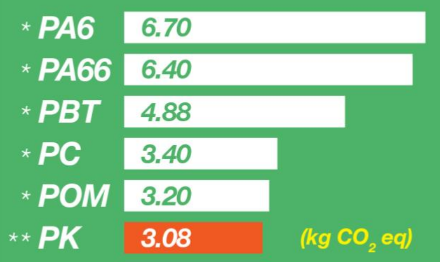
# POKETONE Tubing Material

## Global Warming Potential




* 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*

HYOSUNG CHEMICAL

# Polyketone(PK) Chemical Structure

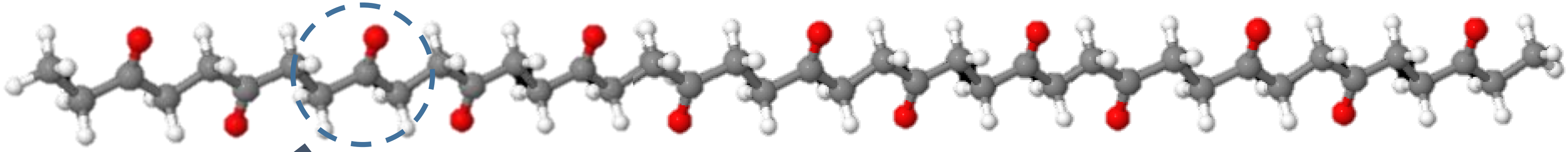
**Polyketone**

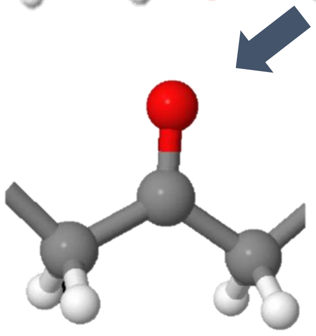
a family of
Semi-crystalline aliphatic Polyketone,
made of **CO** and **olefins**

**Made of**

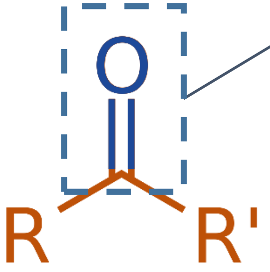
Carbon Monoxide + Olefins

Polyketone





a Ketone



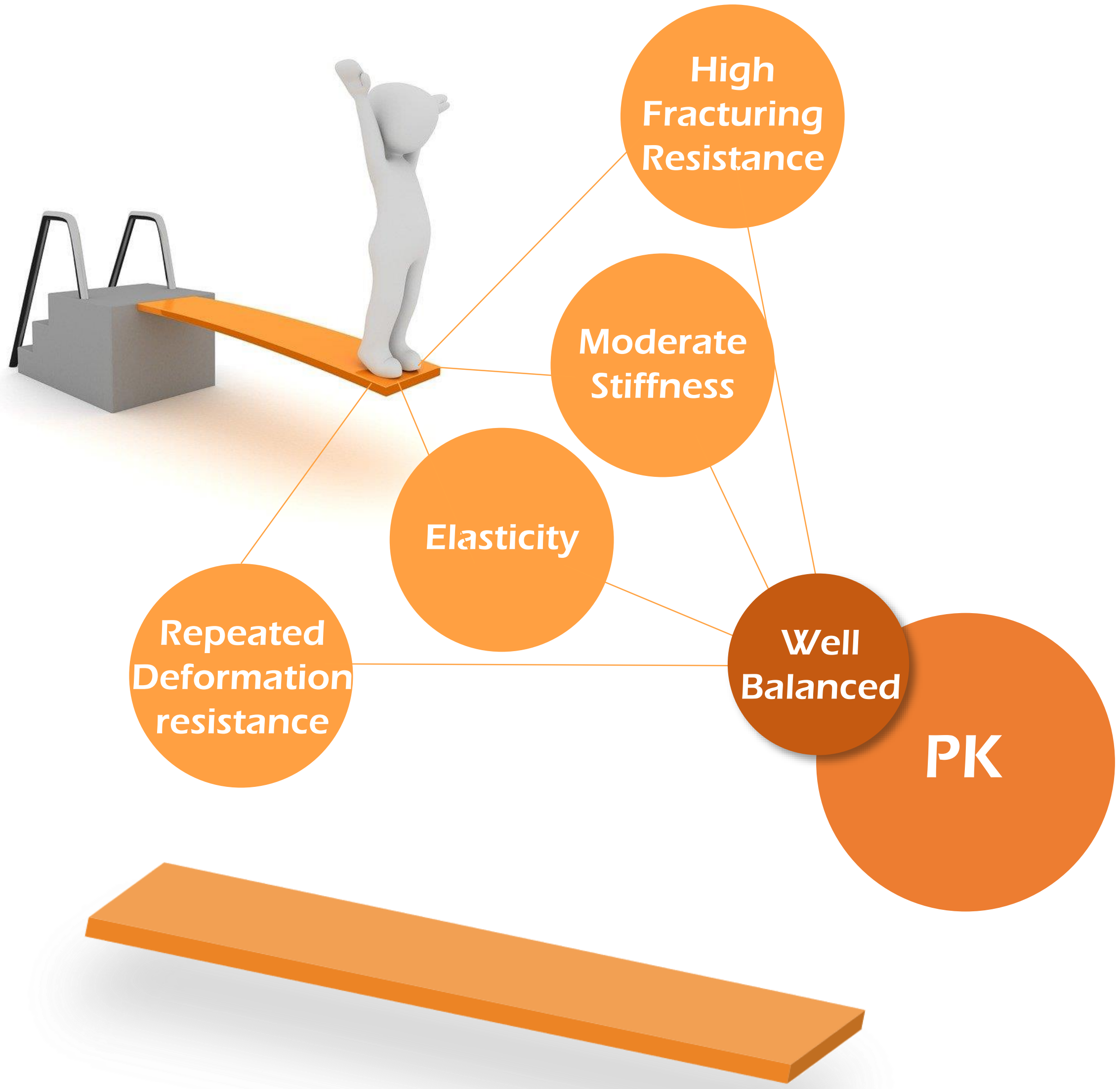

a Ketone

**Carbonyl Group**: Polar
The Oxygen sucks electrons from the carbon

Creating a strong attraction between polymer chains. ⇒ High Melting Point
Strong interaction

# What is so special about PK?

Imagine jumping on the PK springboard……




## Mechancal Properties

PK polymers can be characterized as strong, tough, and ductile. Tensile yield stress is 60MPa. Stiffness iss moderate, with tensile and flexural modulus of 1.5~1.7 Gpa. PK polymers also exhibit good retention of stiffness.

**Superior Resilience and Snapability**
Elongation at yield is very high(25%), and PK polymers can subjected to much larger(repetive) deformation than any other engineering plastics before permanent deformation occurs. PK polymers are also very resilient and well suited to snap-fir assemblies, allowing for relatively large design strain.

**Very good Impact Performance**
PK polymers' impact strength is unusually high and they exhibit a high level of ductility over a broad temperature range.

# What is so special about PK?

**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.

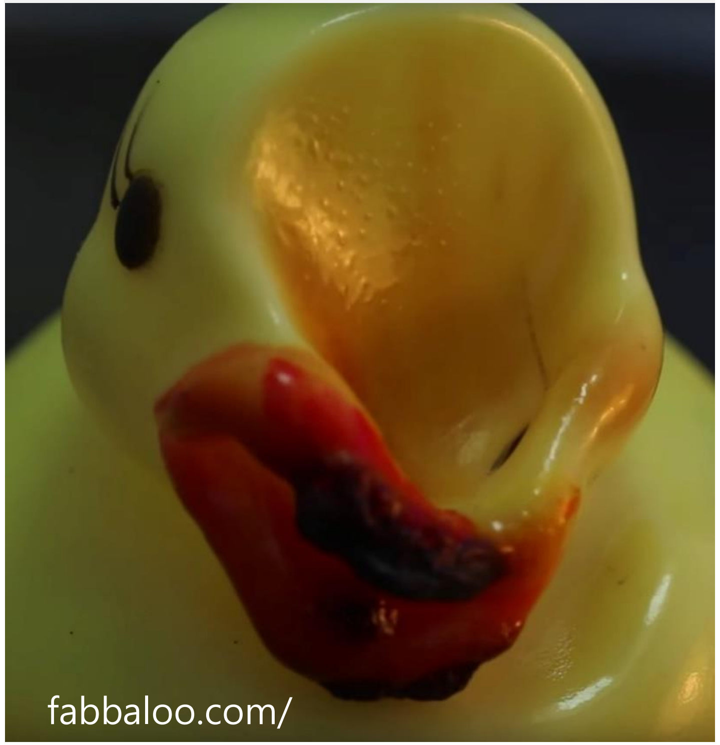
**Very Good Hydrolysis Stabiliy**
PK polymers are not susceptible to hydrolysis. They exhibit resistance to hydrolysis in a broad range of aqueous environment and absorb small amounts of water, resulting in almost no effect on strength

**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 is so special about PK?

**Good Barrier Performance**
PK Polymers are resistance to a wide range of chemicals an exhibit good solvent and fuel barrier performance. This makes them attreactive for use in pipe anc barrier packaging

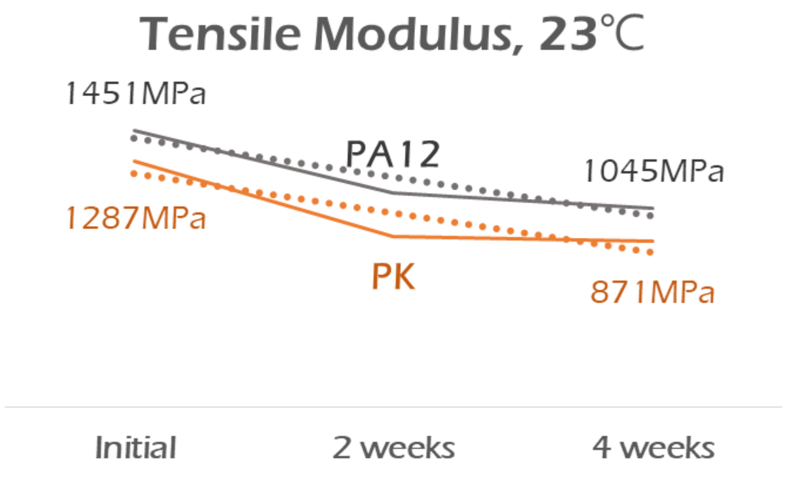
**Heat resistance**
PK have better thermal properties than many of the leading plastics with higher melt point at max 220℃, ) heat deflection temp. (210°C, at 0.46 Mpa). and VICAT softening point(195°C).

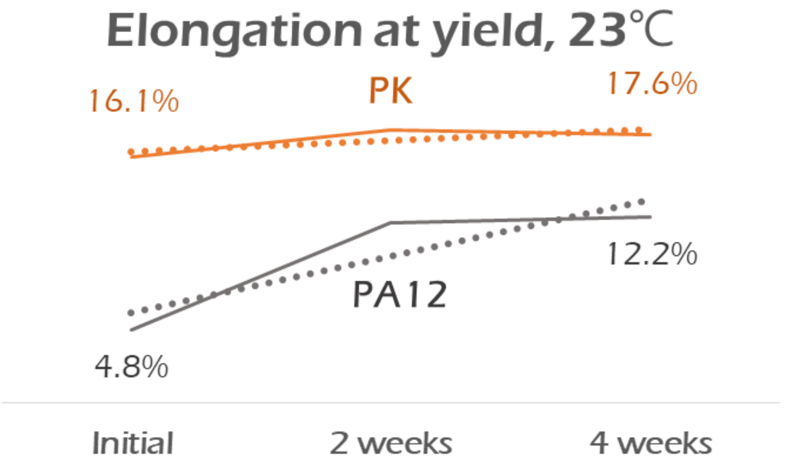


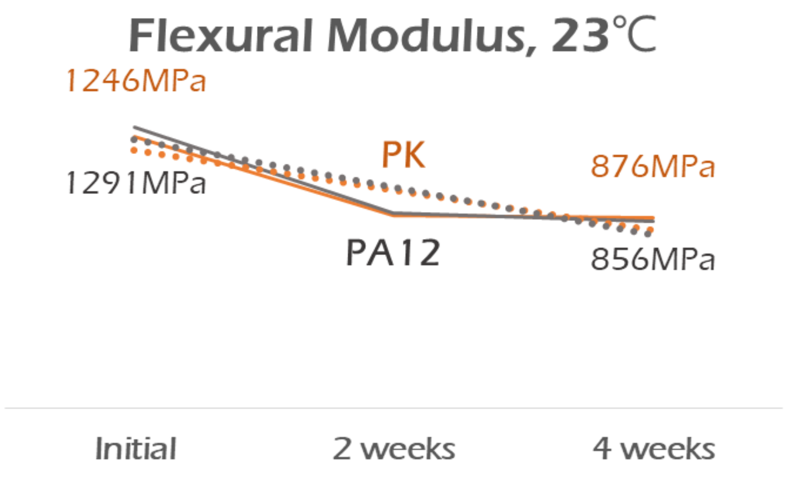

**Non-toxic**
For all the base grades, PK are filed with the FDA and used in the development of food contact and medical devices. They also safe with low to zero volatile organic compounds emission,.(VOCs)

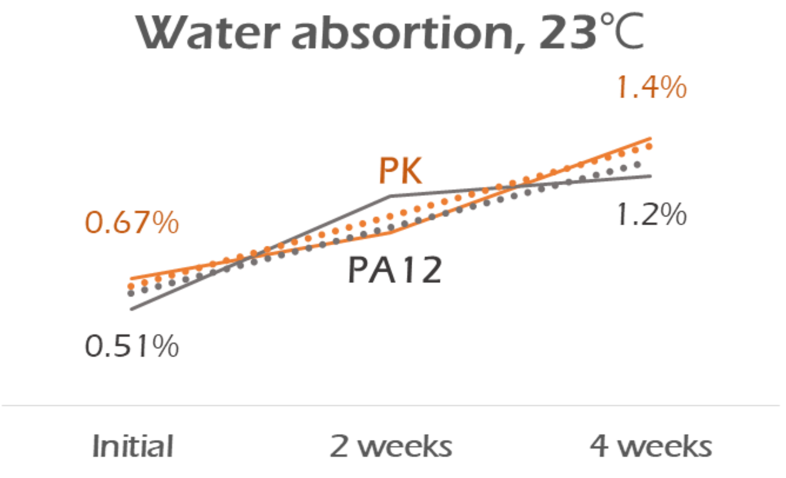
# PA12 vs PK

# PK vs PA12 Water resistance 23℃



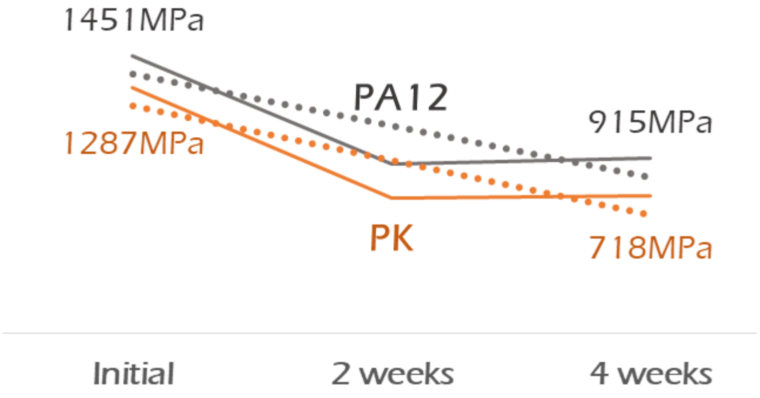



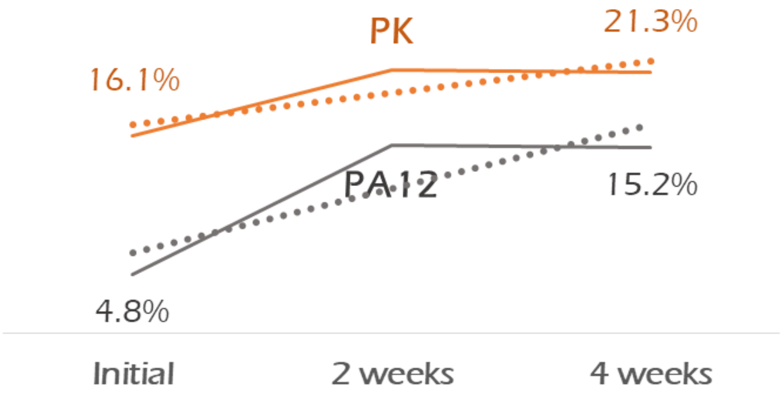

- Test Method: Water immersion
- Specimen: Injection Molded
- Material
  - PK: M710F
  - PA12: Base

