

HYOSUNG CHEMICAL

POKETONE In Gear Application

Global Warming Potential

* PA6	6.70	
* PA66	6.40	
* PC	3.40	
* POM	3.20	
* ABS	3.10	
** PK	3.08	(kg CO ₂ eq)

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

** PK Data is based upon Korea LCI database and Ecoinvent database.



Non Toxic High Efficiency

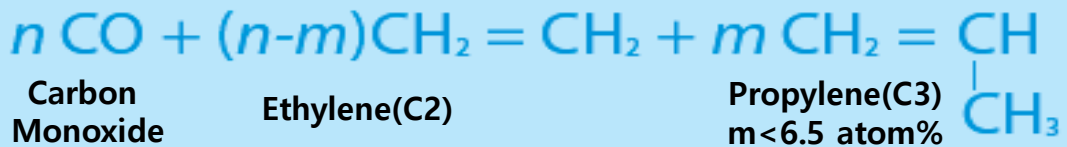
- Acrylate Free
- Melamine Free
- Bisphenol A Free
- Formaldehyde Free
- Lead/ Chrome/ Free
- Phthalate Free



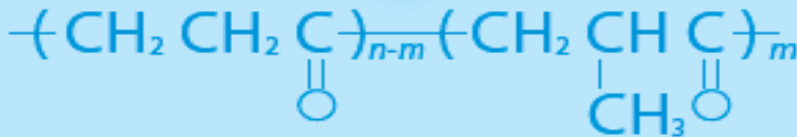
Further Information
www.poketone.com

Overview

HYOSUNG POKETONE is a Semi-crystalline aliphatic polyketone resin, polymerized with carbon monoxide(CO) and C2, C3 olefins. This POKETONE is categorized as engineering plastics, and used in a broad range of application with wear resistance, chemical protective, eco-friendly and low VOCs and balanced stiffness and toughness required resin.



Catalyst, pressure



Poketone (Aliphatic Polyketone)
Melting point 220°C, density 1.24g/cm³

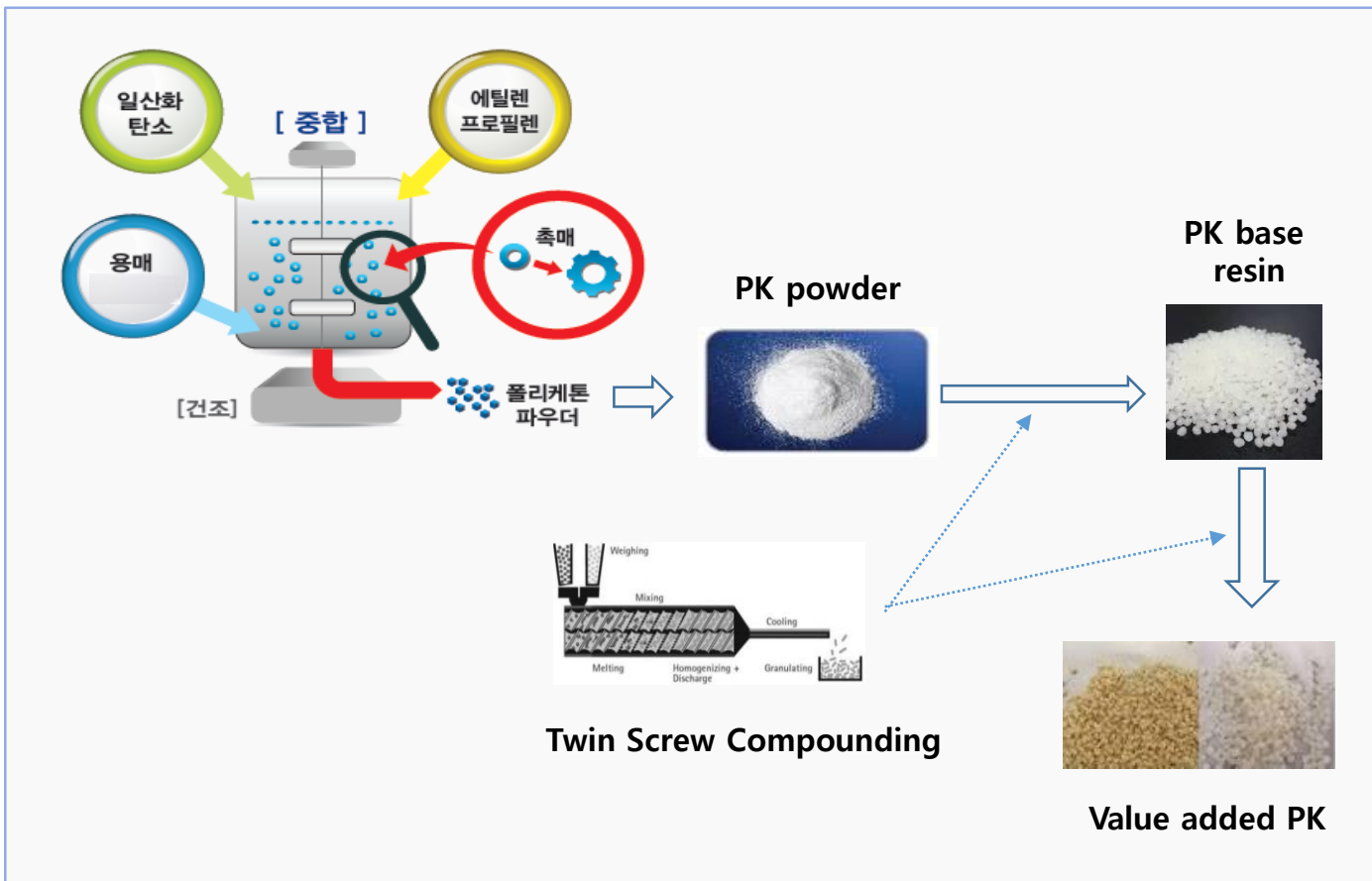
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1. Introduction – Production of PK pellet

