes over time [Note] Even if color shifts PK's mechanical properties rarely changes
POKETONE Grades	M330A M330F-L	M630V(UV 1164) M33FX0A-WH1 (TiO ₂) M33FX0A-BK1 (C/B) M33FG6A(GF)	M33FX0A-BK0(Black) M63FX0A-BK0(Black) M33FG6A-BK1 (GF/Black)

POKETONE History



- **1970s:** US, Japanese companies attempted Polyketone development.
- **1999:** US Shell started its 20,000-ton/yr Polyketone production.
- **2000:** Shell exited 14 downstream businesses including Polyketone.
- **2004-2013:** Hyosung pursued Polyketone commercialization research.
- **2011:** Acquired a Shell License from SRI.
- **2012:** A 1,000-ton/yr pilot plant was built
- **2015:** A 50,000-ton/yr factory was launched for mass production (Ulsan Yongyeon Factory).

POKETONE Yongyeon Plant



I . Market Trend & Challenges

II. POKETONE Sustainability

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Evolution & Success of **Big 5 Engineering Plastics**

Penetrating a saturated market is **challenging but achievable** with new products and needs; seizing **market opportunities** is crucial. Plastics' popularity varies across industries due to properties like strength, heat resistance, and optical clarity. Mass production and new applications have further boosted this popularity.

Plastic	Development	Popularity
PA66	Developed by DuPont in the 1930s as a silk substitute	Immediately popular in the textile industry, gained popularity in the automotive and industrial sectors after WWII
POM	Commercialized by DuPont as "Delrin" in the 1960s	Gained popularity as a metal substitute in precision parts expanded popularity into consumer goods in the 1970s
PBT	Developed by Ticona in the 1970s	Quickly became popular in the automotive and electrical industries, expanded use to consumer appliances and electronics in the 1980s
mPPO	Introduced as Noryl by General Electric Plastics in the 1960s	Became a popular choice in electrical applications due to low water absorption and good electrical properties, expanded to other applications in the 1970s and 80s
PC	Commercialized by Bayer and General Electric in the mid-20th century	Its toughness , optical clarity , and heat resistance led to its initial popularity in eyewear and safety equipment , increased usage in CDs, DVDs , and electronic devices in the 1980s and 90s

Global Warming Potential

* PA6	6.70
* PA66	6.40
* PBT	4.88
* PC	3.40
* POM	3.20
** PK	3.08 (kg CO ₂ eq)

High HDT (1.82MPa/GF30%)

PK GF	215°C
mPPO GF	140°C

Competitive Price

PK	
mPPO	



Water Purifier Tank



Pump Housing



IC Chip Tray



Solar PV Junction Box



Electric Meter Housing



Connector



EV Busbar



Gear



Food Conveyor belt

Big 5 Weakness

High Price & Low HDT

Weak Chemical Resistance

Poor Hydrolytic Resistance

Formaldehyde Emission

High Water Absorption

Flexural Strength

Excellent Hydrolytic Stability
(85°C, 85% RH, 30days)

PK	65MPa
PBT	22MPa

High Impact Strength
(kJ/m², Charpy)

PK (M630)	15
PBT	5.5

Thin walls Moldability

Melt Flow: PK >>>> PBT

Thermal Cycling Resistance

PK >>>> PBT

Formaldehyde Free
(90°C, 24hr mg/L)

PK	0.0
POM	0.066

Low Density(g/cm³)

PK	1.24
POM	1.41

Less Squeaky noise

Noise: PK <<<< POM

POKETONE™

HYOSUNG POLYKETONE

poketone@hyosung.com

Dimensional Stability
(Water Absorption, 23°C)

PK	2.1%
PA66	8.5%

High Impact Strength
(kJ/m², Charpy)