# PK vs PA12 Water resistance 80℃

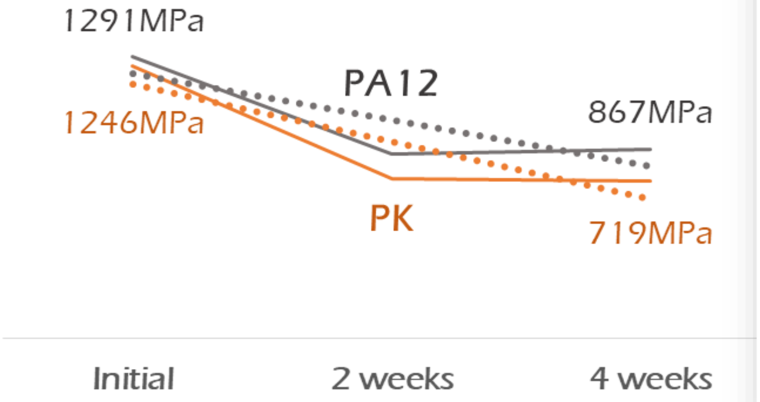
Tensile Modulus, 80℃



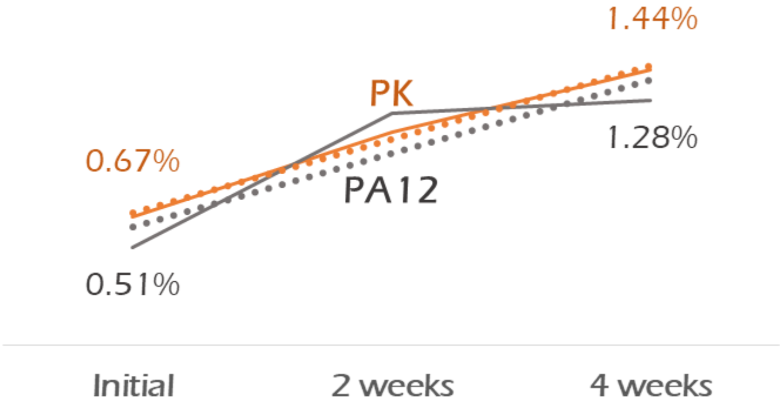

Elongation at yield, 80℃




Flexural Modulus, 80℃

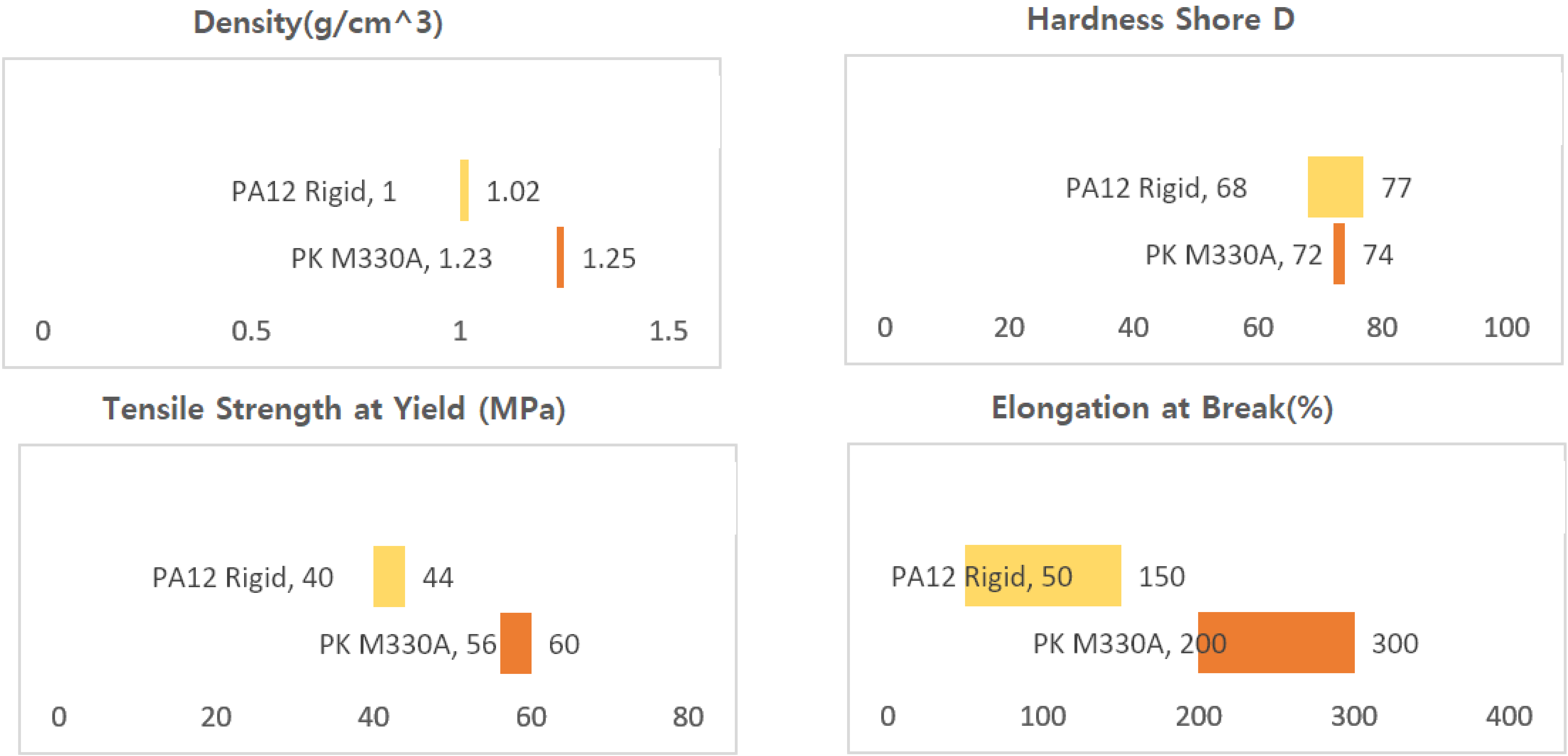



Water absortion, 80℃

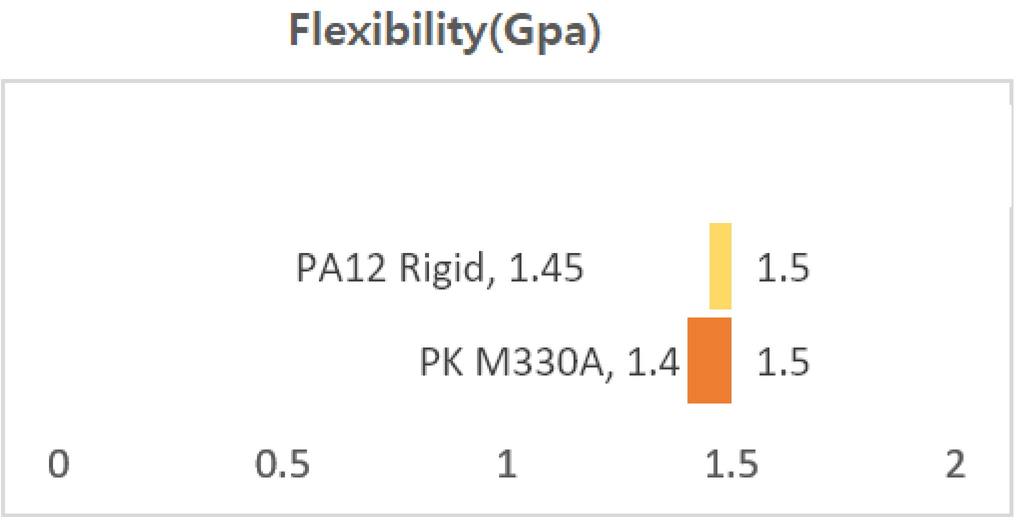


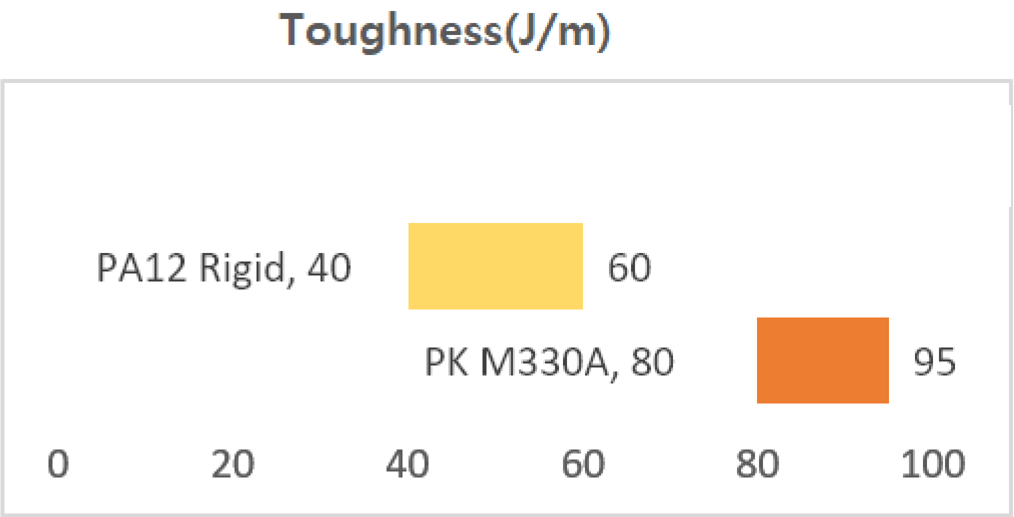

- *Test Method: Water immersion*
- *Specimen: Injection Molded*
- *Material*
  - *- PK: M710F*
  - *- PA12: Base*

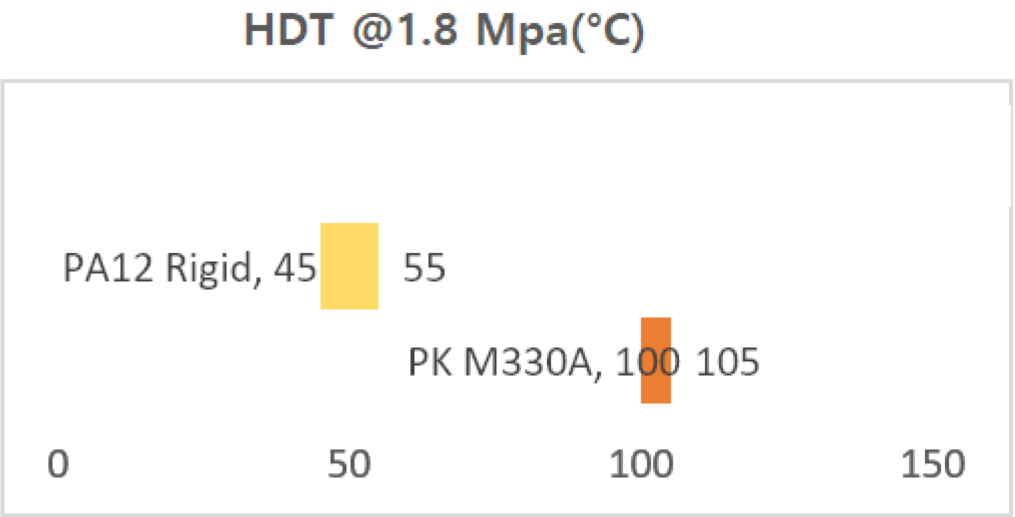
# PA12 vs PK Properties(Base)