Polymerized PK resin has the form of powder. PK base resin pellet is made through twin screw compounding using optimized process conditions.

For value adding such as wear resistant, filler reinforcing, flame retardant an additional compounding process is applied at the PK base resin with an appropriate additives/fillers under optimized process conditions

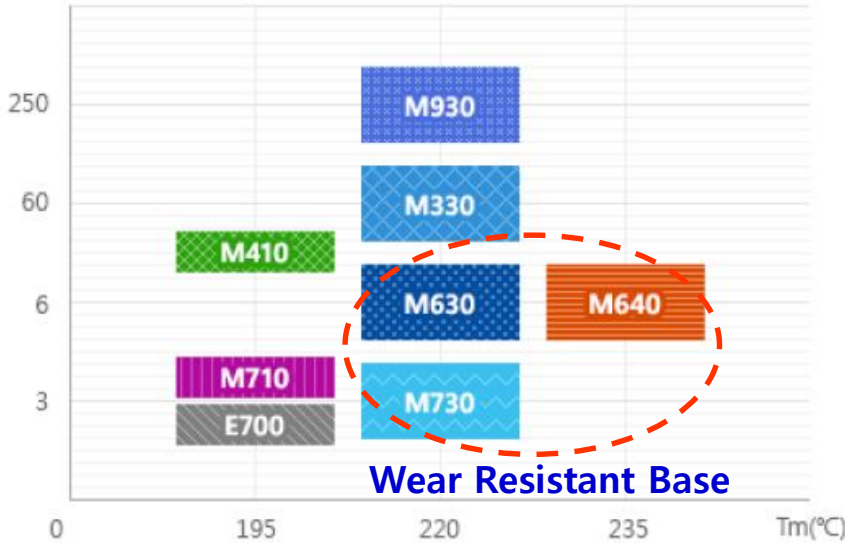


Basically POKETONE is provided as four major colors: NP, BK, GY, WH. But we support RED, BLUE, YELLOW, GREEN and ORANGE coloring according to customer's requirements.

1. Introduction – Base and Compound Portfolio

We have 7 PK base resin portfolio. For wear resistant, we recommend High viscosity PK like M630, M640 and M730.

MI (g/10min)