PK (M630)	15
PA66	4

High HDT @ 1.82MPa

PK 105°C PA66 70 °C



Water Meter



Sludge Collector Chain



Vacuum Cleaner Parts

Non Toxic High Efficiency

**EARTH
FRIENDLY**

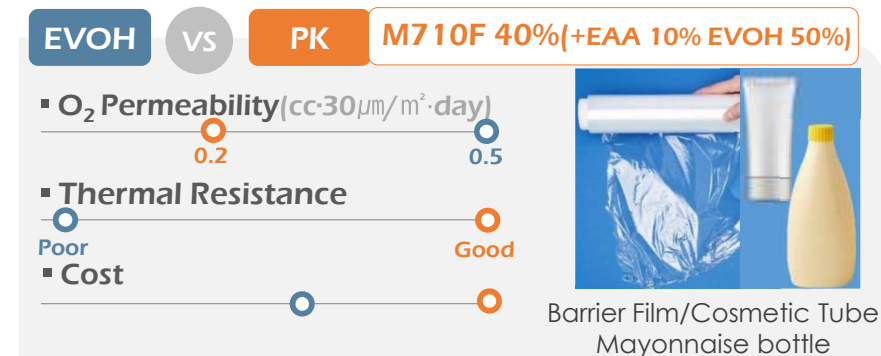
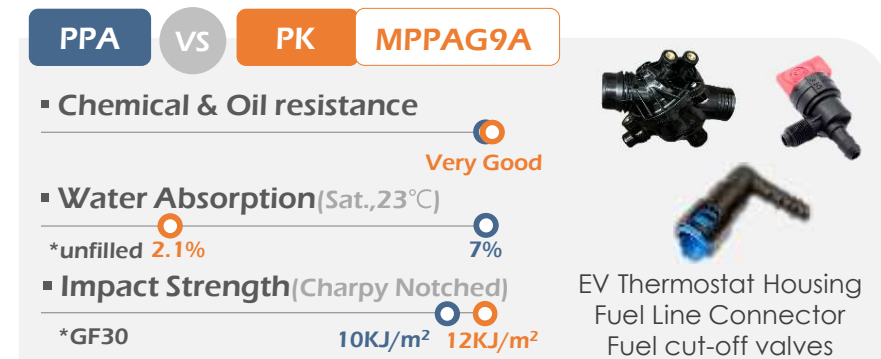
Formaldehyde Free
Phthalate Free
Bisphenol A Free
Acrylate Free
Melamine Free
Lead/ Chrome Free

POKETONE

HYOSUNG POLYKETONE

Bridging Engineering and High-Performance Plastics poketone@hyosung.com

Designed for moderate temperatures, POKETONE ensures substantial cost savings without sacrificing the high-performance features you require. Its innovative composition strikes the perfect balance between thermal efficiency and durability, making it an ideal choice for a wide range of applications. **Price is under \$5 per kilogram.**(FOB Korea)