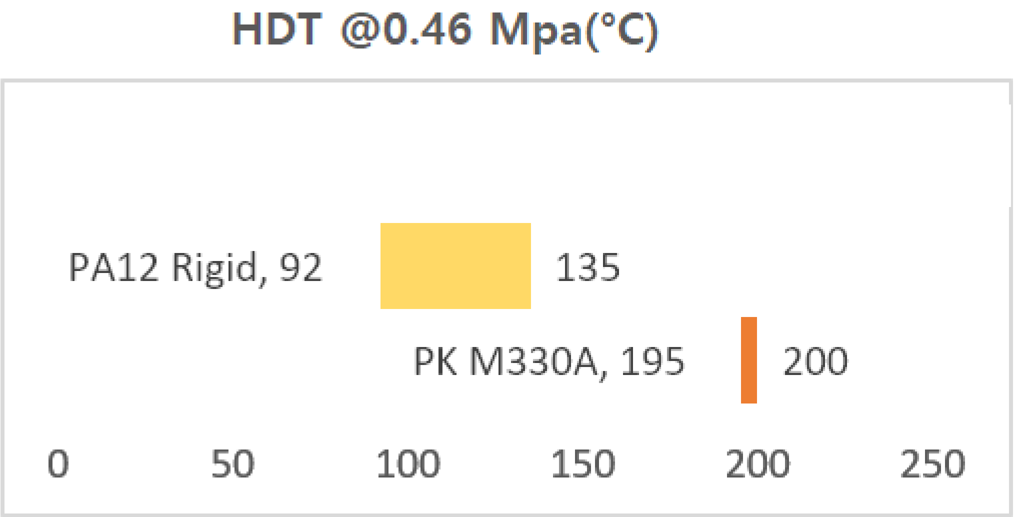


# PA12 vs PK Properties(Base)

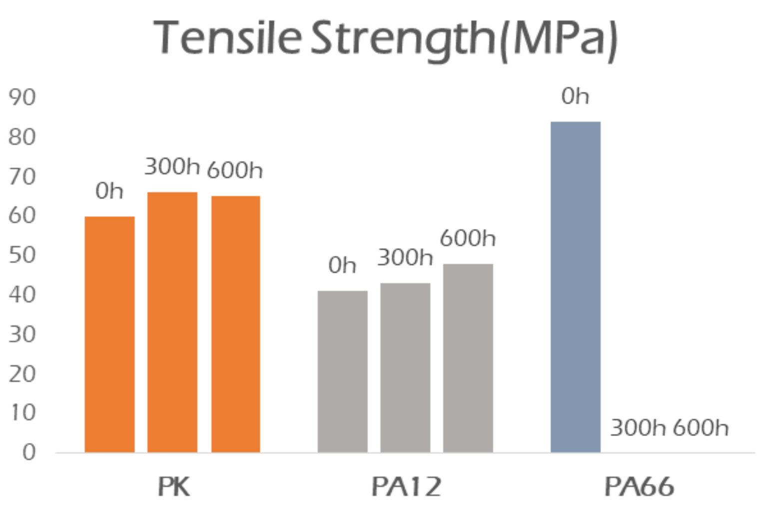


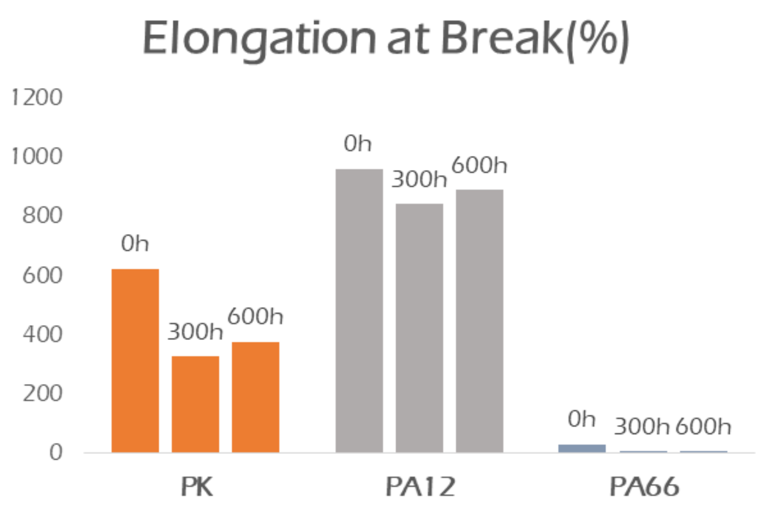



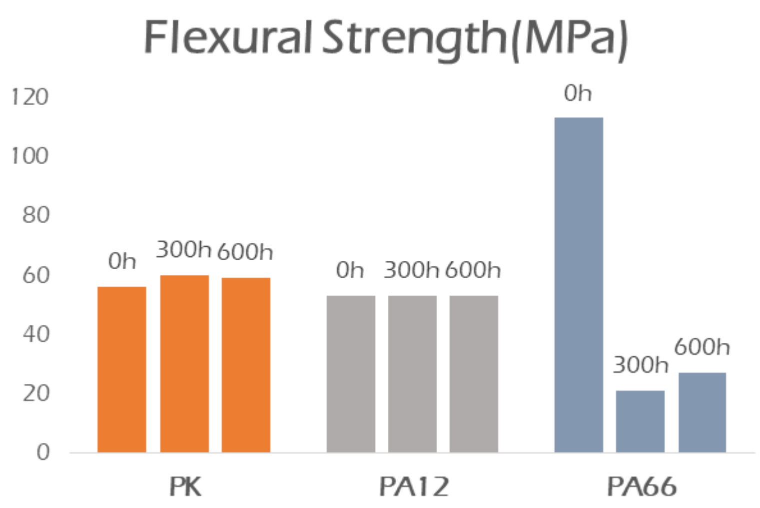



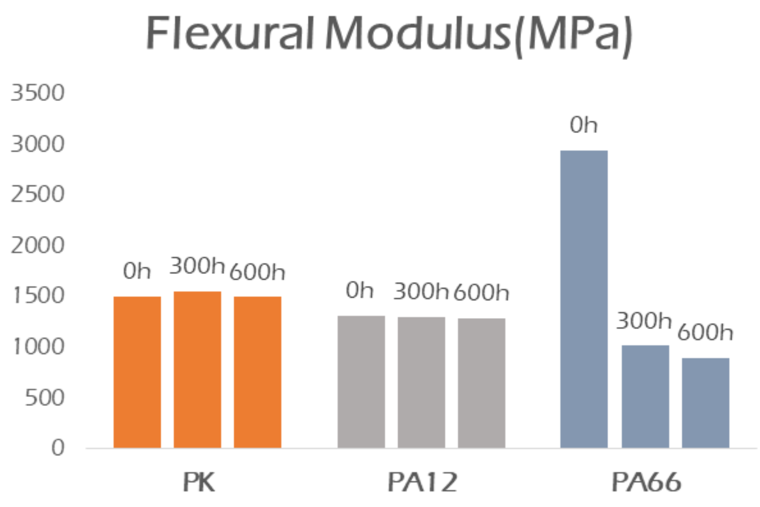
# PA12 vs PK Chemical Resistance: HCl 10% 23℃

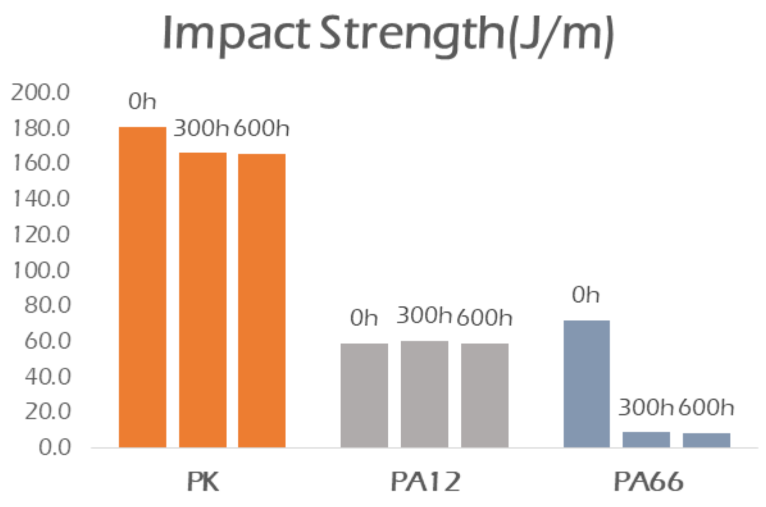


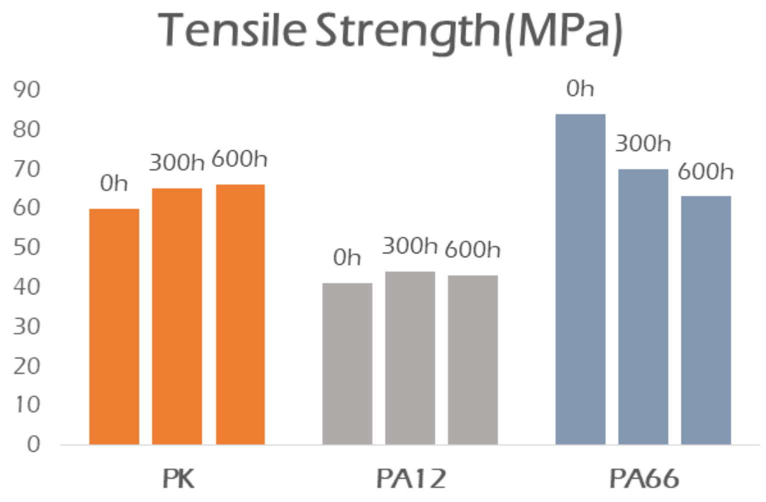

■ Materials
- ◎ PK: M630A
- ◎ PA12: 3***U
- ◎ PA66: 10**SL

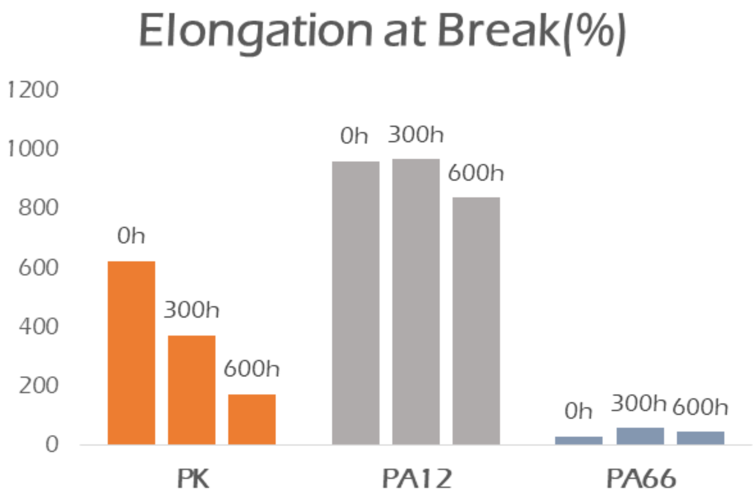


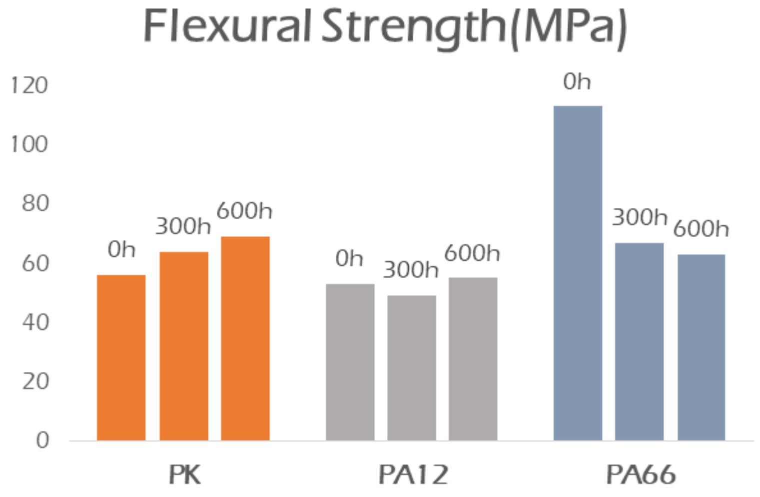



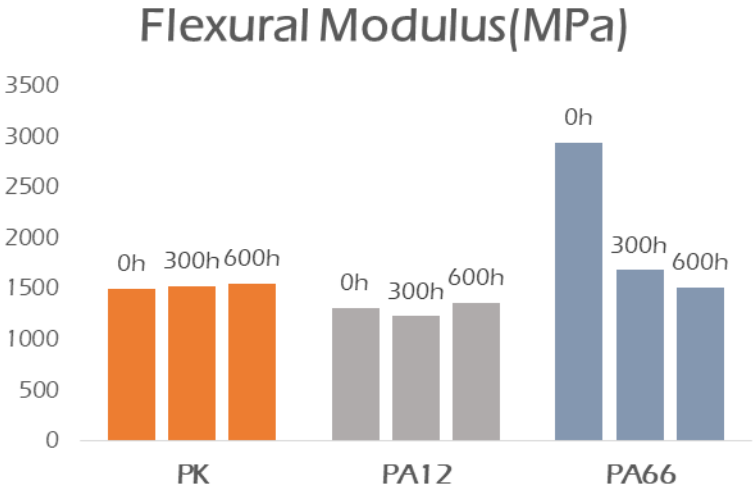
# PA12 vs PK Chemical Resistance: NaOH 10% 23℃

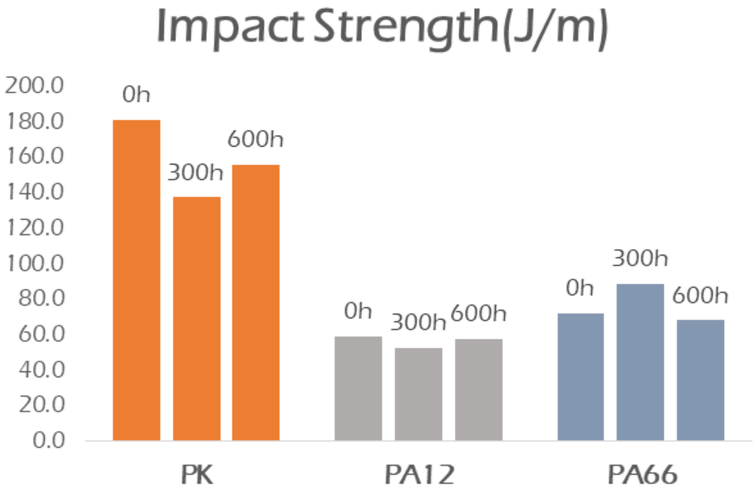


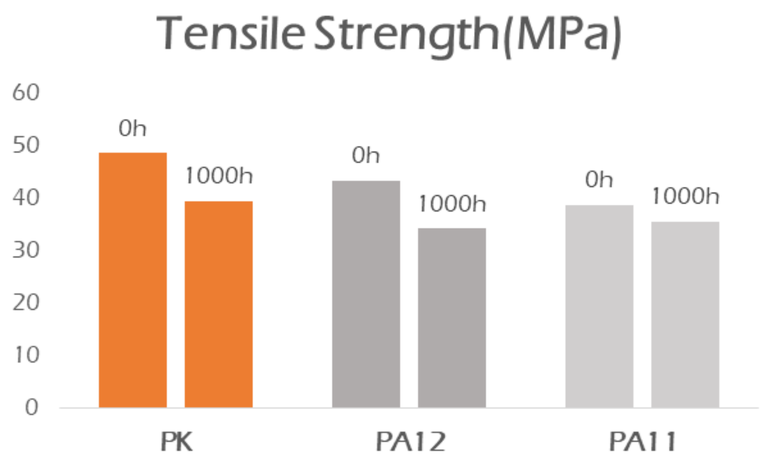

- Materials
  - PK: M630A
  - PA12: 3***U
  - PA66: 10***SL

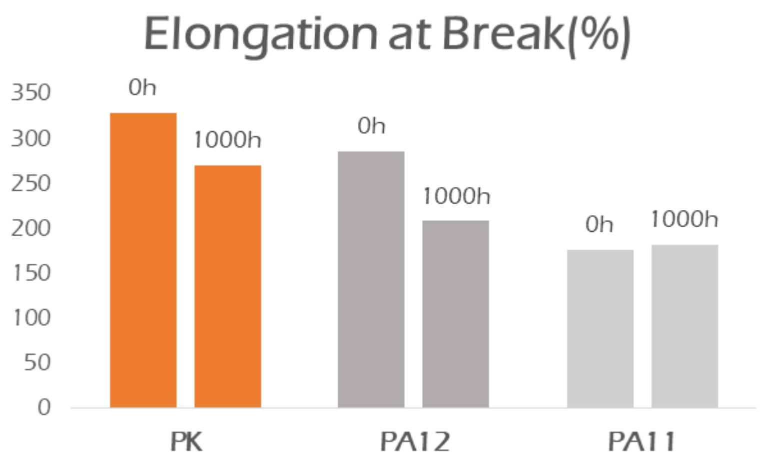


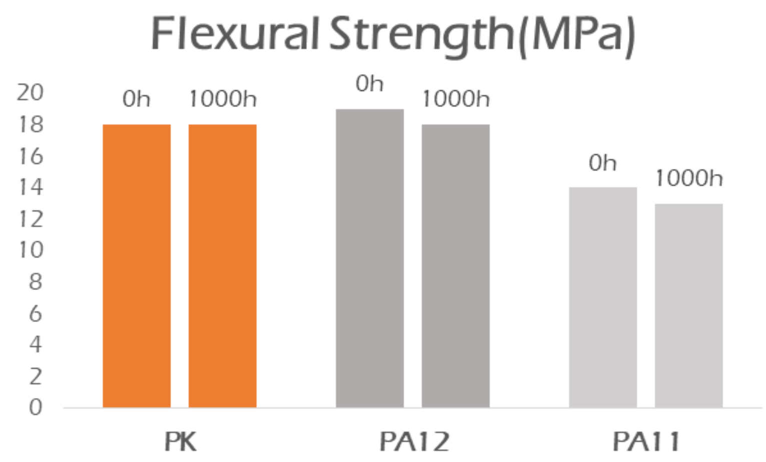
# PA12 vs PK Chemical Resistance: NaCl 5% 23℃

