Polyimide P84® NT and P84® UHT

Bringing plastics beyond the limits.

EVONIK
Leading Beyond Chemistry

Introducing outstanding high-performance polymers:

P84® NT - for challenging friction and wear applications under high temperature

P84® UHT - for extremely high temperatures and demanding requirements on mechanics

- **Excellent performance at high temperatures**
  Polyimides are used in applications where ordinary plastics would sooner melt or decompose.
- **High strength and excellent shape stability**
  Parts and components made of Polyimide P84® NT and P84® UHT provide a rigid structure and can bear high mechanical stress and elongation.
- **Very good impact resistance**
  The high impact strength of polyimides from Evonik ensures easy machinability with standard tools and good quality of edges and surfaces.
- **Processing by state-of-the-art sinter technologies**
  Polyimide P84® NT and P84® UHT are processable cost-efficiently by common sinter technologies such as hot compression moulding or direct forming.

Why choosing Polyimide P84® NT and P84® UHT?

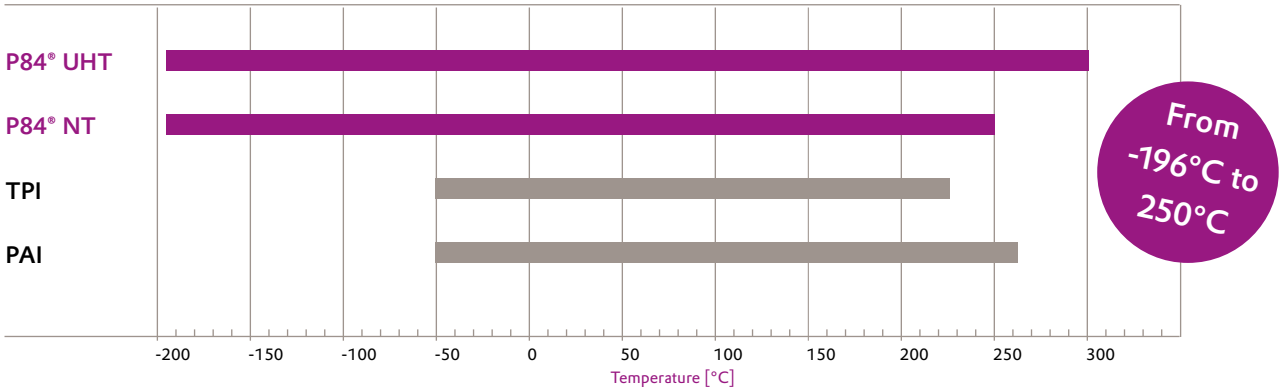
Demanding applications

High temperatures or frictional wear at high speeds and loads often limits the use of engineering plastics. Hence, advanced high-performance polymers have taken their place in demanding applications.

From liquid nitrogen to hot atmosphere

Plastics processors can use polyimides — which exhibit remarkable heat stability and creep resistance, even at elevated temperatures up to 300°C — where conventional plastics are limited by thermal stability. Evonik polyimides are providing their strength and stiffness even at extremely low temperature (cryogenic applications).

Temperature ranges



Different grades

Evonik offers several grades of P84® NT powders. In addition to the granulated standard type, grades with different particle size distribution are available for various areas of application: P84® NT Fine (d90<60µm) and P84® NT Superfine (1-10µm).

Due to its original particle size distribution, P84® UHT powder does not require granulating and can be used especially in direct forming process for the production of parts with low wall thicknesses.

Type	Particle size	Processing	Characteristic
P84® UHT	Fine d90<60µm	HCM & DF	Low coefficient of friction, high thermal conductivity, highest thermal stability
P84® NT	Superfine 1-10µm	HCM	Matrix for abrasive tools, filler in resins or thermoplastics
	Fine d90<60µm	HCM	Filler in resins or thermoplastics, for making custom tailored HCM compounds
	Granulate 300-700µm	HCM & DF	Insulating, tribological properties, high mechanical strength

