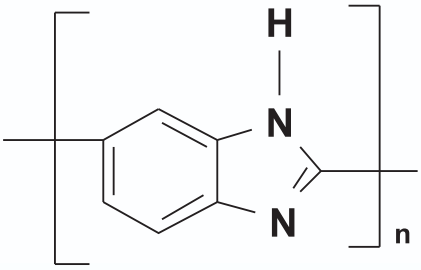
GAZOLE™ 5000 Series (Polybenzimidazole)

GAZOLE™ 5000 series is based on a basic polymer containing benzimidazole groups (PBI, poly (2,5-benzimidazole)), with high thermal and chemical stability, and non-flammable characterstic. The polymer is synthesized from the monomer 3, 4 diaminobenzoic acid.



PBI, Poly (2,5-benzimidazole)

- Sintering Compression Molding process at High Temperature and Pressure to make parts
- Highest Compressive Strength of any unfilled resin
- Excellent Tensile and Flexural Strength
- Lowest coefficient of friction (CoF) and highest Wear Resistance
- Excellent Hardness
- High Tg (467°C) and Heat Deflection Temperature (HDT)
- Very good Plasma Resistance.
- It offers the highest Heat Resistance and Mechanical Properties retention upto 400°C
- Low Outgassing in vacuum (dry material)

1 GAZOLE™ 5000 Grades:

GAZOLE™ is available in variety of grades for specific applications, and the main grades available are the following:

Standard GAZOLE™ 5000 Polymers

Polybenzimidazole polymers are available as powder or dope solution in following grades:

Ultra high performance polymer material, Polybenzimidazole (GAZOLE™ 5000), semi crystalline, fine powder for extrusion compounding and compression molding, highly uniform particle size distribution, color natural green.

Grade	IV (dl/g)	Application
GAZOLE™ 5100P	2.5-3.0	Compression Molding
GAZOLE™ 5200P	2.0-2.5	Compression Molding
GAZOLE™ 5300P	1.0-1.2	Extrusion Compounding

Polybenzimidazole (GAZOLE™ 5000), semi crystalline, dope solution in methane sulphonic acid for fiber spinning and membranes. Color natural brown.

Grade	IV (dl/g)	Application
GAZOLE 5200S	2.0-2.5	Fiber Spinning
GAZOLE 5100S	2.5-3.0	Membrane

2. Heat Distortion Temperature

The short term thermal performance of a material may be characterized by determining the Heat Distortion Temperature (HDT, ASTM D 648).

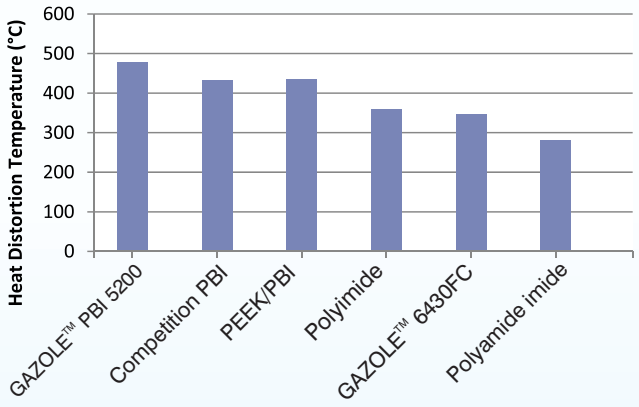


Fig. 1 Heat Distortion Temperature for Range of High Performance Materials.

A comparative chart of high performance material using ASTM D 648, HDT values (Fig. 1) for a defined applied stress of 1.8 MPa shows that GAZOLE ™ 5200 grade is superior to all of the other polymeric wear grade composites.

3. Abrasion Resistance

The ability of a material to withstand mechanical action such as rubbing, scraping or erosion, that tends progressively to remove from its surface.

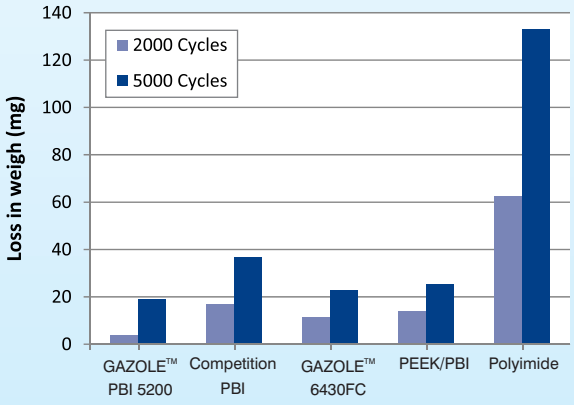


Fig. 2 Abrasion resistance at 1.0 Kg load & CS-17 abrasion wheel of GAZOLE™ 5000 Series & its competitive grades .