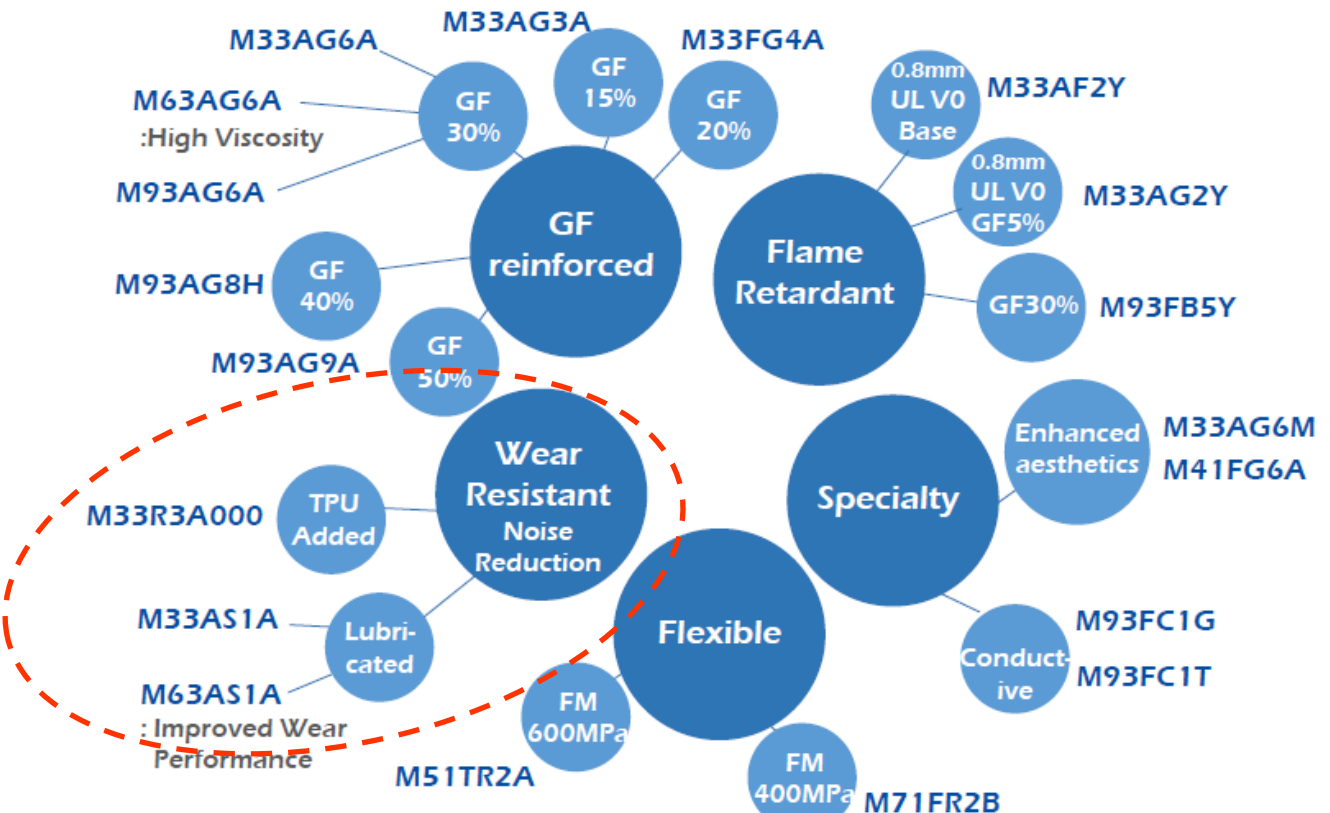
Main Product

- M930 Advanced High Flow
- M330 High Flow
- M630 General Purpose, High Impact
- M730 Low Flow
- M710 Low Flow, Low Tm
- M410 Monofilament, Low Tm

Special product

- E700 PK Compound for EVOH Blend, Resistance to retort treatment
- M640 High Impact at Low temp., High Tm

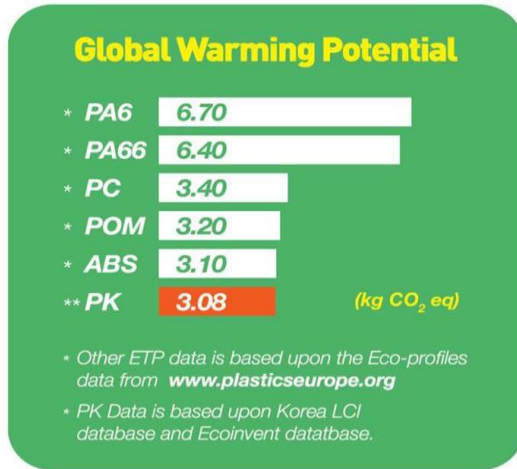
For more wear resistant performances than PK base, we recommend lubricated PK resin



Wear Resistant Compound

2. Eco-Friendliness and Harmlessness of PK Base Resin

HYOSUNG POKETONE has inherently lower CO₂ emission compared with other engineering plastics