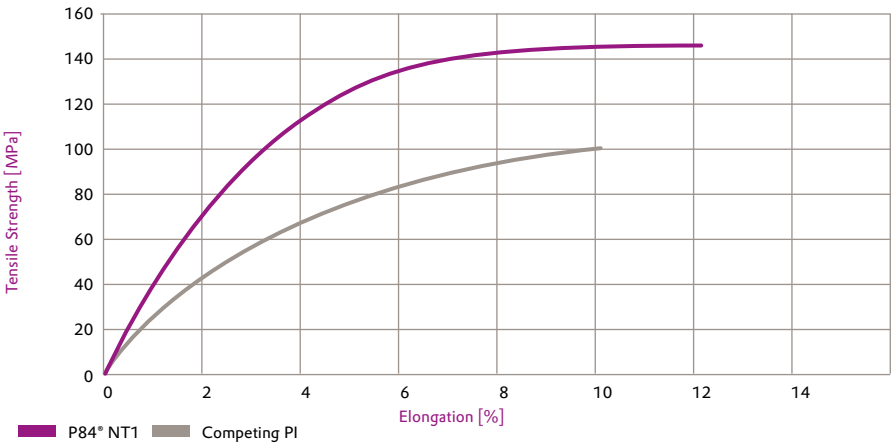
Top of the plastics pyramid due to outstanding characteristics

Advantages of Polyimide P84® NT and P84® UHT

Evonik Fibres GmbH is offering Polyimide P84® NT and P84® UHT in powder or granulate form, allowing plastics processors to develop PI parts by employing common sinter technologies such as hot compression moulding or direct forming. The high mechanical stability and the impact resistance of P84® NT parts ensure good machinability with standard tools.

Parts made of Polyimide P84® NT and P84® UHT are excellent performers in thermally and mechanically stressed applications.
This polymer material features a high glass transition temperature and a rigid structure, combined with a high elongation at break and high impact strength.

Tensile test (ISO 527)

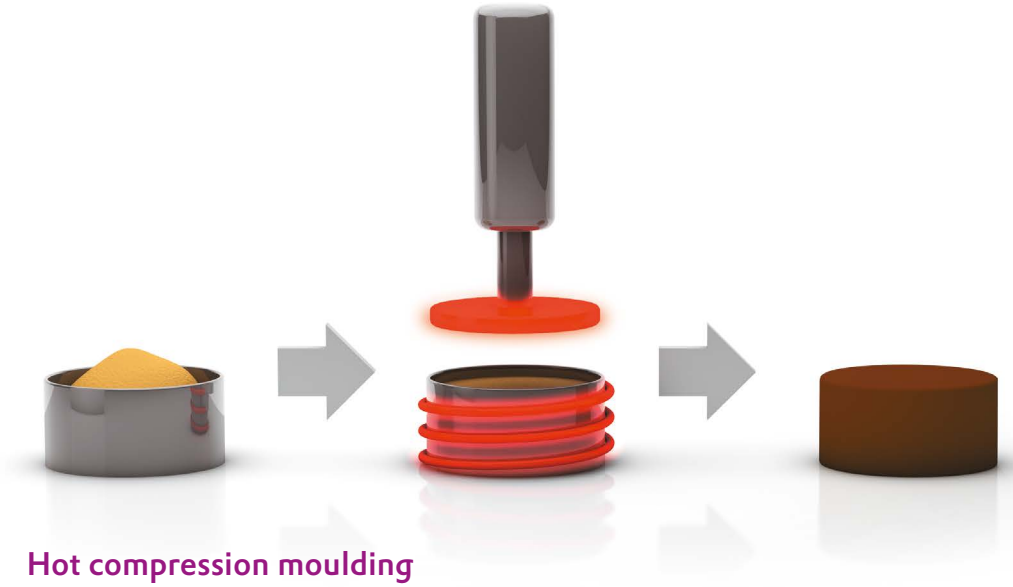


Comparison of stress-strain-curves in tensile test (ISO 527). Polyimide P84® NT shows a wide area of elastic behaviour and high mechanical stability.