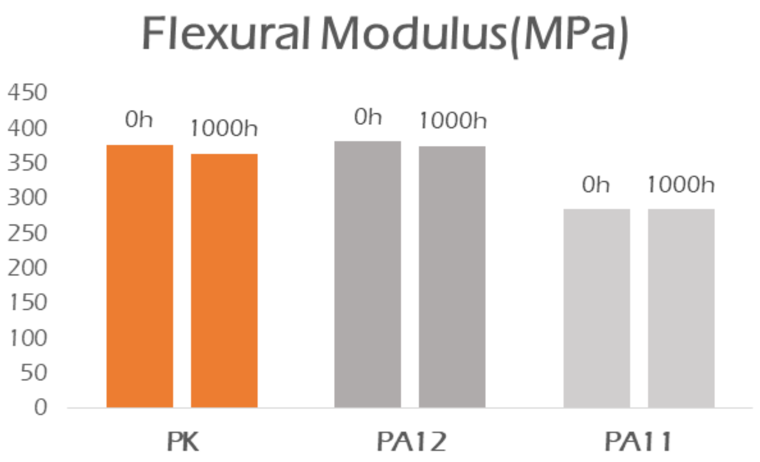


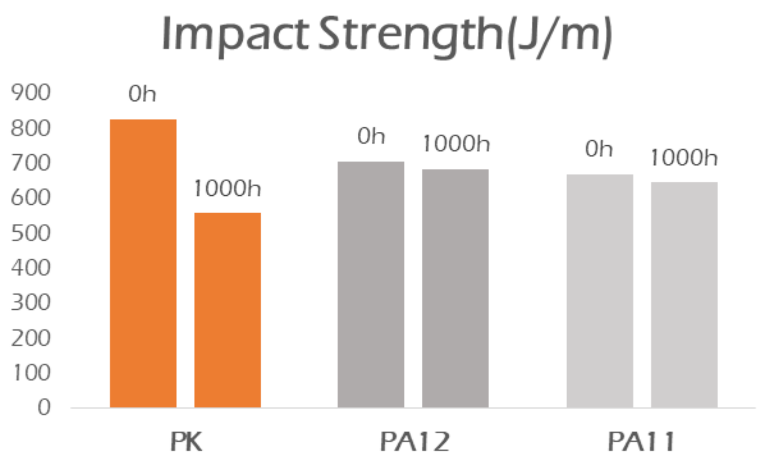




■ Materials

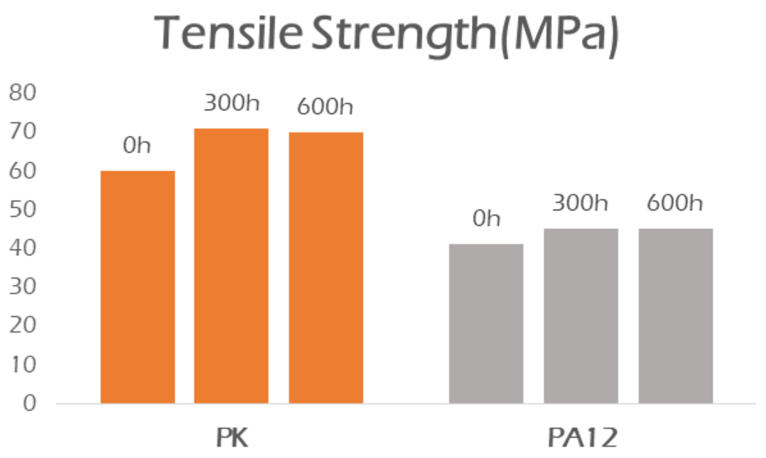
- PK: M710F Flexible
- PA12: X7**7
- PA11: BESNO *** TL

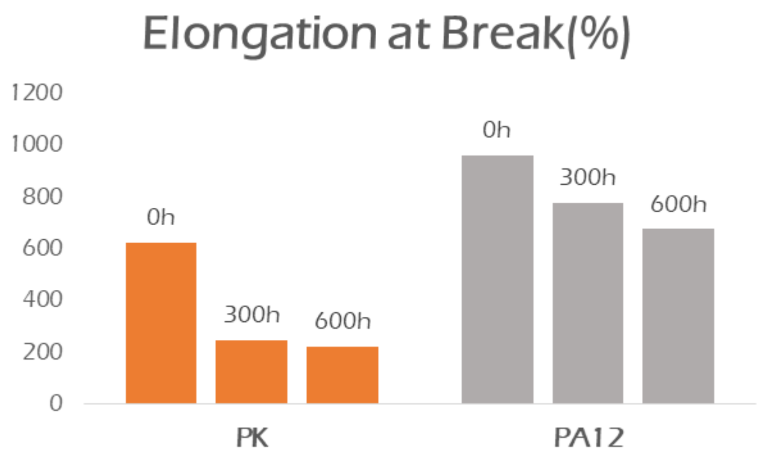


# PA12 vs PK Chemical Resistance: HCl 1% 80℃

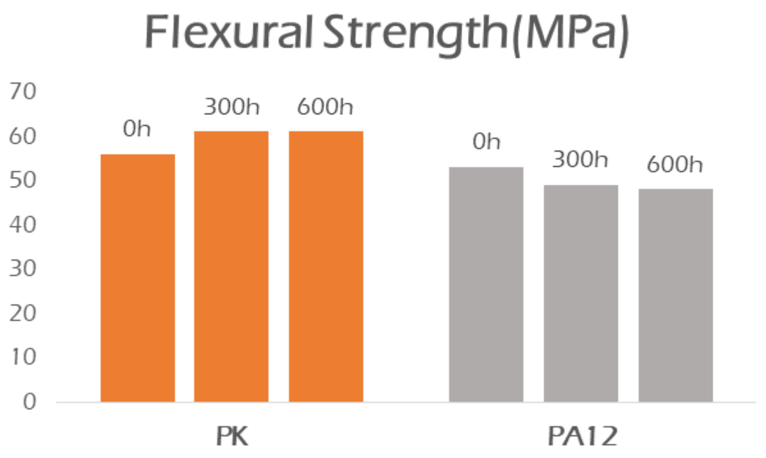


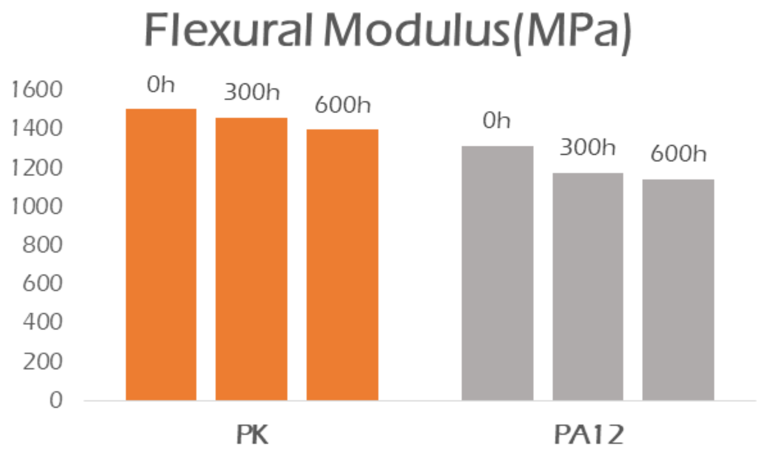



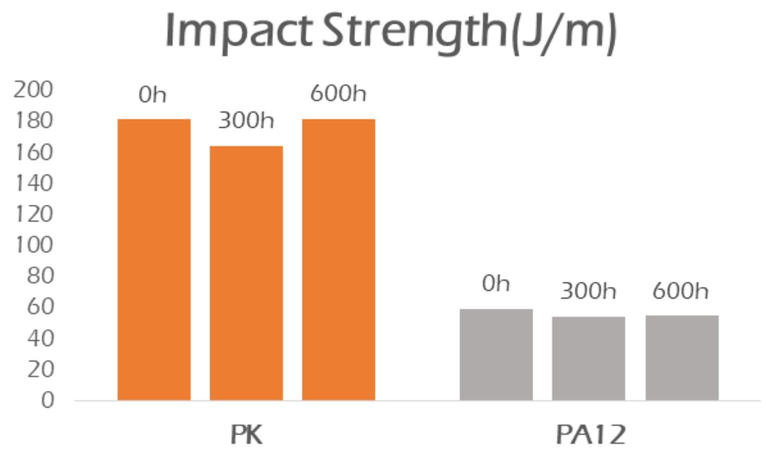

■ Materials

◎ PK: M630A

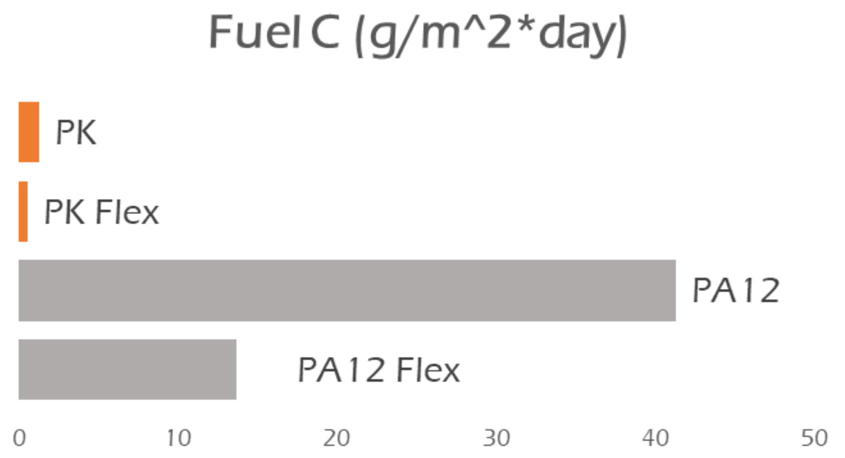
◎ PA12: 3***U



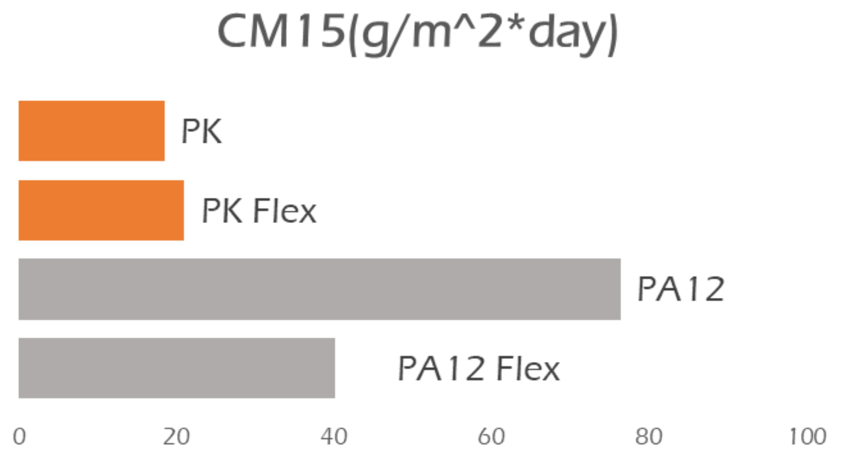



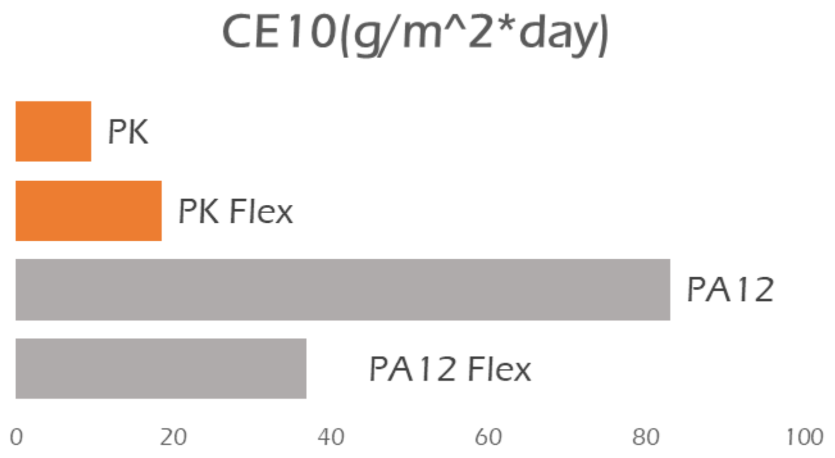



# PA12 vs PK Fuel Permeation

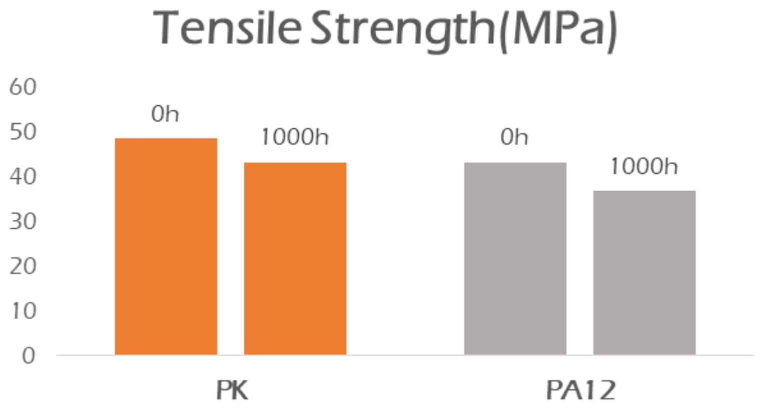


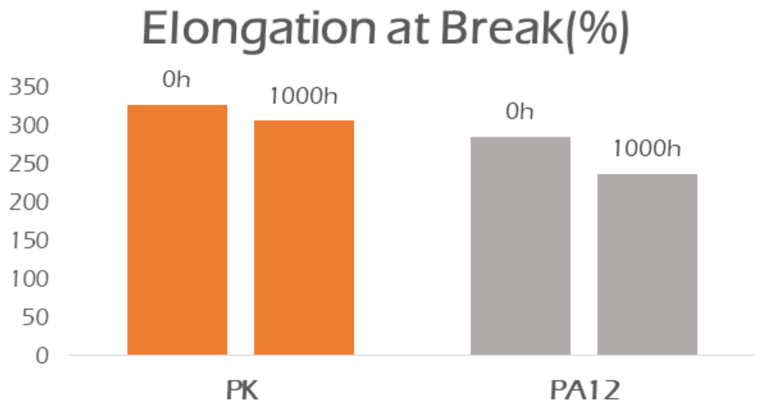

- **Test Standard** : SAE J2260 Permeability Test for Fuel Hose and Tubing
- **Test Method:** Measure weight change of fuel seal by tube [70days, 23℃]
- **Fuel**
  - ◎ Fuel C : Isooctane : Toluene = 50 : 50
  - ◎ CM-15 : Fuel C : MeOH = 85 :15
  - ◎ CE-10 : Fuel C : EtOH = 90 :10
- **Materials**
  - ◎ PK: M710U, PK Flexible
  - ◎ PA12: L1***, PA12 Flexible: X7**3