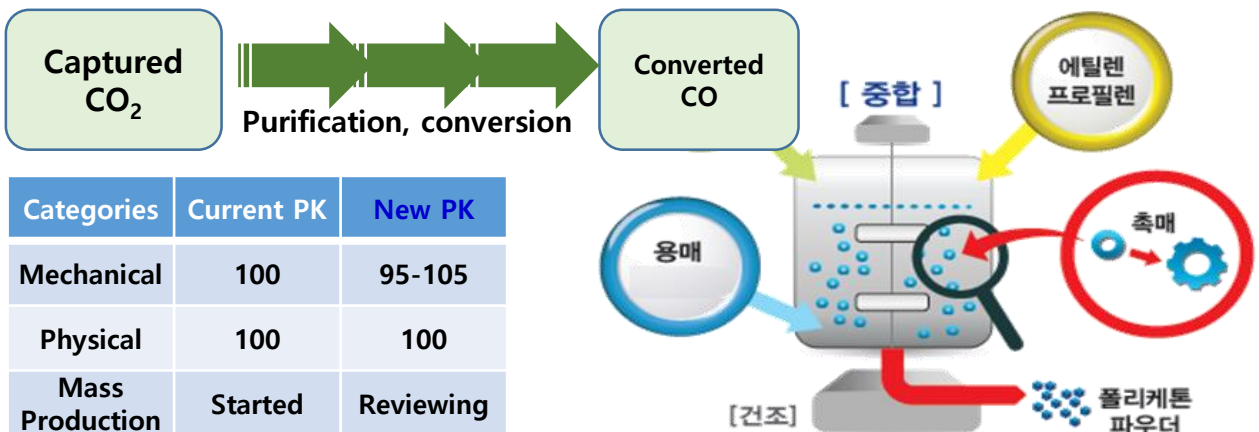


kg CO₂ eq = amount of emitted CO₂ per production of given resin 1kg

HYOSUNG POKETONE has many eco-related and health-related Certificates as NSF, KTW, EU 10/2011, USP 65 and ISO10993.



Hyosung Chemical has a future plan to produce Poketone using recycled CO₂ gas. Named as **NEW PK**, its mechanical & physical properties is verified the same as that for current PK.

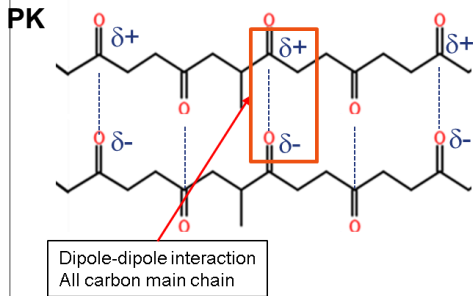


3. Chemical Structure Comparison

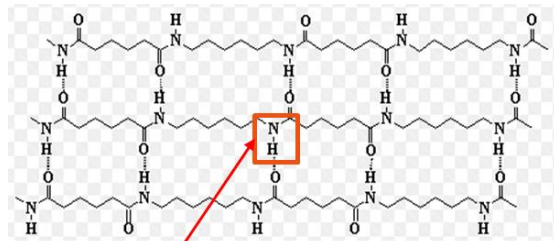
Poketone shows high elongation, impact resistance and good chemical resistances over wide range chemicals compared with other engineering plastics.

It is related to its unique chemical structures: all carbon main chain + dipole interaction

	POKETONE	Other Engineering Plastics
Main chain	All Carbon atom	O, N is periodically inserted
Secondary bonding	Dipole-dipole moment	PA: hydrogen bonding PBT, POM: Van Der Waals
Characteristics	High elongation & impact Generally good chemical resistance	High stiffness Vulnerable to humidity and several chemicals (humidity, steam, CaCl ₂ , chloramine etc)

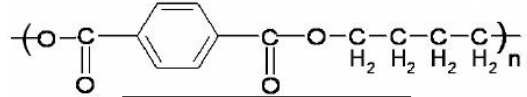


PA



Hydrogen bond
Carbon-Nitrogen main chain

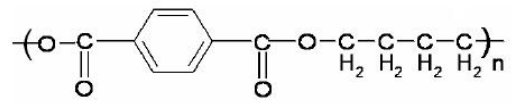
Greatly absorbs humidity
Weak at CaCl₂



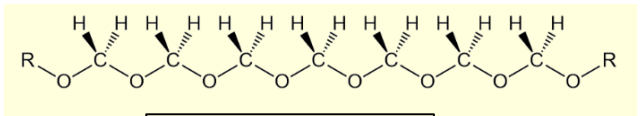
PBT

Van Der Waals forces
-COO- main chain

Hydrolysis can occur
at steam exposure

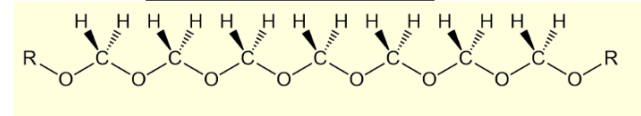


POM



Van Der Waals forces
-C-O- main chain

Weak at chloramine
(Br+Cl detergent)



3. Chemical Resistance: PK vs. other Engineering Plastics

PK is the only engineering plastic with all carbon main-chained back-bone . It gives generally good chemical resistances compared with other engineering plastics which contain O, N atoms in their back bone.