Selected properties - Full set of results available in technical data sheets

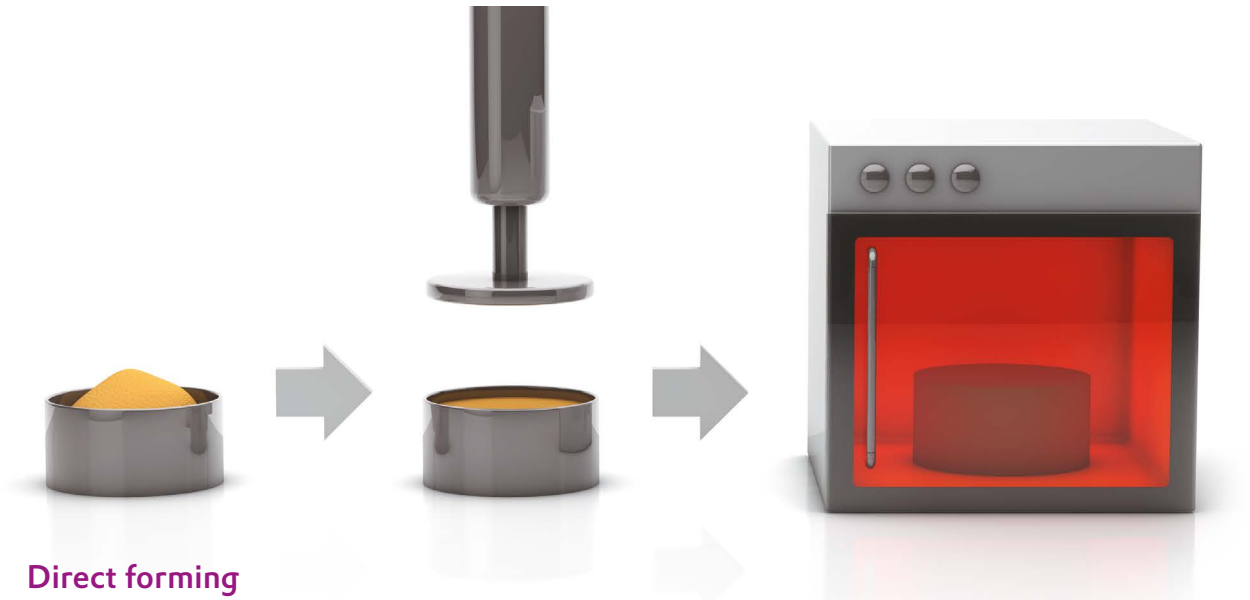
Property	Test method	Unit	P84® NT1
Tensile strength	ISO 527	MPa	140
Tensile elongation at break	ISO 527	%	10
Tensile modulus	ISO 527	MPa	3581
Impact strength (Charpy)	ISO 179-1/1eA notched	$kJ \cdot m^{-2}$	7
	ISO 179-1/1eU unnotched	$kJ \cdot m^{-2}$	122
Heat deflection temperature	1.8MPa Method Af	°C	319
	0.45MPa Method B	°C	343
Glass transition temperature Tg	DSC	°C	337
Electric strength AC	DIN EN 60243-1	$kV \cdot mm^{-1}$	34

Evonik Fibres GmbH provides extensive PI processing support



Hot compression moulding

Big semi-finshed parts like plates, rods and tubes are produced by “Hot compression moulding” (HCM), applying high pressure and temperature above the glass transition point (Tg) for several hours. The manufacturing of precise components with high mechanical stability is done by machining these semi-finished parts. Processing parameters are up to 500kg/cm^2 pressure and 350-415°C temperature.



Direct forming

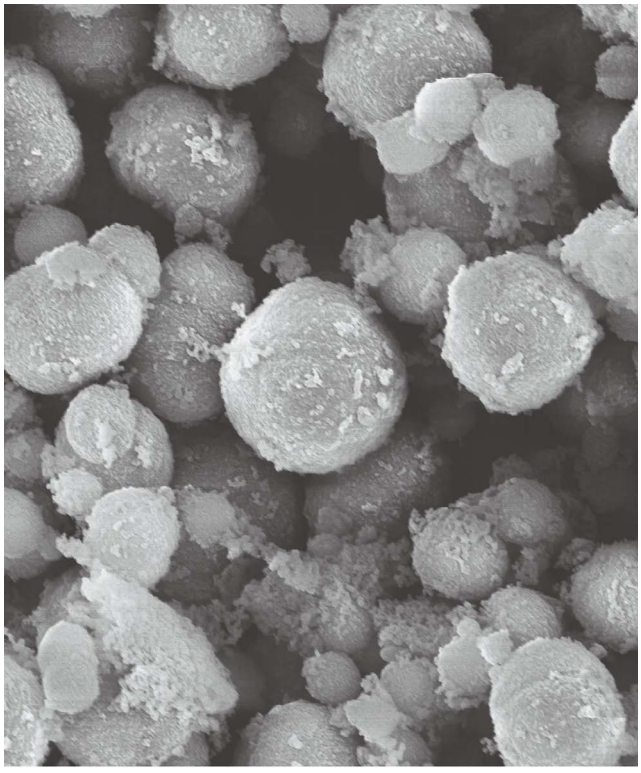
If a large quantity of small parts is to be produced cost efficiently and rapidly, Polyimide P84® NT and P84® UHT powder can be processed by means of direct forming. This technology includes the production of “green parts” at extremely high pressure and ambient temperatures, with subsequent sintering in an external furnace. Processing is done at up to 4000kg/cm^2 pressure and 350-410°C temperature. The sintered parts can be manufactured with a high degree of precision and require little or no machining before they are used. High number of cycles of up to 40 parts per minute are possible.