POKETONE™
Goes **Green**

Non-Toxic

Bisphenol A, Formaldehyde, Lead, Phthalate Free

Low GWP

Low Global warming potential: 3.08

High Efficiency

Shorter Cycle time with quick Cooling

High Performance

PI
PAI
PEEK
PAEK

PSU PPS
PVDF EVOH
PTFE
PA12 PA612

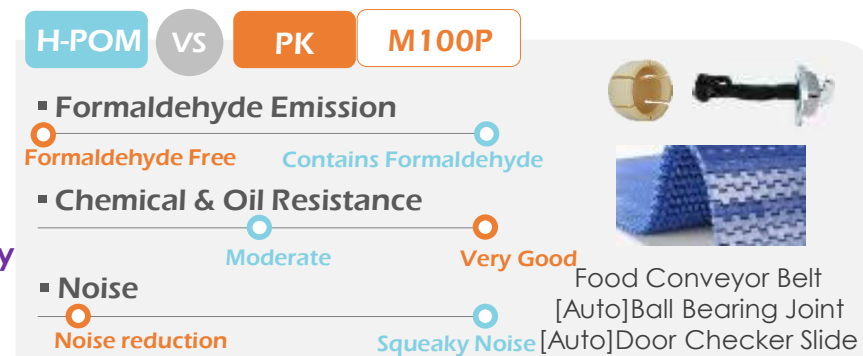
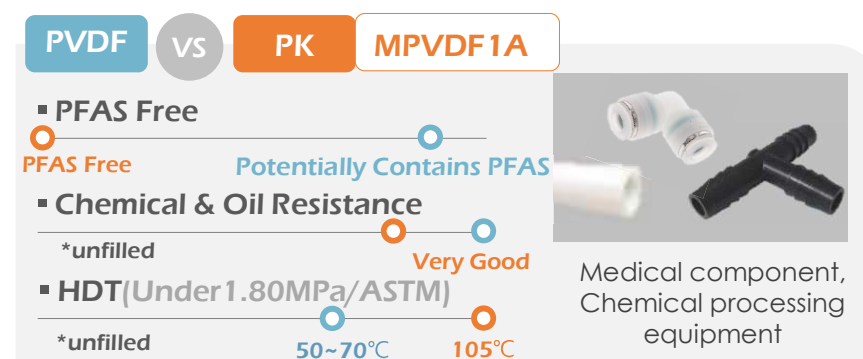
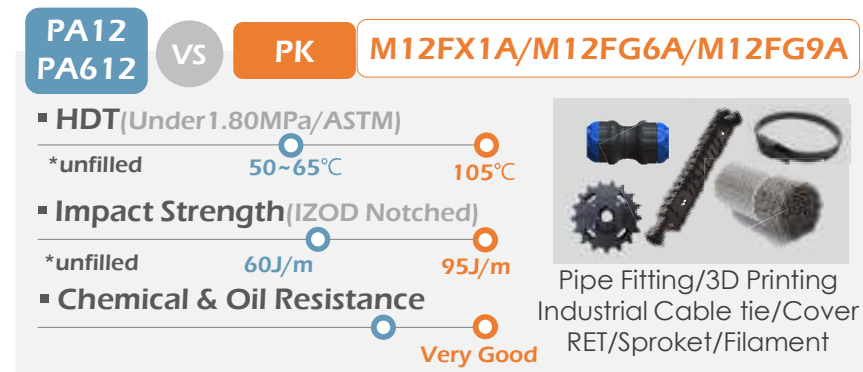
PA6 PA66
PBT mPPO
POM PC

PP PE ABS

PK

Engineering

Commodity



Beyond Metal: Redefining Strength with POKETONE™ Innovation

Are you still relying on traditional metal components in your industrial processes? It's time to explore the cutting-edge possibilities offered by POKETONE, a revolutionary plastic material that is set to redefine the way you think about plastic-to-metal replacement.



POKETONE: The Ideal Replacement for Metal

Cost Reduction
Experience significant cost savings in both material and manufacturing processes with POKETONE. Lower production costs without compromising on quality or durability.

Weight Reduction
POKETONE offers remarkable strength with a fraction of the weight, enabling substantial weight reductions in products. Enhance fuel efficiency, transportation, and handling ease.

Corrosion Resistance
POKETONE is inherently resistant to a wide range of chemicals, ensuring durability in harsh environments. Ideal for applications where exposure to corrosive substances is a concern.

Design Flexibility
Unleash your creativity with POKETONE's design flexibility, allowing complex and intricate shapes that were once challenging with traditional metals. Easily adapt to design trends and consumer preferences.

From Spring to Gadgets, POKETONE Replaced Metal Everywhere



Water Meter
Brass to PK+GF



Pipe Fitting
Brass to PK+GF



Hose Nozzle
Brass to PK



Glove Conveyor Part
Steel to PK+GF



Boiler Heat
Exchanger part
Steel to PK+GF



Cosmetic Pump
Spring
Steel to PK



Caster Body
Aluminum to PK



Oil&Gas Pipe(Liner)
Steel to PK lined Steel



Faucet fitting
Steel to PK