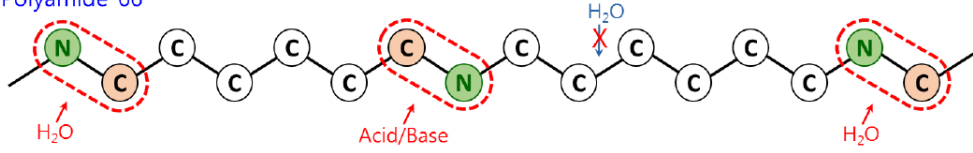
C
Chemical Resistance

against POM

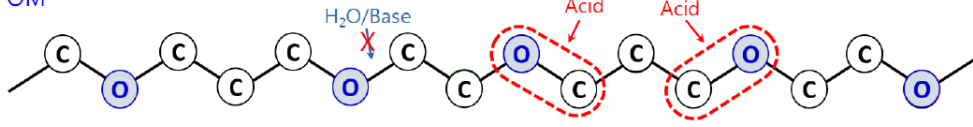
against PA

- PA : Amide Group (-NH-CO-) is weak to Water/Acid/Alkaline
- POM : Ester (R-O-R') group is degraded by acid
- PK : Main Chain is composed with only C-C, so stable to Water/Acid/Alkaline

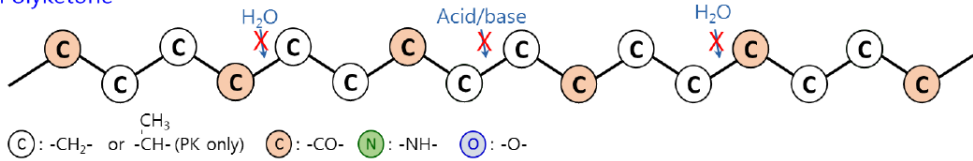
Polyamide 66



POM



Polyketone



	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	●	●	●	○	●	●	●	●	●	●

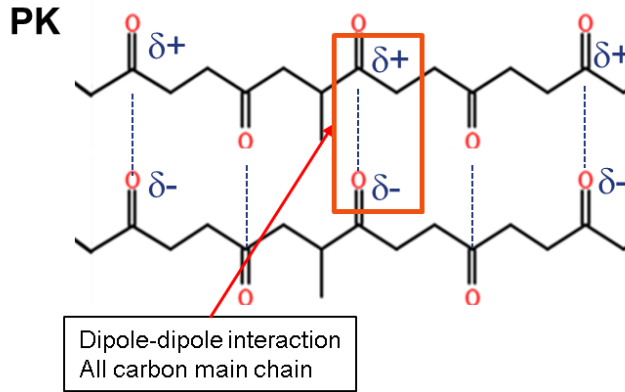
○ : Resistant

● : Not Resistant

3. Key Mechanical Properties Comparison: PK vs. other Enpla.

PK's secondary bonding is dipole-dipole interaction. This gives balanced mechanical properties between stiffness and toughness.

Compared with other engineering plastics, PK's position lies in toughness orientated properties.

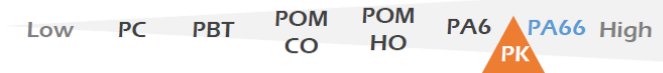


Items	Unit	PK M330	PA6	PA66	PBT	POM
Density	g/cm ³	1.24	1.14	1.14	1.30	1.41
Melting Point	°C	222	220	260	220	160
Notched Charpy	kJ/m ²	9.0	5.2	4.6	5.0	6.5
Tensile Strength	MPa	60	80	80	55	65
Elongation at Break	%	>250	<100	<80	16	35
Flexural Modulus	MPa	1,550	2,600	2,900	2,400	2,500

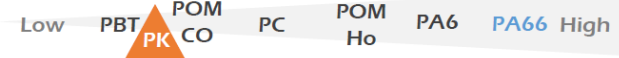
Density



Heat distortion resistance(HDT)



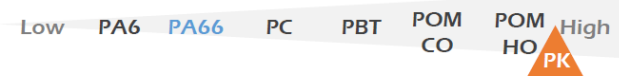
Tensile Strength(Yield)



Toughness



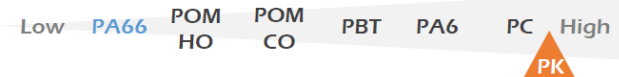
Elongation(Yield)



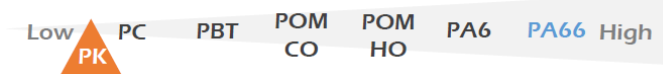
Hardness



Flexibility









Young's Modulus



4. Wear Resistant PK Portfolio

Hosung POKETONE provides 6 wear resistant compounding grades.