Fillers adding function

Compounding

By blending it with functional fillers, plastics processors can adjust the properties of Polyimide P84® NT and P84® UHT to meet specific requirements. Solid lubricants such as graphite, molybdenum disulfide or PTFE make components self-lubricating. Moreover, fillers affect the electrical and thermal conductivity of polyimide compounds and have an impact on thermal expansion. Besides standard compound grades, Evonik offers custom tailored formulations to address specific requirements.
Polyimides are also used as matrix for abrasive material for high performance grinding and polishing tools.

Filler	Tribology	Tribology (vacuum, dry gases)	Tribology (heavy duty)	Electrical conductivity	Thermal conductivity	Thermal expansion	Abrasion
Graphite	•			•	•	•	
Molybdenum disulfide	•	•	•				
PTFE	•	•					
Diamond, Corundum							•



Scanning electron micrograph (SEM) at 4000× magnification. Spherical particles of Polyimide P84® NT with smooth surface.

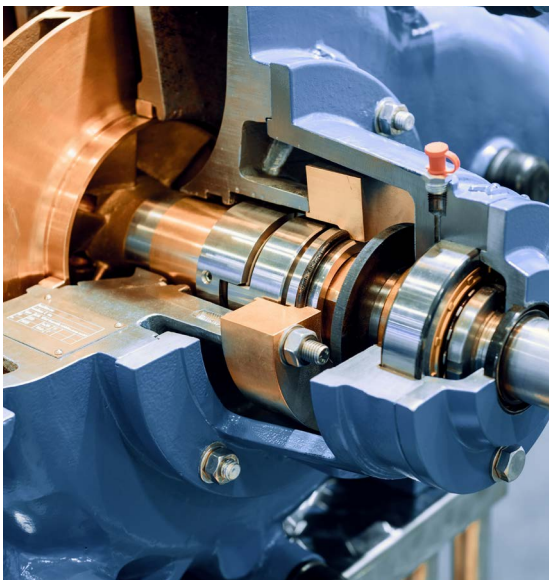
Since Polyimide P84® NT is available as fine powder of 1-15µm particle size of spherical shape and narrow particle size distribution, it can be used as functional filler itself:

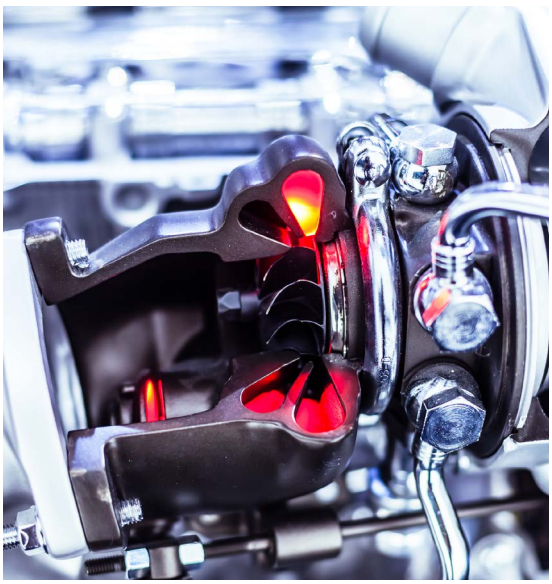
- Thermoplastics
  Improving creep resistance at elevated temperatures or decreasing frictional wear of thermal plastics like PTFE and PEEK (VESTAKEEP®).
- Composites
  Act as toughening in thermoset composite materials, improving impact strength.
- Oil and grease
  Increase load bearing capabilities and frictional properties.