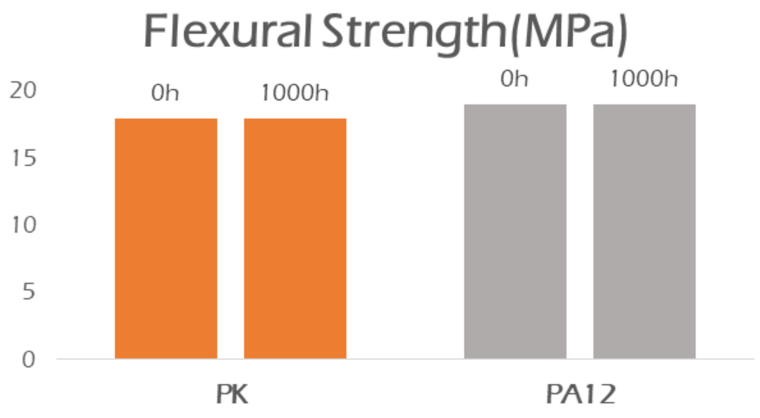



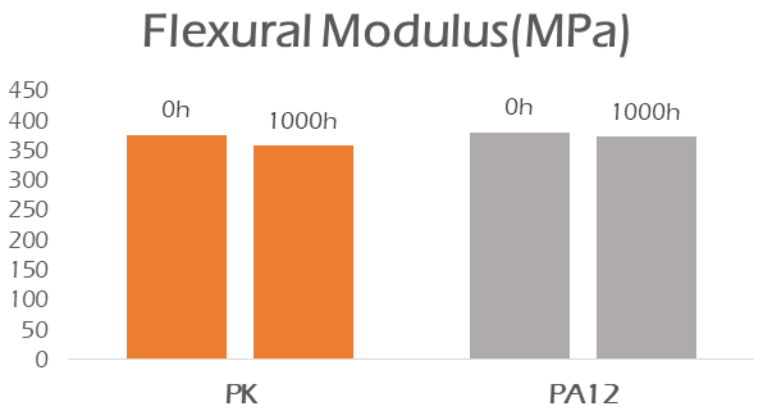

# PA12 vs PK Hydrolysis resistance

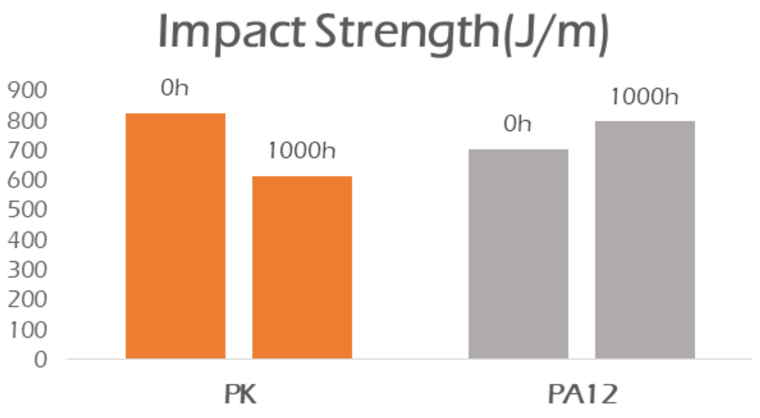


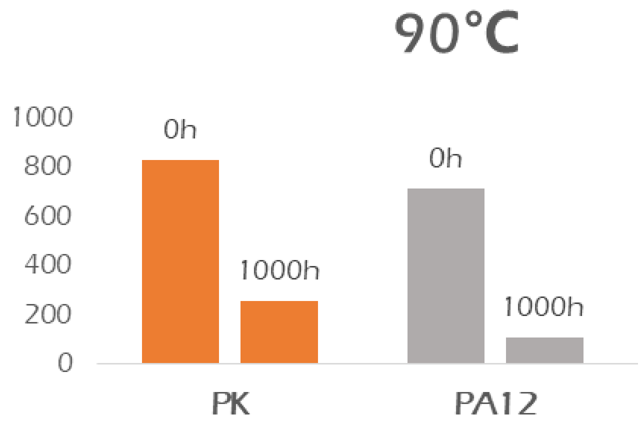

- **Materials**
  - PK: M710F Flexible
  - PA12: X7**7



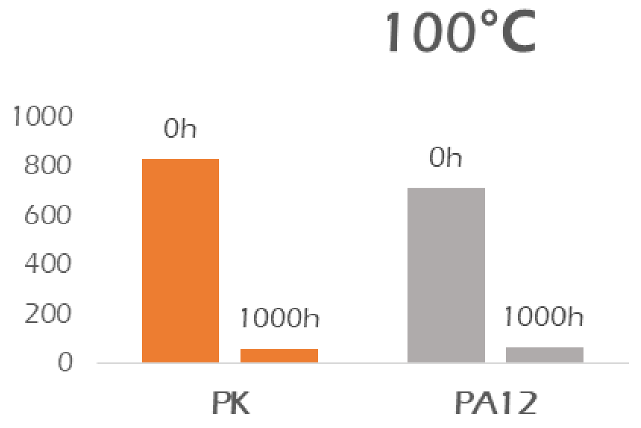



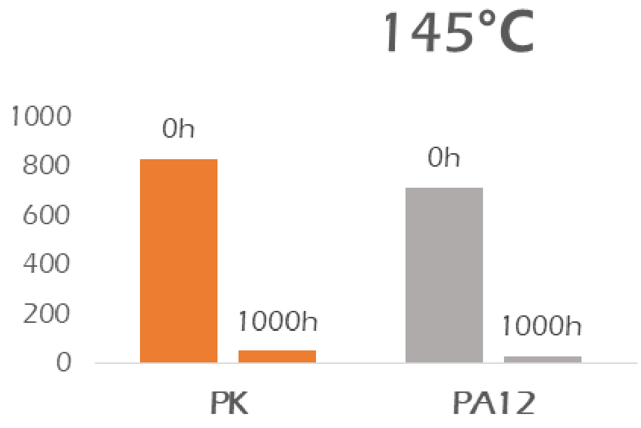



# PA12 vs PK Heat Resistance(Impact Strength J/m)

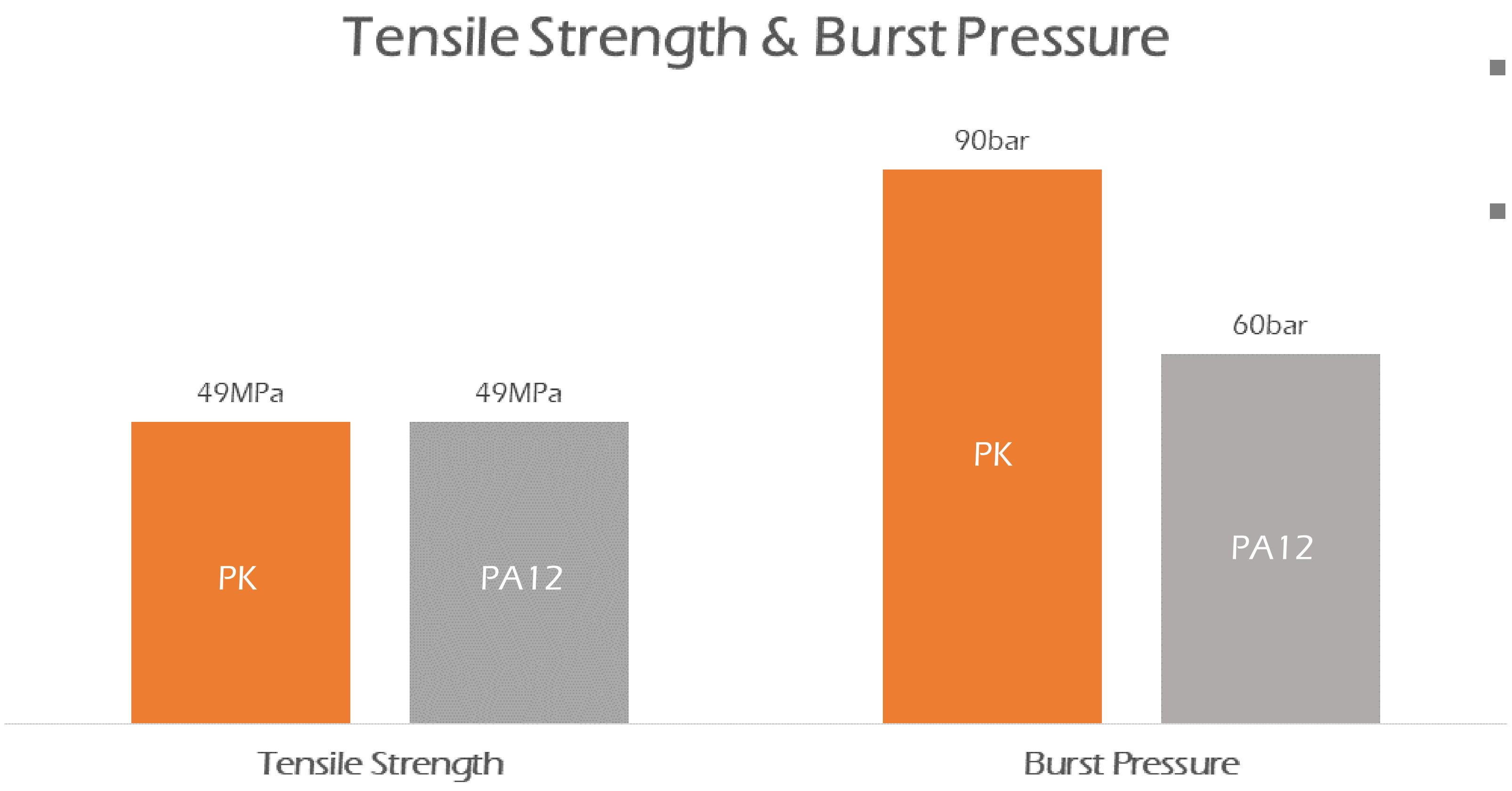



- Materials
  - PK: M710F Flexible
  - PA12: 30****X1



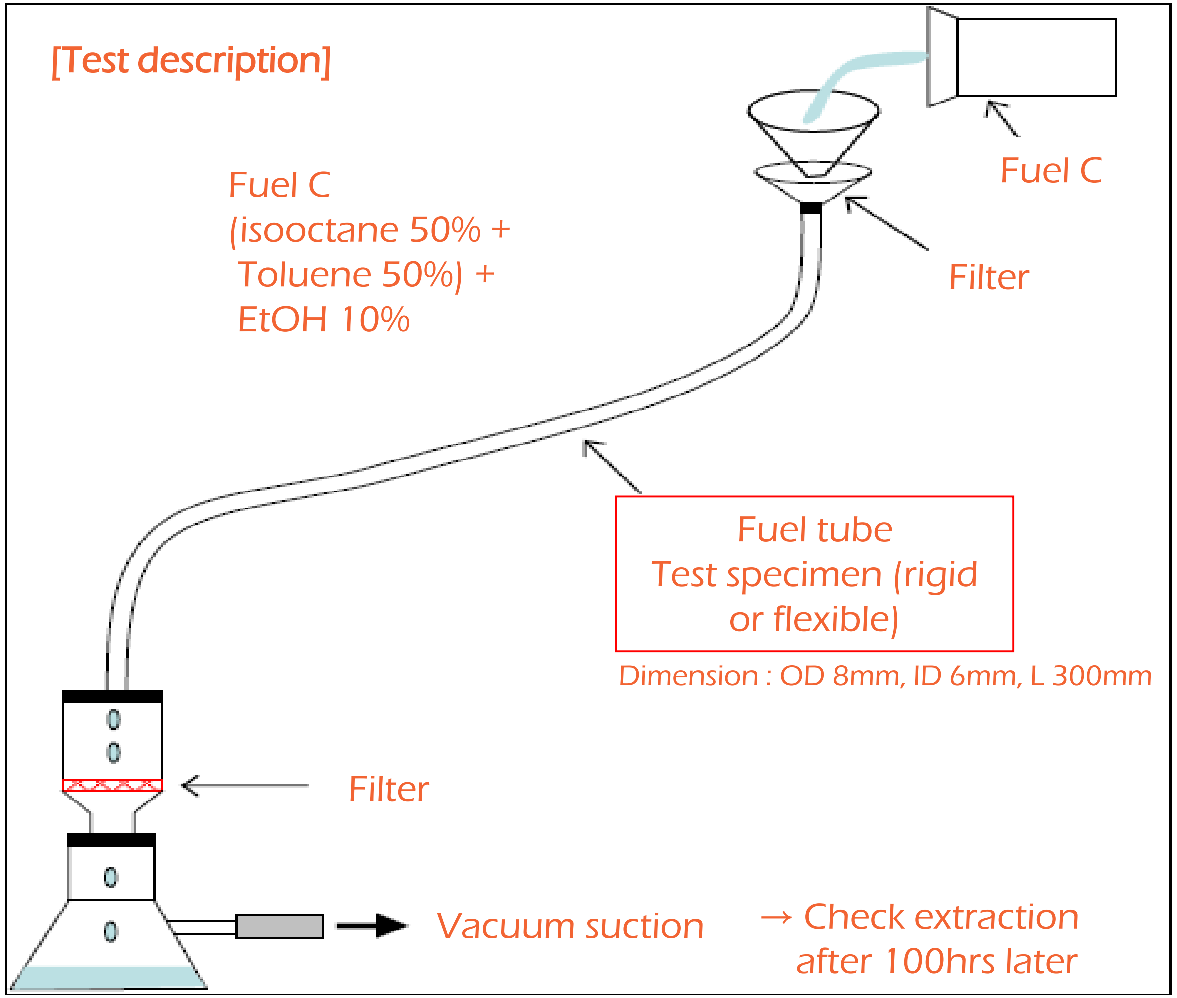



# PA12 vs PK Pressure resistance

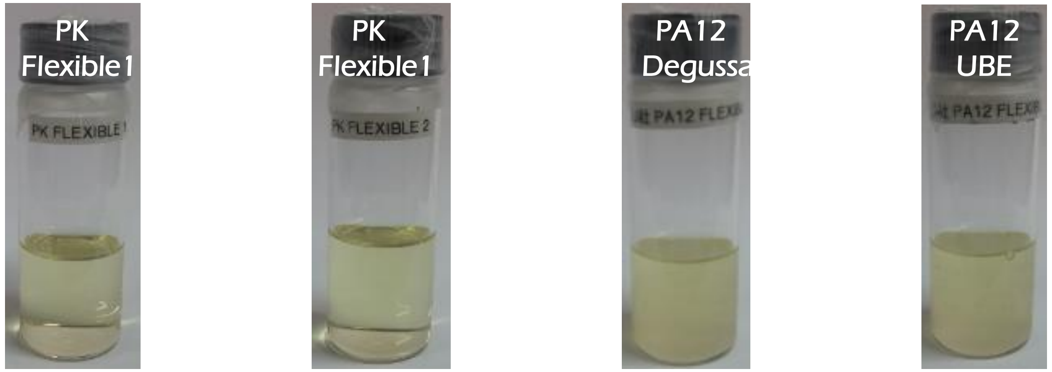



- Materials
  - PK: M710F Flexible
  - PA12: X7***
- **Tube:** OD 8mm ID 6mm

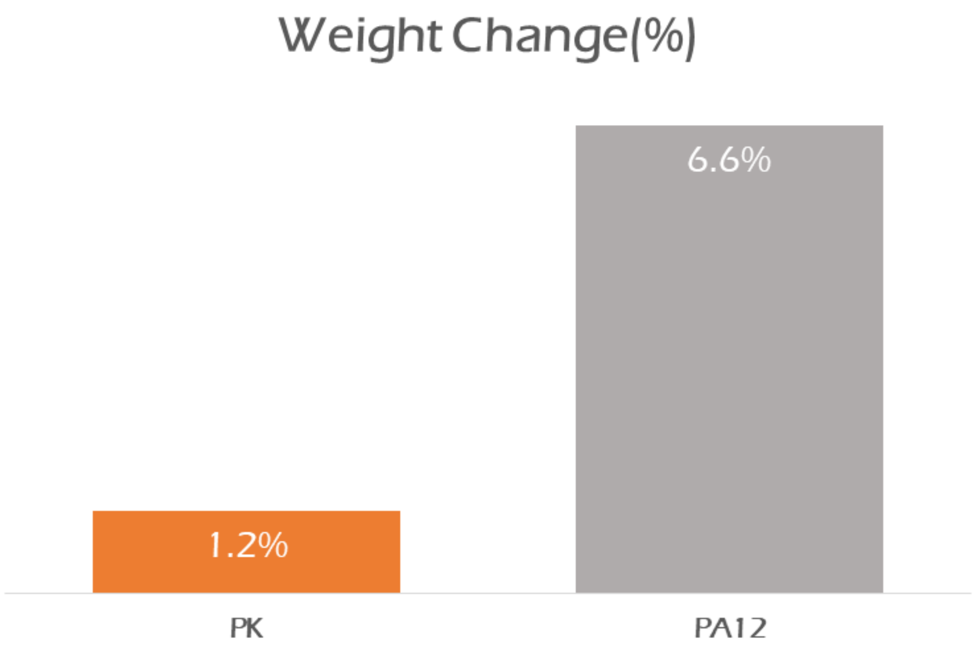
# PA12 vs PK Oligomer Extraction Test




| Grade | Extraction amount after 100hrs (unit : mg) |
| --- | --- |
| PA12 (X7**3) | 22.3 |
| PA12 (UBE 30***FX1) | 60.9 |
| PK base resin | 14.2 |
| PK Flexible 1 | 23.5 |
| PK Flexible 2 | 11.8 |