By adding optimized additives, POKETONE wear resistant grades give best balance of wear properties and toughness with eco-friendliness and human life sustainability.

Category			Wear Resistant					
Grade name			M33AT2E	M33AG2T	M63AM2A	M33AR3B (M33R3A000)	M33AS1A	M63AS1B
Physical Properties	Test Method	Unit						
Density	ASTM D792	g/cm ³	1.29	1.35	1.31	1.23	1.24	1.24
Filler content(GF, MF)	ASTM D5630	wt%	0	10	10	-	-	-
Mechanical Properties	Test Method	Unit						
Tensile Strength	ASTM D638	MPa	50	68	59	45	60	55
Elongation at Break	ASTM D638	%	39	8	77	150	200	135
Flexural Strength	ASTM D790	MPa	52	102	71	42	57	53
Flexural Modulus	ASTM D790	MPa	1530	3150	2400	1100	1500	1500
Notched izod	ASTM D256	J/m	87	132	130	200	76	165
Thermal Properties	Test Method	Unit						
Melting Temperature	ASTM D3418	°C	222	222	222	222	222	222
MFR 240°C, 2.16kg	ASTM D1238	g/10min	20	17	0.2	50	49	6
Grade Characteristics			PTFE/Si	PTFE/Si + GF	High Viscosity PK + MF	Si/TPU	Si	High Viscosity PK + Si
Main Application			Frame for Protective Glasses, caster wheel	Sucker rod guide	Carrierplate for Automotive Ball Bearing Joint	Door closer for Refrigerator	ATM Gear	Conveyor belt Sucker rod centralizer
Device Photographs								

5. When to USE WEAR RESISTANT PK

We recommend WEAR RESISTANT POKETONE when the parts will be subject to:

- wear parts which is directly exposed/near to human body, so harmlessness is especially required
- environment with humidity at RT, and dimensional stability is needed.
- environment with both wear, and impact/chemical resistance.
- environment with both wear and noise reduction.
- lubrication such as grease is avoided



We do not recommend WEAR RESISTANT POKETONE when the parts will be subject to:

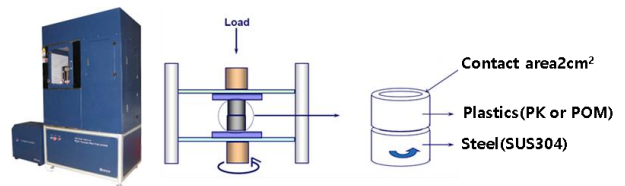
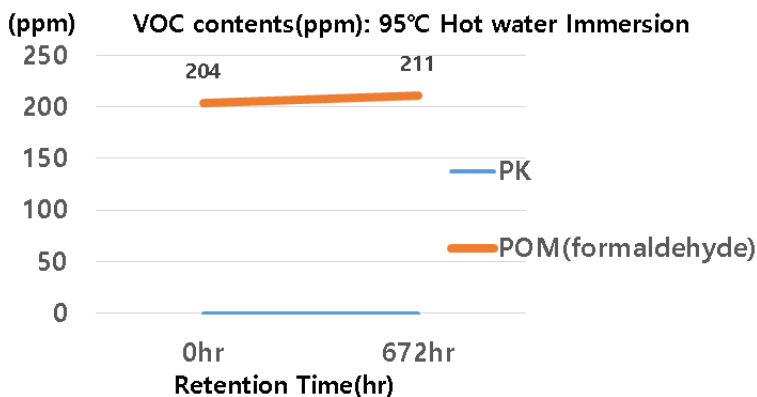
- long term heat or heat + humidity exposure above $> 90^{\circ}\text{C}$
- discoloring issue is critical (we suggest black grade)
- under strong acid or base
- current material is super engineering plastic (PEEK, PSU), and needed the same stiffness/strength & thermal resistance.