Benefitting from Evonik Polyimide

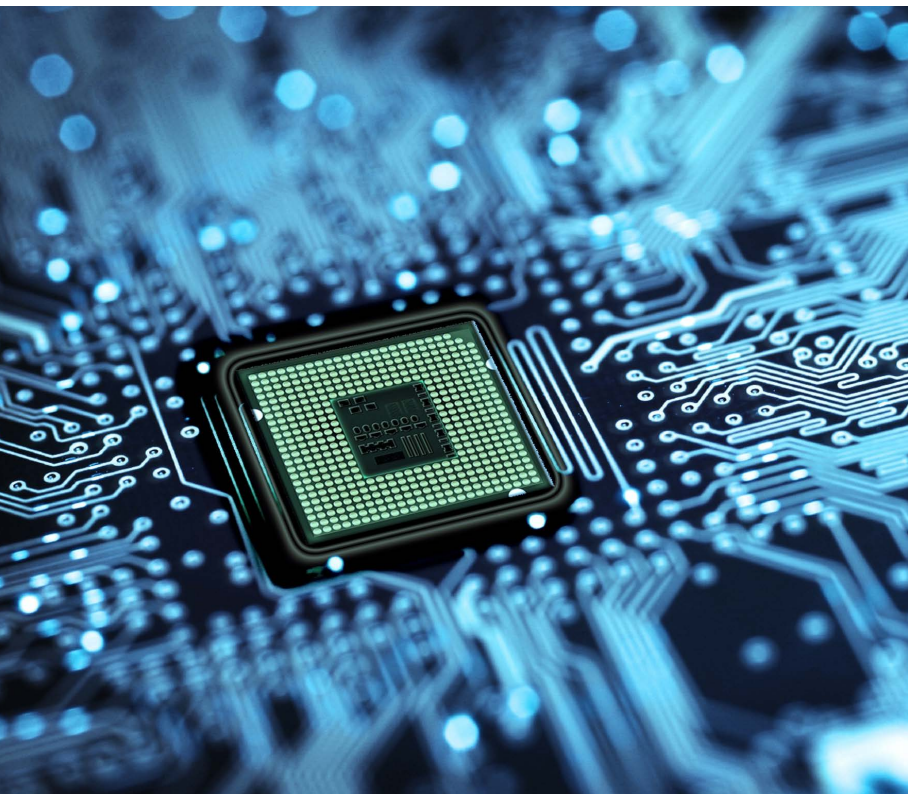
Applications

Polyimide P84® NT and P84® UHT are the right choice for applications where plastics face high demands on temperature stability but need to be applied due to commercial or technical reasons. For example, bushings made of a polyimide-graphite compound are used as bearings for windscreen wipers — for a lifetime of oil- and grease-free lubrication. Spacer discs in gear boxes can be made by direct forming, including all the necessary notches, thus minimizing post-processing and ensuring high-temperature stability and low wear. This promising material is used in bushings, seals, bearings components, guides, gear wheels, and valve parts in the automotive and aerospace industries and in industrial equipment.



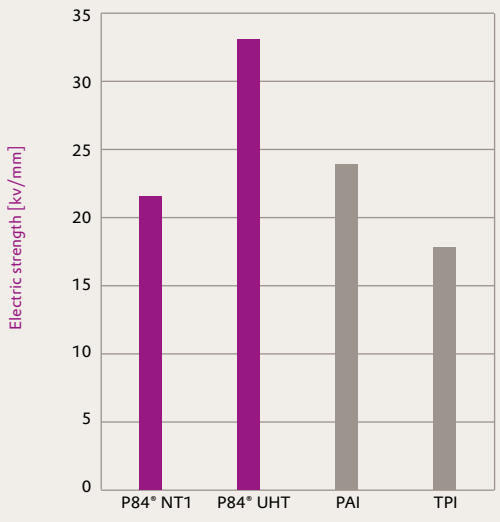


Semicon and electronic applications profit from the high barrier of polyimides against electric break through