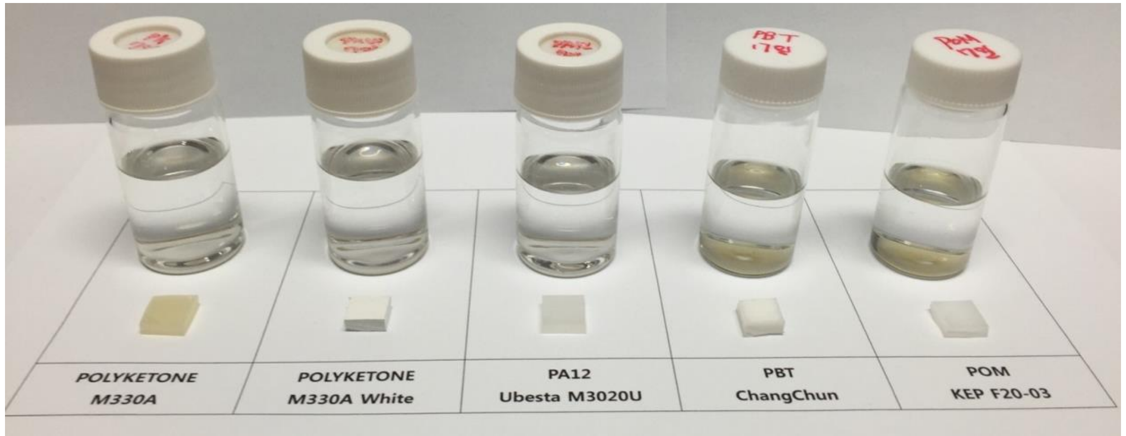


# PA12 vs PK Swelling: Ethanol 95%




| Sample | PK | | | PA12 | | |
|---|---|---|---|---|---|---|
| | 0day | 7days | Weight Change | 0day | 7days | Weight Change |
| 1 | 5.4 | 5.5 | 1.17% | 4.2 | 4.5 | 6.62% |
| 2 | 5.5 | 5.5 | 1.17% | 4.1 | 4.4 | 6.66% |
| 3 | 5.0 | 5.0 | 1.18% | 3.9 | 4.2 | 6.57% |
| Average | 5.3 | 5.4 | 1.17% | 4.1 | 4.3 | 6.61% |

- **Test Method:**
  Measure weight change of specimens of polymers after 7days of immersion in ethanol 95% at 40℃
- **Materials**
  - ◎ PK: M710F Flexible
  - ◎ PA12: 3***U
- **Specimen:** 10mm x 10mm, 3EA for each mateiral



# POKETONE Solution

## POM Gear

### Issue

- Wear loss, Noise
- Breakage, Melt at high Temp.
- Degradation by grease

### PK Value

| | | | |
|---|---|---|---|
| I Impact Strength | W Wear Resistance | S Safety Non-toxic | H Heat Resistance |
| C Chemical Resistance | W Water Resistance | B Barrier Property | R Resilience Recovery |

### Customer Benefits

- Noise decreased, Wear loss down
- No melting at high speed

## POM Food Conveyer Belt

### Issue

- Wear loss, Noise, Breakage
- Formaldehyde emission
- Degradation by solvent cleaner

### PK Value

| | | | |
|---|---|---|---|
| I Impact Strength | W Wear Resistance | S Safety Non-toxic | H Heat Resistance |
| C Chemical Resistance | W Water Resistance | B Barrier Property | R Resilience Recovery |

### Customer Benefits

- Wear loss down, Toxic-free
- No melting at high speed

## PA6/66, POM Toy part

### Issue

- Breakage(Swallowed by babies)
- Dimentional change(PA)
- Formaldehyde emission(POM)

### PK Value

| | | | |
|---|---|---|---|
| I Impact Strength | W Wear Resistance | S Safety Non-toxic | H Heat Resistance |
| C Chemical Resistance | W Water Resistance | B Barrier Property | R Resilience Recovery |

### Customer Benefits

- Toxic-free, Safety guaranteed
- Functional Failure down

# POKETONE Solution

## POM Cosmetic Packaging parts



### Issue

- Formaldehyde emission
- Degragation by cosmetic chemicals
- Wear loss and fuctional issues

### PK Value

I Impact Strength | W Wear Resistance | S Safety Non-toxic | H Heat Resistance
C Chemical Resistance | W Water Resistance | B Barrier Property | R Resilience Recovery

### Customer Benefits

- Toxic-free, Toughness enhenced
- Functional Failure down

## Water Purifier parts


### Issue

- Formaldehyde Elution

### PK Value

I Impact Strength | W Wear Resistance | S Safety Non-toxic | H Heat Resistance
C Chemical Resistance | W Water Resistance | B Barrier Property | R Resilience Recovery

### Customer Benefits

- Toxic-free
- Toughness enhenced

## PA66 Kitchen Tools


### Issue

- Oilgomer issue when heated
- Breakage, Deformation

### PK Value

I Impact Strength | W Wear Resistance | S Safety Non-toxic | H Heat Resistance
C Chemical Resistance | W Water Resistance | B Barrier Property | R Resilience Recovery

### Customer Benefits

- Toxic-free, Safety guaranteed
- Functional Failure down

# POKETONE Solution

## PPS, Steel Oil&Gas Pipe

### Issue

- Chemical corrosion/Wear(Steel)
- High Price(PPS)

### PK Value

- I Impact Strength
- W Wear Resistance
- S Safety Non-toxic
- H Heat Resistance
- C Chemical Resistance
- W Water Resistance
- B Barrier Property
- R Resilience Recovery

### Customer Benefits

- Cost Down, Longer life cyle
- Functional Failure down

## PA612/PA610 Filament

### Issue

- Wear Loss(abrasion)
- High Price
- Property down by water/chemicals

### PK Value

- I Impact Strength
- W Wear Resistance
- S Safety Non-toxic
- H Heat Resistance
- C Chemical Resistance
- W Water Resistance
- B Barrier Property
- R Resilience Recovery

### Customer Benefits

- Cost down
- Better Recovery(Longer life cycle)

## PA12 Industrial tube

### Issue

- High Price, Supply issue
- Oligomer issue
- Low melting point

### PK Value

- I Impact Strength
- W Wear Resistance
- S Safety Non-toxic
- H Heat Resistance
- C Chemical Resistance
- W Water Resistance
- B Barrier Property
- R Resilience Recovery