6. Wear Performance Comparison – JIS K7218

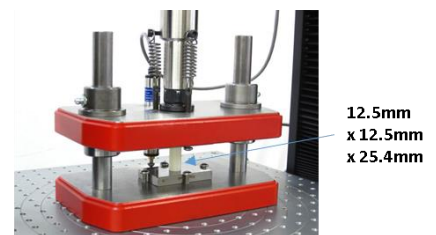
High Viscosity Poketone – as an Alternative for high Performance homo-POM

Need to find an alternative for homo-POM due to formaldehyde issue, or its low service temperature? High Viscosity PK M630/M640/M730 and mineral filled M63AM2A are good Candidates.

Properties	unit	M630	M63AM2A	M640	M730	High Performance Homo-POM	comments	
Filler content	wt%	-	10	-	-	-	Mineral filler	
Resin Melting Point	°C	220	220	230	220	180	-	
density	g/cm ³	1.24	1.31	1.24	1.24	1.42		
MFR(240°C, 2.16kg)	g/10min	6.0	1.9	6.0(250°C)	2.0	2.0(190°C)		
Mechanical properties (ISO)	Tensile Str.	MPa	58	59	64	58	72	-
	Elong. at break	%	>200	77	>200	>250	31	
	Flexural Str.	MPa	57	71	58	48	90	
	Flexural Mod.	GPa	1.3	2.5	1.5	1.2	2.8	
	N. Charpy	kJ/m ²	15.0	13.2	16.0	19.0	13.9	
ASTM D695 compression	Compressive Strength	MPa	84	77	114	96	89	-
Ring on Ring vs. SUS 304	Wear amount	1/100g	0.66	0.06	0.06	0.04	1.32	80N,100rpm, 3km



Ring on Ring tester(JIS K 7218)



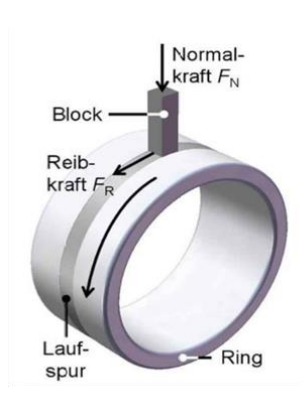
Compression Tester(ASTM D695)

6. Wear Performance Comparison - ASTM G-137

High Viscosity Poketone – as an Alternative for high Performance homo-POM

Under high temperature wear application, PK M630 shows steady wear resistances due to its higher melting point, whereas POM melts under high load/temp and loses its wear resistance.

PK M630/PA66			POM/PA66			Test condition		
Block	Ring	Wear rate (um/h)	Block	Ring	Wear rate (um/h)	load (MPa)	Velocity	Temp. (°C)
PK M630	PA66	0.5	POM	PA66	2.0	5	0.7m/s (26.7 rpm)	130
		1.8			3.1	10		
		2.0			4.0	15		
		3.1			14.0	20		
		21.0			53.0	25		
		86.0			melting	30		
		-			melting	35		
		5			6	15	0.7m/s (26.7 rpm)	140
		10			30			150
		14			42			160
		16			3,202			170
		19			melting			180
		21			melting			190

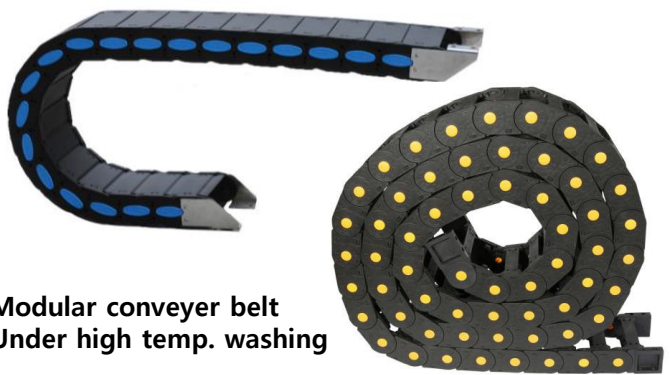


ASTM G-137 Block on Ring

High Viscosity Poketone can be good candidate on the application with high temperature treatment(plating, washing etc) and high humidity on which POM or PA6, PA66 cannot stand wear resistant due to its lower service temperature or high water absorption.