The abrasion resistance of GAZOLE ™ compounds was evaluated using the abrasion resistance test (ASTM D 1242, Wheel: CS-17, Load: 1000 gm) The data in Fig. 2 shows that natural PBI 5200 polymer has the lowest value of loss in weight.

4. Typical Properties of GAZOLE™ 5000 Series

Property	Test Method	Unit	Gazole™ 5200
General Properties			
Solid Density	23°C	g/cc	1.3
Moisture Content	GSRF	%	5-7
Hardness Rockwell	ASTM D 785	M	125
Hardness Shore D	ASTM D 2240	D	95
Thermal Properties			
Glass Transition Temperature (Tg)	DMA	°C	467
Heat Deflection Temperature (HDT)	ASTM D 648 / 1.8 MPa	°C	478
Continuous Use Temperature (Expected)	UL 746B	°C	400
Temperature of Initial (5%) Weight Loss in			
Air	TGA	°C	584
Nitrogen	TGA	°C	641
Mechanical Properties at 23°C			
Tensile Strength	ASTM D 638	MPa	160
Tensile Modulus	ASTM D 638	MPa	5900
Elongation at Break	ASTM D 638	%	3
Compressive Strength	ASTM D 785	MPa	390
Compressive Modulus	ASTM D 785	MPa	5900
Flexural Strength	ASTM D 790	MPa	220
Flexural Modulus	ASTM D 790	MPa	6500
Izod Impact Strength (Notched)	ASTM D 256	J/m	21
Izod Impact Strength (Unnotched)	ASTM D 256	J/m	600

5. Dynamic Mechanical Analysis (DMA)

The Dynamic Mechanical property of GAZOLE™ (PBI) polymer surpasses those of all engineering thermoplastics. The thermomechanical and viscoelastic behavior of GAZOLE™ 5000 polymer is provided by Dynamic Mechanical Analysis (DMA). This storage modulus represents the recoverable elastic energy stored in a viscoelastic material during deformation.

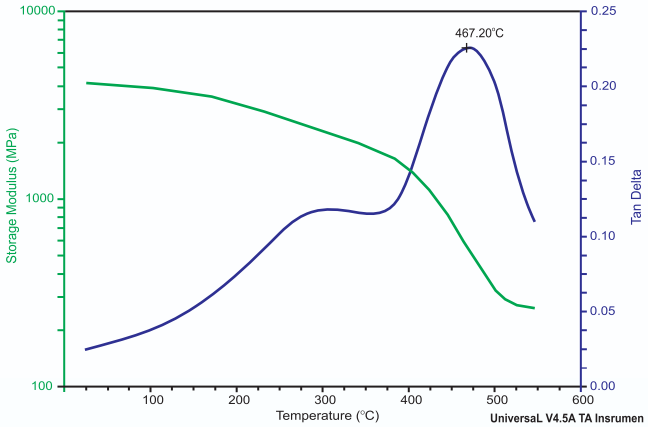


Fig. 3 : Temperature sweep scan of PBI.
Storage Modulus (E') and Tan Delta against Temperature.

In Fig.3, GAZOLE™ 5000 series polymers showed glass transition temperatures of 467°C, above which the material will have rubbery properties instead of glassy behavior and the stiffness of the material will drop dramatically with an increase in viscosity. At the glass transition, the storage modulus decreases dramatically and the loss modulus reaches a maximum. Fig. 3 shows a temperature sweep scan of PBI. Storage Modulus (E') and tan delta against temperature.

6. Processing

GAZOLE™ 5000 Series powder can only be processed by compression molding. PBI polymer has imidazole linkages, it tends to absorb moisture, and it needs pre-drying at 200-220 ° C for 2-3 hours by air circulating type dryer. GAZOLE™ 5000 Series (PBI - 2, 5 Polybenzimidazole) is a crystalline polymer having glass transition temperature point of 467°C and no melting point. Parts from GAZOLE™ 5000 are prepared by high pressure compression molding process at temperatures between 450°C - 500°C. Compression pressure > 10000 psi applied for 3 - 4 hours at 450°C - 500°C is required to make parts from PBI less than 7 – 10 mm in thickness and 100 mm in diameter and for thicker parts and larger diameters, compression pressures of around 30,000 psi is required, which cannot be achieved by normal axial pressing compression molding process. These pressures are achieved by HIP (Hot Isotactic Pressing) traditionally used for powder metallurgy.

7. Applications

GAZOLE™ (PBI) is ultimate for applications where requirements cannot be met by any other engineering plastics in tremendous high temperatures, in harsh chemical or plasma environments, or in applications where durability and wear resistance are important. GAZOLE™ PBI molded parts used in following applications.

- Semiconductor
- Electrical insulating parts
- Bushes, Seals, Bearings and wear plates required extremely high wear resistance.

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