### Customer Benefits

- Cost Down
- Better Chemical barrier, resistance

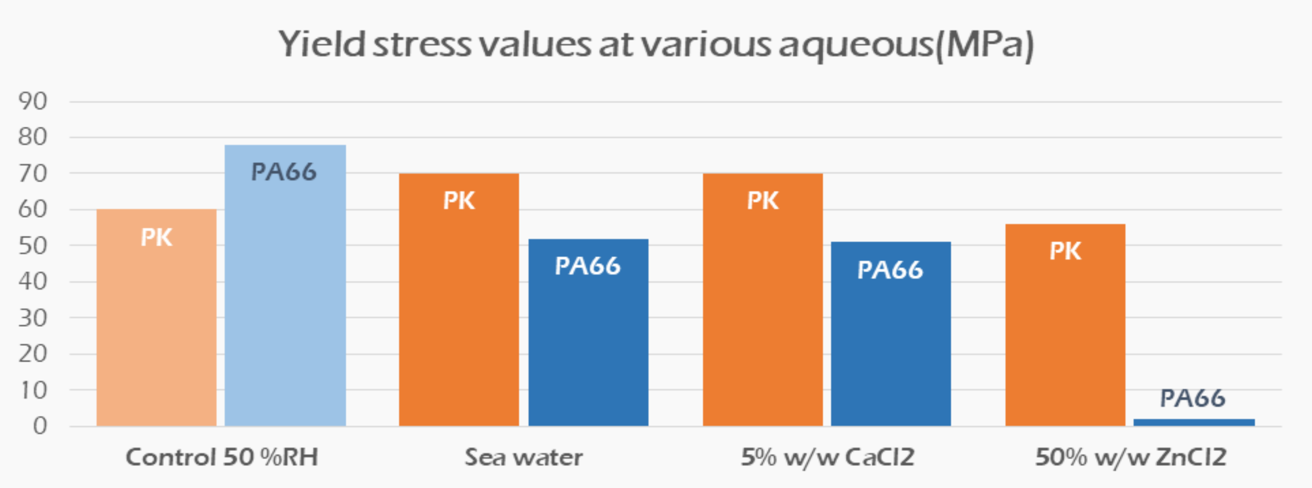
# POKETONE Performance

**C** Chemical Resistance | against POM

After 670hrs at 70℃ In Chlorinated Water

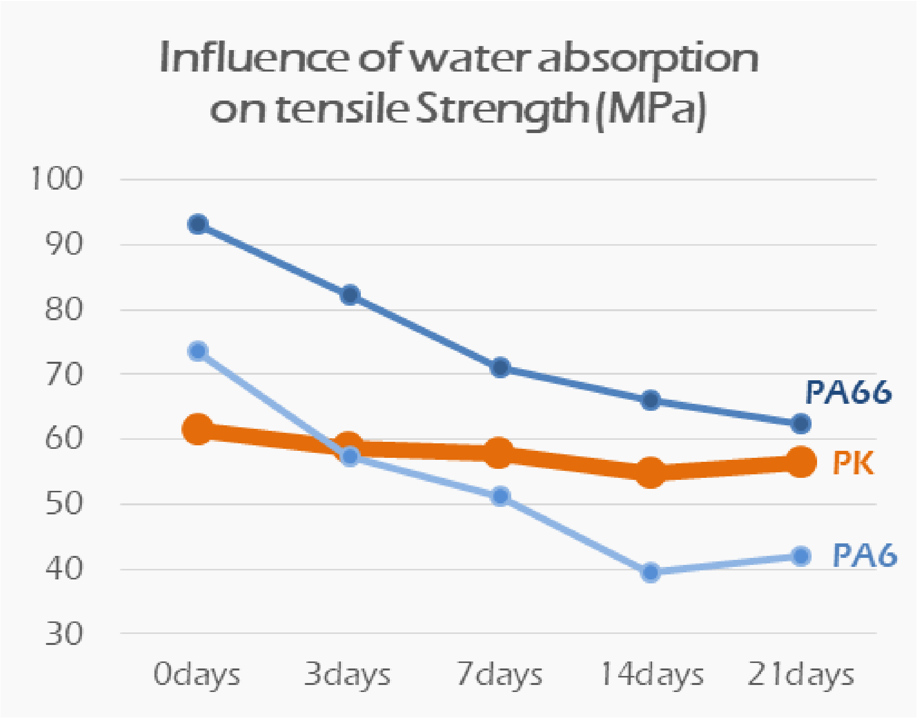

**C** Chemical Resistance | against PA

Tensile bar Chemical resistannce Test

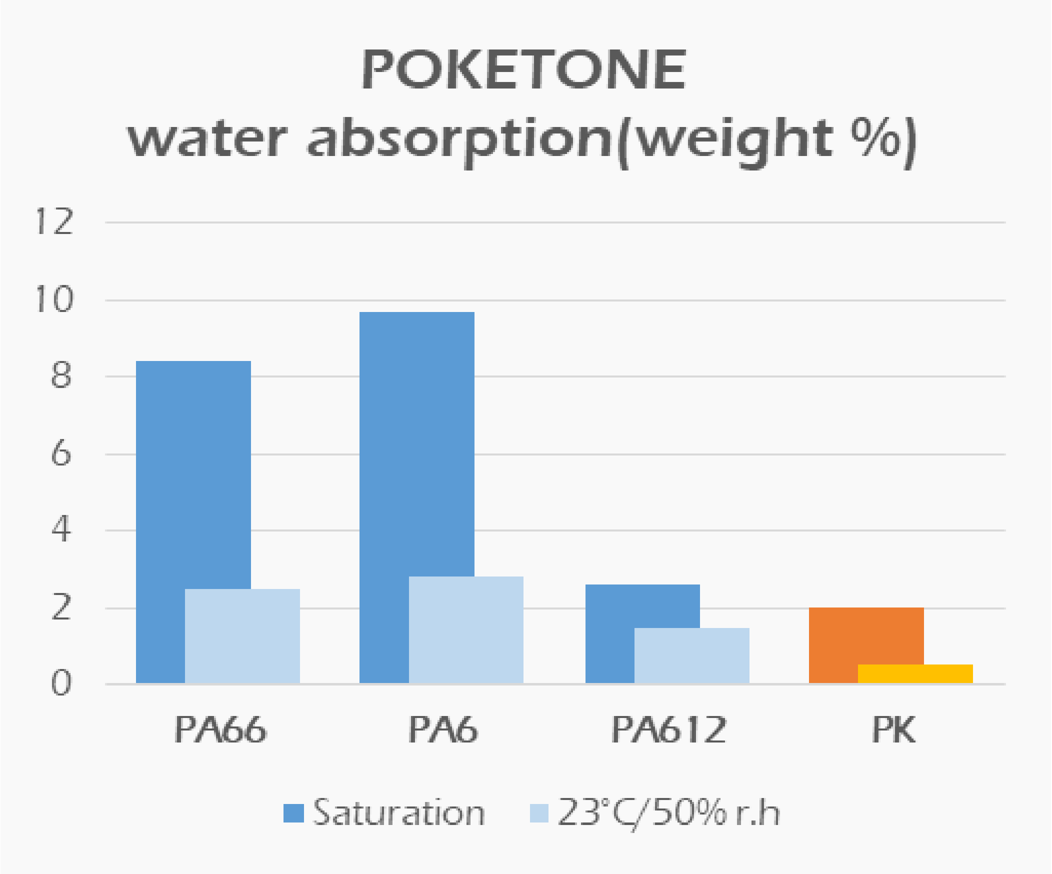


# POKETONE Performance

W Water Resistance against PA



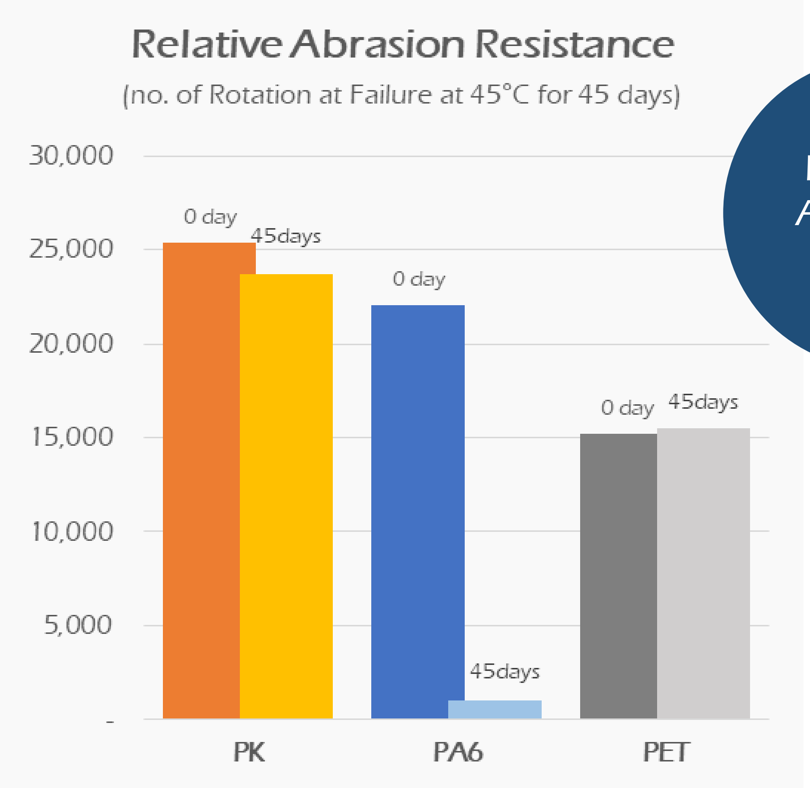

W Water Resistance against PA



# POKETONE Performance

**W** Wear Resistance | **W** Water Resistance | against PA

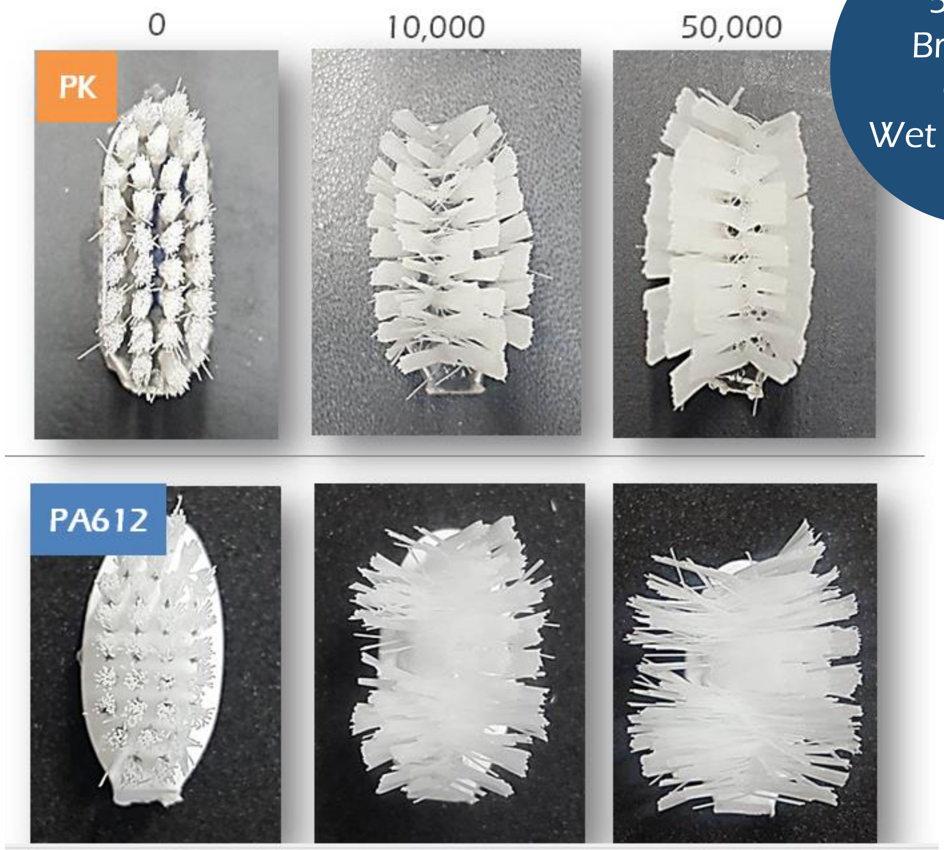
**Test Method:**
Running the filament on the rotating ceramic drum to the point of failure. This procedure avrades the filament until the contact area get worn to the point of failure. Ceramic/ 200rpm/ 200g




Filament Abrastion Test

**W** Water Resistance | **R** Resilience Recovery | against PA

No. of Brushing cycle ▹



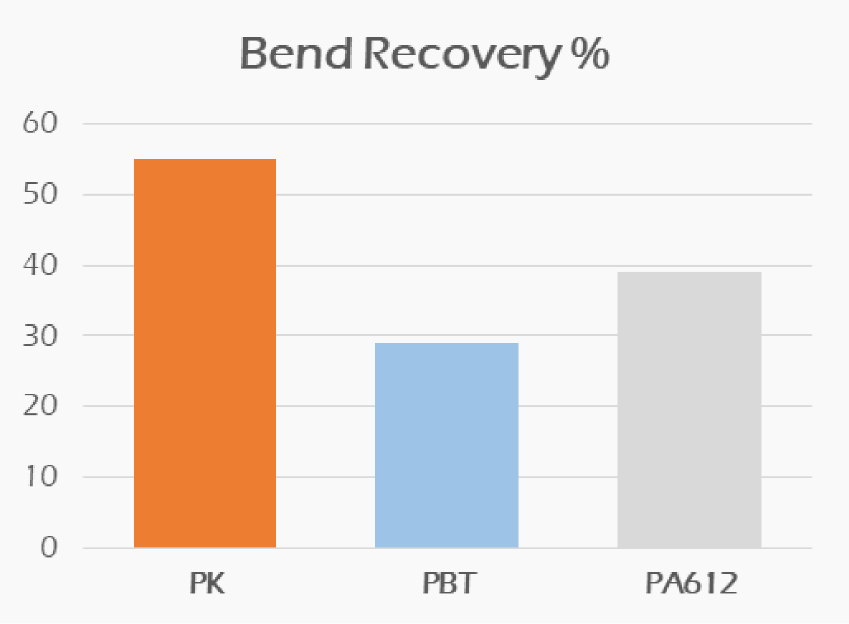

50,000 Brushing Cycle Wet condition

# POKETONE Performance

R Resilience Recovery | against PA

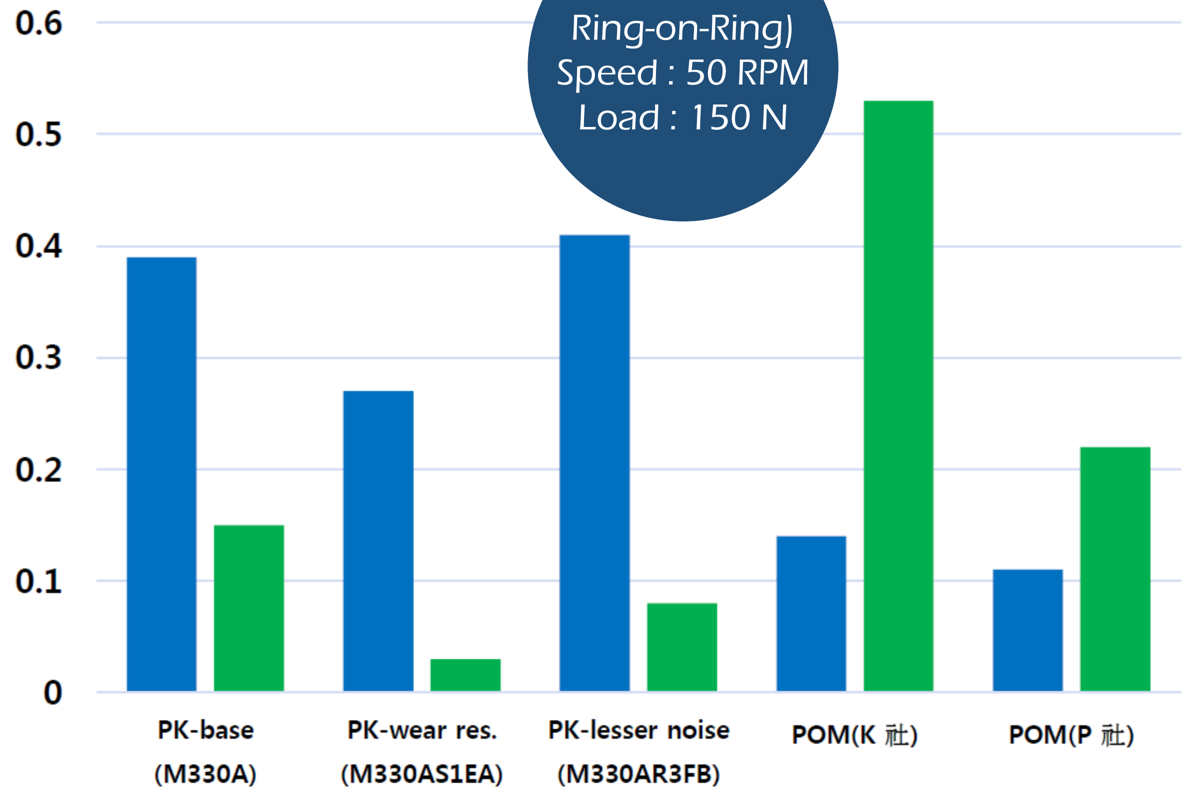
Filament Bend recovery Test

**Test Method:** Measure free recovery angle of single filament after folding




W Wear Resistance | against POM

Ring-on-Ring)
Speed : 50 RPM
Load : 150 N



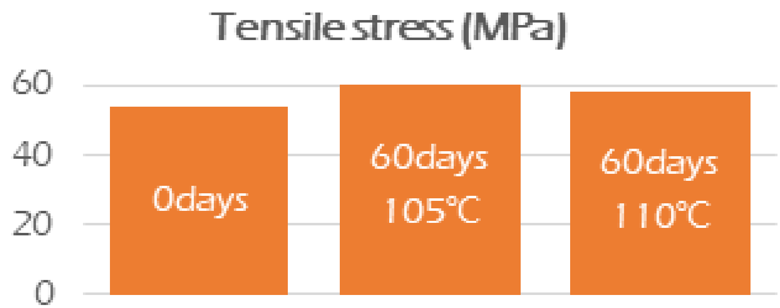
# POKETONE Performance

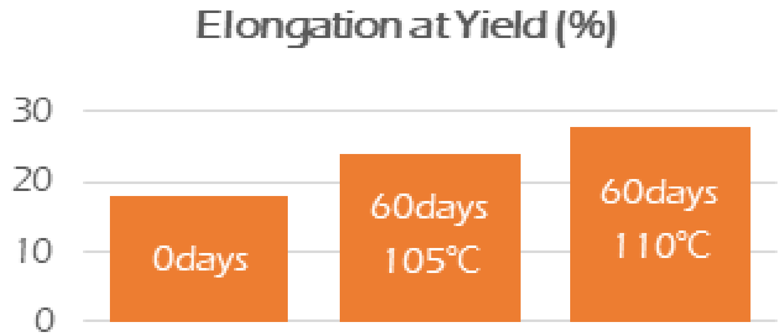
**C** Chemical Resistance | **H** Heat Resistance | **W** Water Resistance | **I** Impact Strength

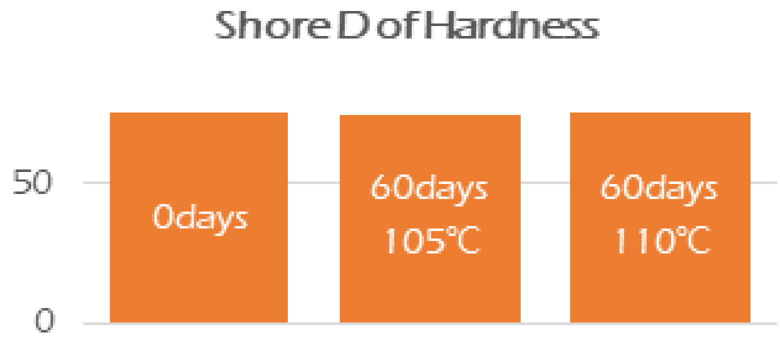
Downhole Pipe liner Performance Test

**Test standard:**
TM0185-2006, Evaluation of Internal Plastic Coatings for Corrosion Control of Tubular Goods by Autoclave Testing, By SwRI

**Gas concentration and test conditions**
High gas concentration and test conditions
33% water + 42% Hydrocarbon
(Aromatic, Aliphatic – Benzene 1%, Toluene 7%, Xylene 11%, Cyclopentene 6%, Cyclohexane 6%, C4-C5 17%, C6-C10 42%, C11 10%) + 25% "Ph4" Gas ($CO_2$ 10%+ $H_2S$ 5% + $CH_4$ 85%)

# POKETONE Performance

C
Chemical Resistance

against Enpla

Chemical Resistance Against Engineering plasitics

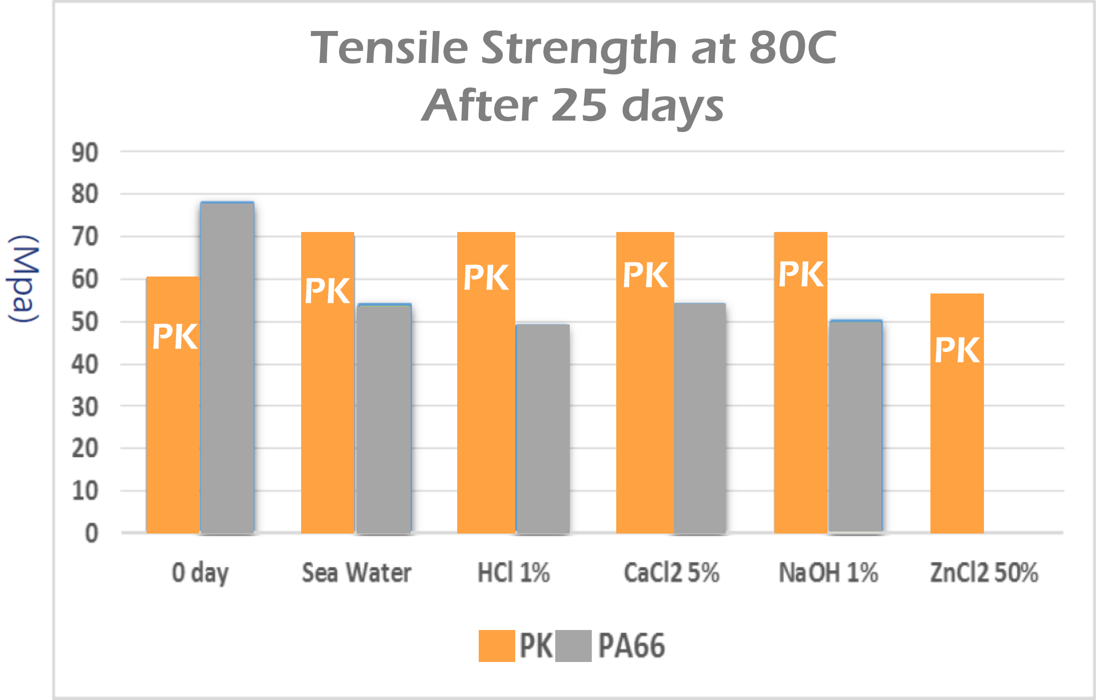
| | Semi-Crystalline | | | | | | | Amorphous | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PK | PA66 | PA12 | POM | PBT | PPS | PVDF | PPO | PSU | PC |
| Hydrocarbons | | | | | | | | | | |
| Aliphatic | ◎ | ◎ | ◎ | ◎ | ◎ | ◎ | ◎ | ● | ● | ● |
| Aromatic | ◎ | ◎ | ◎ | ◎ | ◎ | ◎ | ◎ | ● | ● | ● |
| Halogenated | ◎ | ◎ | | ◎ | | ◎ | ◎ | ● | ● | ● |
| Ketones | ◎ | ◎ | ◎ | ◎ | ◎ | ◎ | | ● | ● | ● |
| Esters/Ethers | ◎ | ◎ | ◎ | ◎ | ◎ | ◎ | ◎ | ● | ● | ● |
| Aldehydes | ◎ | ● | ● | ◎ | ◎ | ◎ | ◎ | ● | ● | ● |
| Aqueous | | | | | | | | | | |
| Water | ◎ | ● | ◎ | ◎ | ● | ◎ | ◎ | ◎ | ◎ | ◎ |
| Weak Acids | ◎ | ● | ● | ● | ● | ◎ | ◎ | ◎ | ◎ | ◎ |
| Weak Bases | ◎ | ● | ● | ◎ | ● | ◎ | ● | ◎ | ● | ◎ |
| Strong Acids | ● | ● | ● | ● | ● | ● | ◎ | ◎ | ● | ◎ |
| Strong Bases | ● | ● | ● | ◎ | ● | ● | ● | ● | ● | ● |