Ball Bearing Joint Under high temp. plating



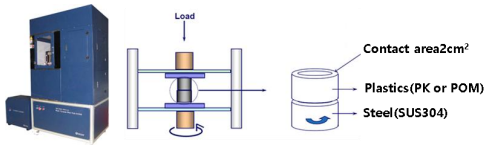
Modular conveyer belt Under high temp. washing

6. Wear Performance Comparison – JIS K7218

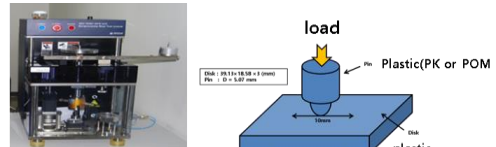
Silicon Lubricated POKetone – Excellent wear resistant material

We also provide Silicon lubricated Polyketone with various base resin - M330, M630, M730 and various type of Silicon additives.

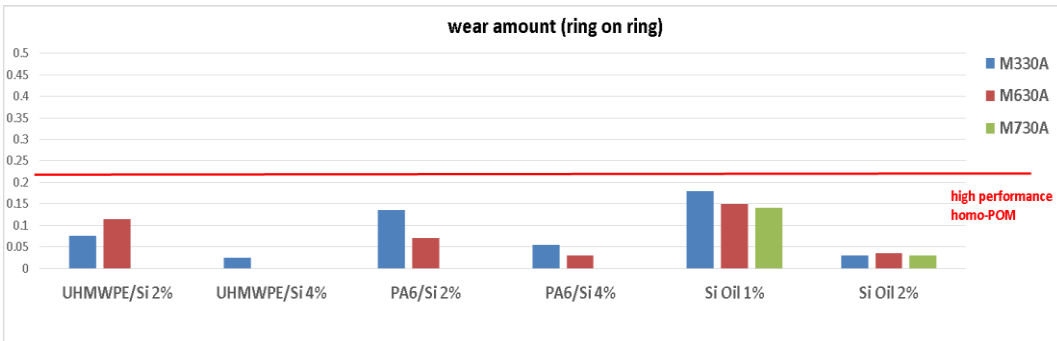
Materials		Commercialized grade	Ring on ring wear 80N, 100rpm, 3km(2hr)		Pin on disc wear 100N, 3Hz, 0.65km(6hr)	
			Frictional coeff.	Wear amount (1/100g)	Frictional coeff.	Wear amount (1/100g)
High Performance Homo-POM		-	0.07	0.23	0.30	0.50
M330A	UHMWPE/Si M/B 2%	yes(M33AS1A/B)	0.11	0.08	0.12	0.07
M630A		yes(M63AS1A/B)	0.11	0.12	0.13	0.06
M330A	UHMWPE/Si M/B 4%	No	0.05	0.03	0.07	0.03
M330A	PA6/Si M/B 2%	Not currently	0.13	0.14	0.13	0.11
M630A		Not currently	0.05	0.07	0.12	0.09
M330A	PA6/Si M/B 4%	No	0.10	0.06	0.09	0.02
M630A		No	0.10	0.03	0.08	0.02
M330A	Si Oil 1%	No	0.17	0.18	0.21	0.42
M630A		No	0.09	0.15	0.22	0.3
M730A		No	0.06	0.14	0.20	0.26
M330A	Si Oi 2%	No	0.06	0.03	0.08	0.13
M630A		No	0.05	0.04	0.06	0.11
M730A		No	0.05	0.03	0.07	0.16



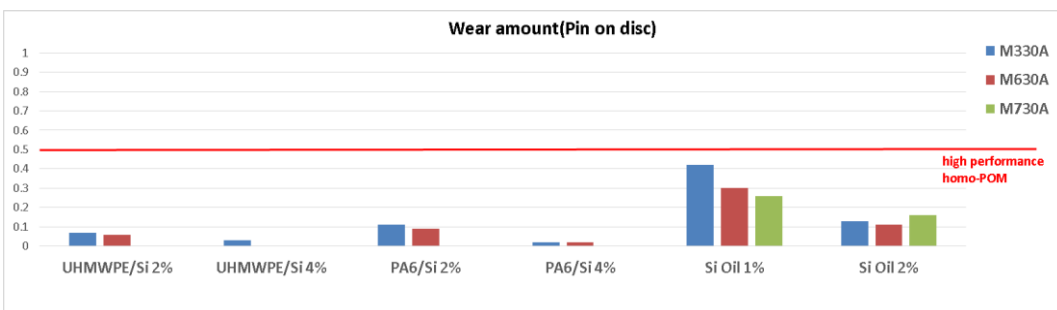
Ring on Ring tester(JIS K 7218)



Pin on disc tester(JIS K 7218)



Rotational wear



Reciprocated wear



· Excellent Wear Resistance · Low Noise · Low abrasion loss (no particle) · Excellent chemical resistance

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HYOSUNG POLYKETONE

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