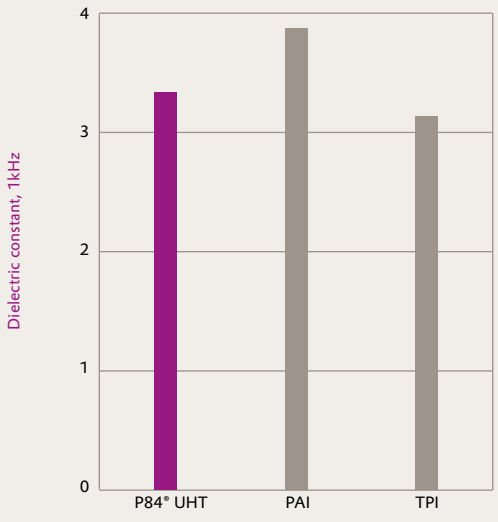


In the manufacturing process of electronic components all products have to pass a final test. For this test the chip is placed in a test socket, which is made of polyimide.
Required properties include high dimensional stability over a wide temperature range, good machinability and good mechanical strength and stiffness. Materials used in this application has to pass various qualification procedures including cycling tests to prove to be durable and resistant. The test socket also requires high dimensional stability and resistance against harsh cleaning conditions. Test sockets based on
P84® UHT fulfill these challenging specifications and allow increased lifetime of the component.
Polyimides convince in semicon and electronic processing equipment with low outgassing in vacuum, excellent thermal stability and high electric strength.

Electric strength (DIN EN 60243-1)

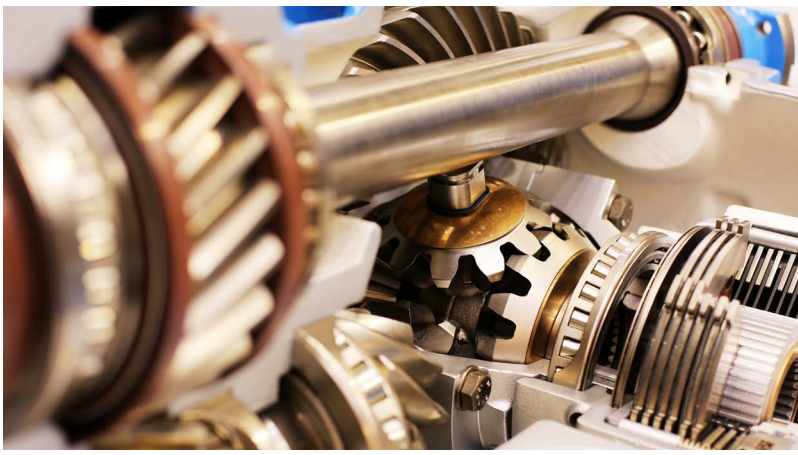


Dielectric constant (DIN EN 62631-2-1)



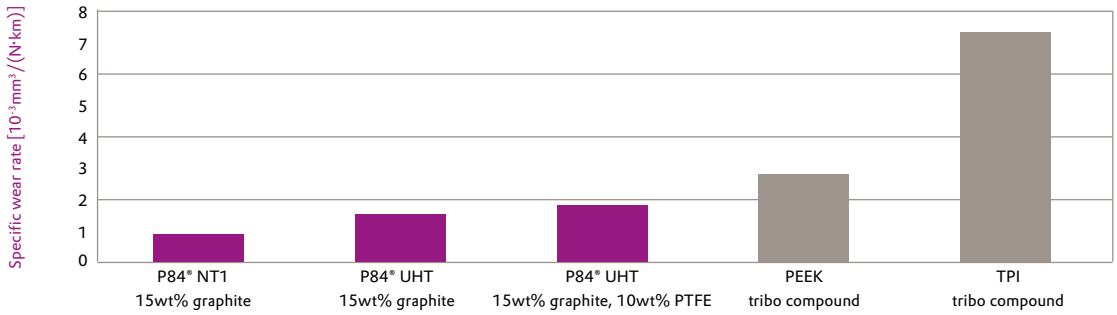
Reducing wear – Tribological applications under challenging conditions