◎ : Resistant ● : Not Resistant

# POKETONE Performance

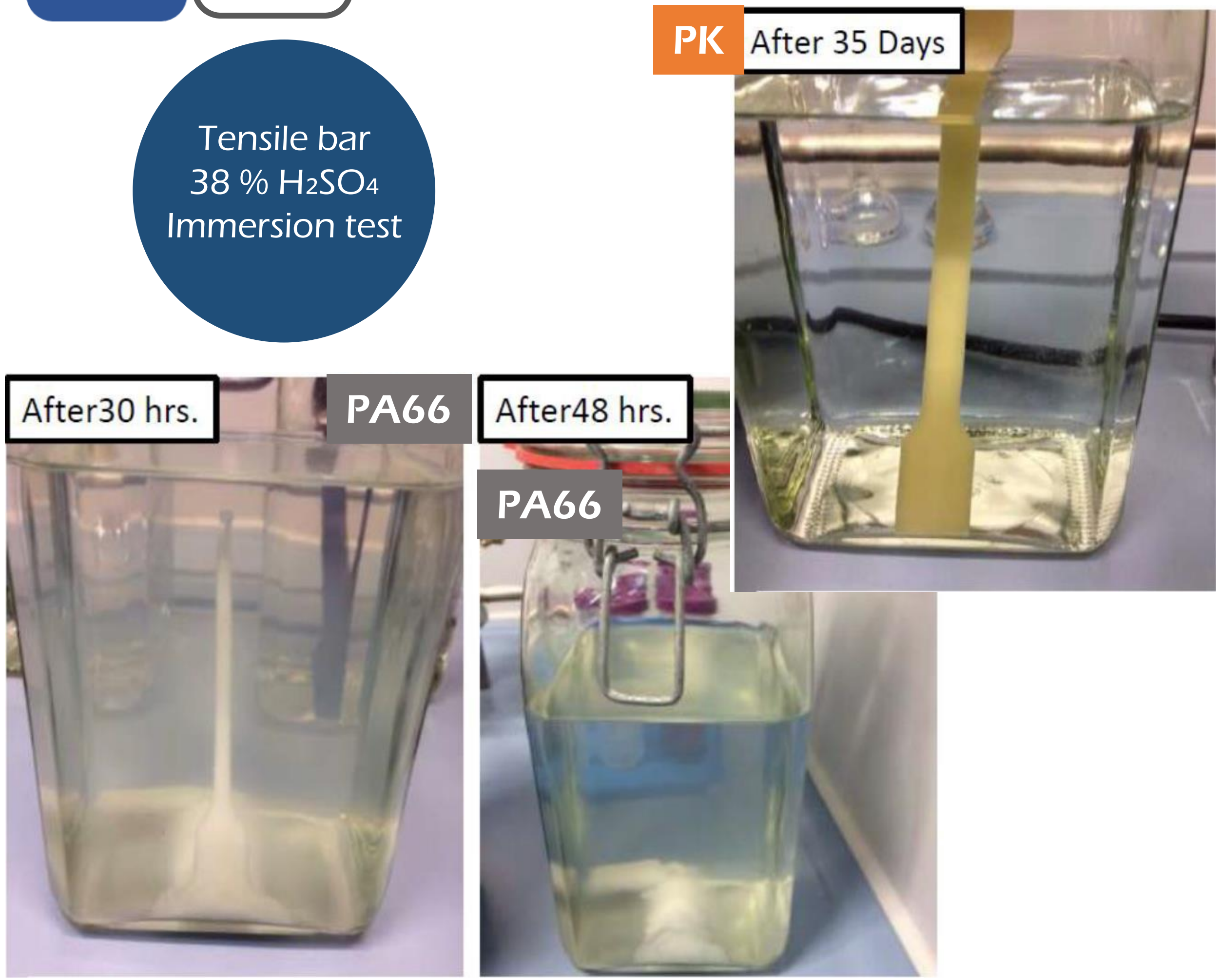
**C** Chemical Resistance | **H** Heat Resistance | against PA66

Tensile bar Chemical Immersion test




**C** Chemical Resistance | against PA

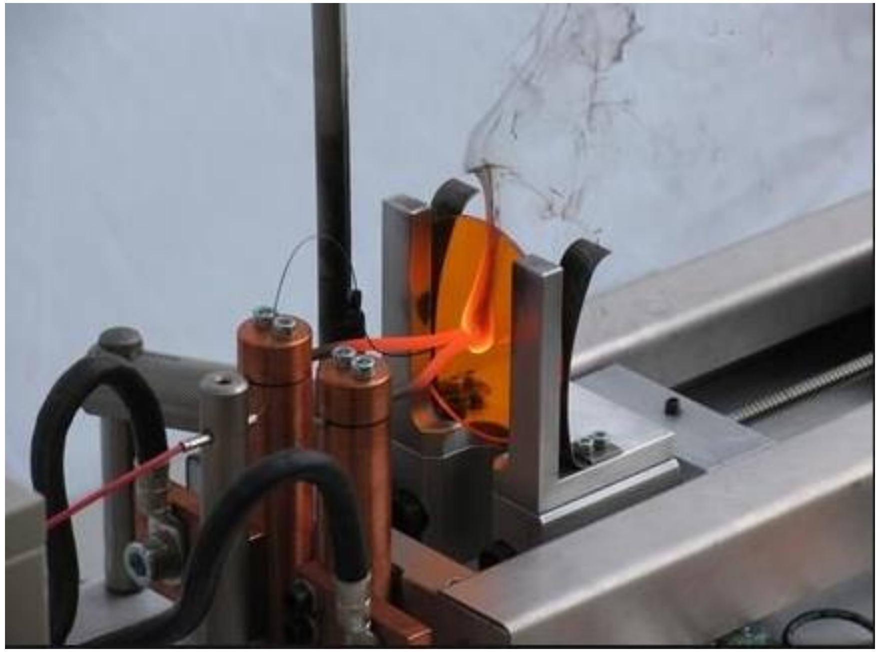
Tensile bar 38 % $H_2SO_4$ Immersion test



# POKETONE Performance

**H** Heat Resistance | against PA66

GWT @ 750℃

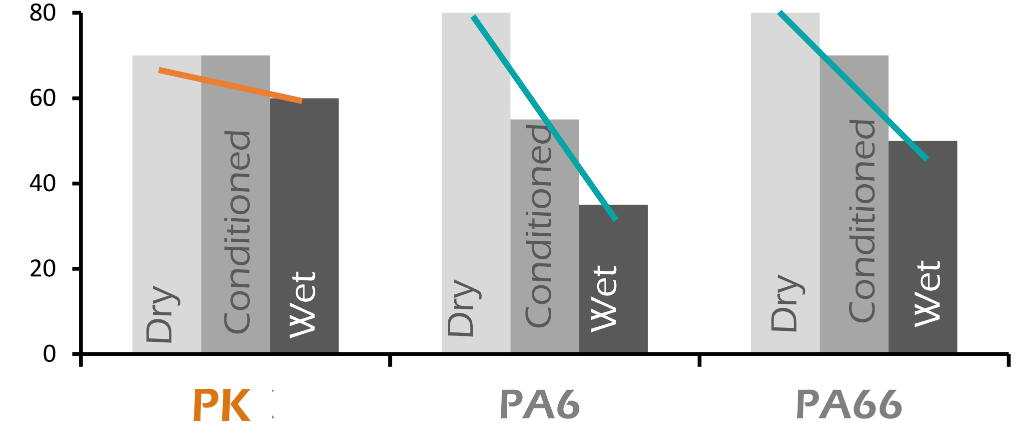


**Result**
**PK FR grade: No ignition**

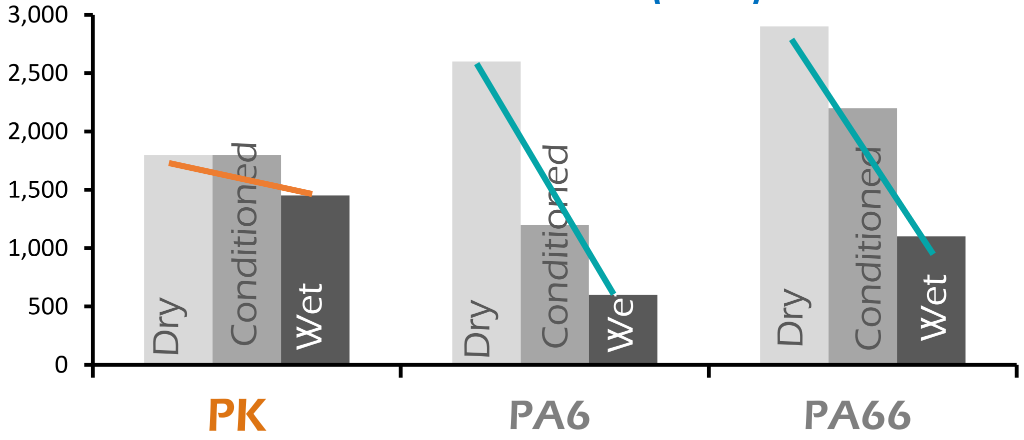
**W** Water Resistance | against PA

- Dry: 23℃, 50% RH, 24hrs
- Conditioned: 23℃, 50% RH, 60days
- Wet: 23℃, 90% RH, 60days

Tensile Strength (MPa)




Flexural Modulus(MPa)



# POKETONE Performance

W
Wear Resistance

R
Resilience Recovery

against POM

Gear Performance Test

| Test Method | | |
|---|---|---|
| Condition | | |
| Speed (RPM) | Time (Day) | Interval (㎛) |
| 600 | 7 | 100 |

| Test Result | | | | |
|---|---|---|---|---|
| Item | | Abrasion Loss(g) | | Noise |
| Drive Gear | Driven Gear | Drive Gear | Driven Gear | dB |
| POM | POM | 0.0016 | 0.0086 | 62 |
| PK | PK | 0.0006 | 0.0029 | 56 |

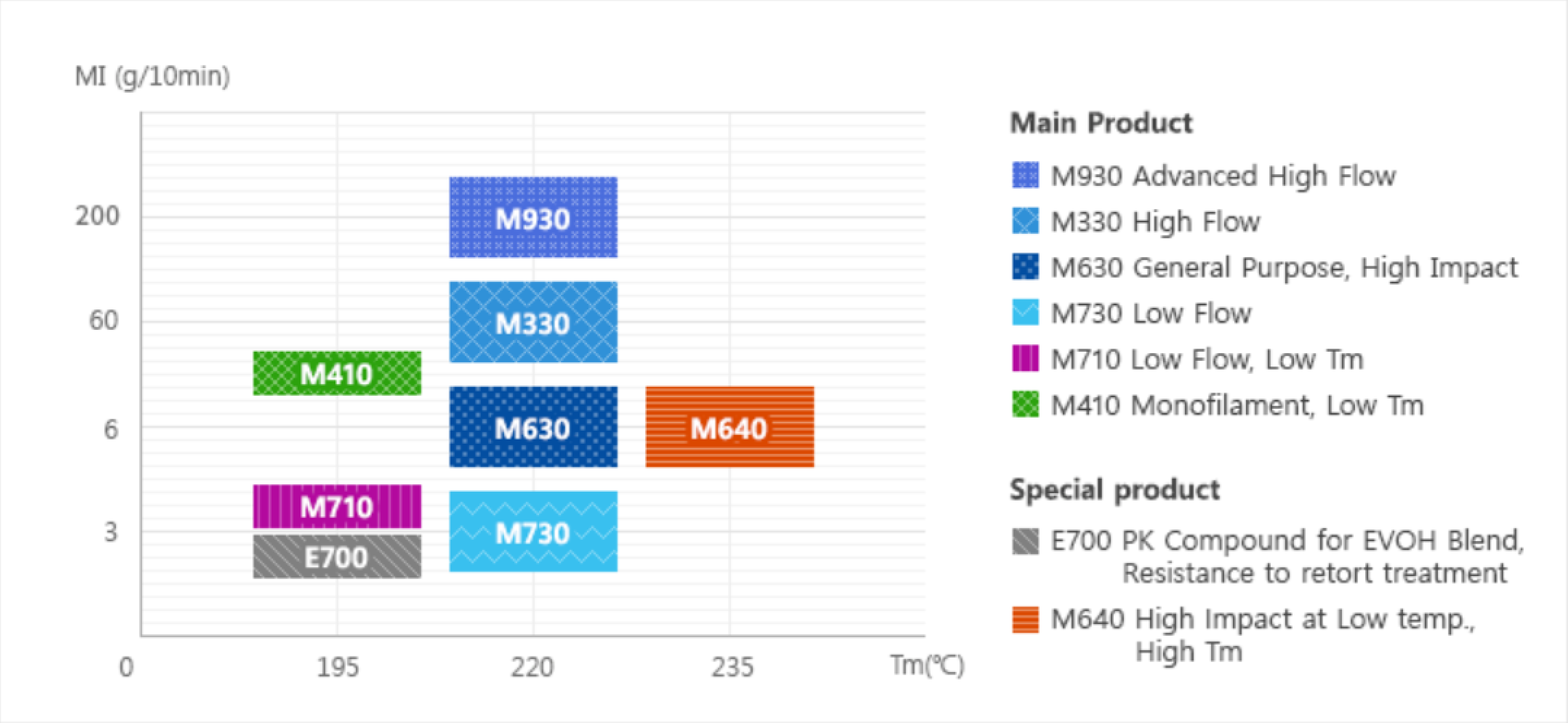
# POKETONE Properties

| Items | Unit | PK | PA6 | PA66 | PBT | POM |
|---|---|---|---|---|---|---|
| Density | $g/cm^3$ | 1.24 | 1.14 | 1.14 | 1.30 | 1.41 |
| Melting Temperature | ℃ | 222 | 220 | 260 | 220 | 160 |
| Impact Strength | $KJ/m^2$ | 15 | 5.2 | 4.1 | 5.0 | 6.5 |
| Tensile Strength at Yield | MPa | 60 | 80 | 80 | 55 | 65 |
| Nominal Strain at Break | % | 300 | 17 | 19 | 16 | 35 |
| Flexural Modulus | MPa | 1,250 | 2,600 | 2,900 | 2,400 | 2,500 |

# Safety & 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

# POKETONE material Selection(Base)



# POKETONE material Selection(Compound)