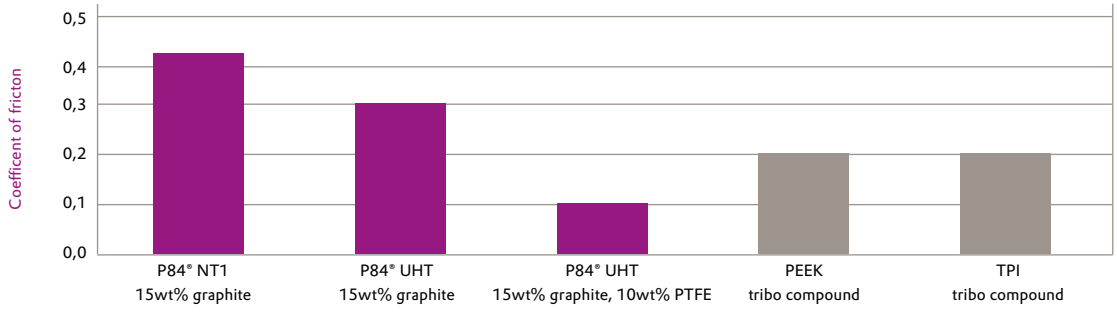
The trend in the use of high-performance plastics is towards miniaturization and lightweight design. Polyimides are therefore preferably used in areas of application in which engineering plastics can no longer meet the requirements due to thermal stress. Especially in applications with tribological contact under high load and speed, such as plain bearing bushings, they can play to their strengths.
The excellent temperature resistance and dimensional stability of polyimides contribute to extraordinary wear resistance.
Compounds with graphite and/or PTFE additionally improve the friction behaviour. The solid lubricant filler allows dry running conditions or add failsafe running properties.
In comparison to conventional types of high-performance plastics, P84® NT and P84® UHT show low coefficient of friction and the wear rate at room temperature is always more than 50% lower.



- Longer lifetime due to high wear resistance
- Low friction without liquid lubricants
- Cost efficient part production by direct forming process

Sliding bearing test





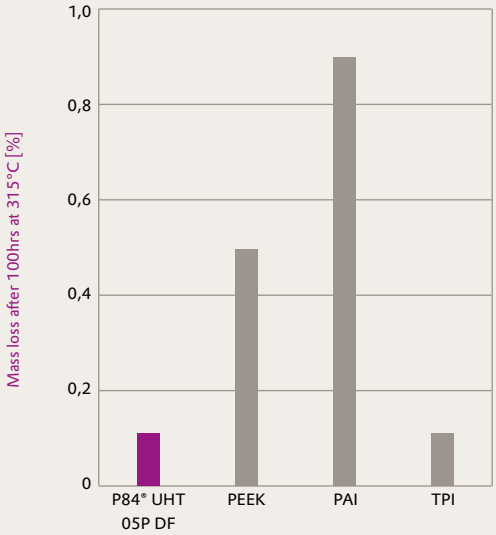
F_N = 250 N, v = 1 m/s, 23°C, 20 hrs, counterpart: 100Cr6, bearing dimension: inner diameter = 30 mm, outer diameter = 34 mm; no lubrication

Polyimide P84® UHT for glass handling

During manufacturing of glass bottles, graphite or brass parts are needed for handling purposes. These parts guide the hot glass bottles through the process. Due to brittleness or extended heat conductivity parts get broken or glass bottles are damaged.
Glass gripper made out of compounds of P84® UHT with graphite can withstand the temperatures. The higher ductility of the polymer material enhance the liftime of those components.

- Longer lifetime of glass gripper
- Less production shut down for gripper exchange, less maintenance costs
- P84® UHT shows high integrity and low weight loss even at temperatures above 300°C

Thermal oxidative stability



Excellent chemical stability in hydrocarbons, solvents, acids, oil and grease

24h at 23°C	P84® UHT	P84® NT
Acetonitrile	●●●	●●○
Acetic acid	●●●	●●○
Aniline	●●●	●●●
1,4-Dioxane	●●●	●●●
Hydrochloride acid	●●●	●●○
N-Heptane	●●●	●●●
Sodium chlorate	●●●	●●○
Sodium hydroxide	●●○	●○○
Sulfuric acid	●●●	●●○
Toluene	●●●	●●●

24h at 70°C	P84® UHT	P84® NT
Acetonitrile	●●○	●●○
Acetic acid	●●●	●●○
Aniline	●●●	●●○
1,4-Dioxane	●●●	●●○
Hydrochloride acid	●●○	●○○
N-Heptane	●●●	●●●
Sodium chlorate	●●○	●○○
Sodium hydroxide	●○○	●○○
Sulfuric acid	●●○	●○○
Toluene	●●●	●●●

300h at 150°C	P84® UHT
Engine oil	●●●
Gearbox oil	●●●

Rating	●●● - Excellent	●●○ - Satisfying	●○○ - Poor
Description	no change, negligible change of mechanical properties	moderate change, material with limited lifetime	material decomposition within short time
Material class	Organic solvents, hydrocarbons, oil and grease, weak acids, salts, peroxides	Moderate acids and alkalines	Strong acids and alkalines

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