LOW ENVIRONMENTAL IMPACT POLYAMIDES MADE FROM SELECTED RECYCLED MATERIALS

Integrated sustainability and performance are what many industries, notably automotive, are looking for in product solutions.

With its long experience in the field of polymeric materials, RadiciGroup High Performance Polymers can fulfil this requirement with its wide range of products, encompassing Heramid® PA6 and PA6.6 polymers made of 100% selected materials primarily recovered from the production units of RadiciGroup Business Areas.

RADICI GROUP

Origin of products

RadiciGroup is an Italian multinational offering a very large product portfolio of primary materials.
In the **RadiciGroup High Performance Polymers** (HPP) business area, industrial scraps from various Group production units are sorted and recovered by mechanical processing to obtain secondary (recycled) PA6s and PA6.6s.

As shown in Figure 1, these recycled products are made using materials recovered from scraps produced by the RadiciGroup polymerization and spinning. The reuse of such production waste, enabled by extensive experience in raw materials selection, is one of the factors that allows the Group to fulfil its sustainability commitment through a more environmentally friendly approach.

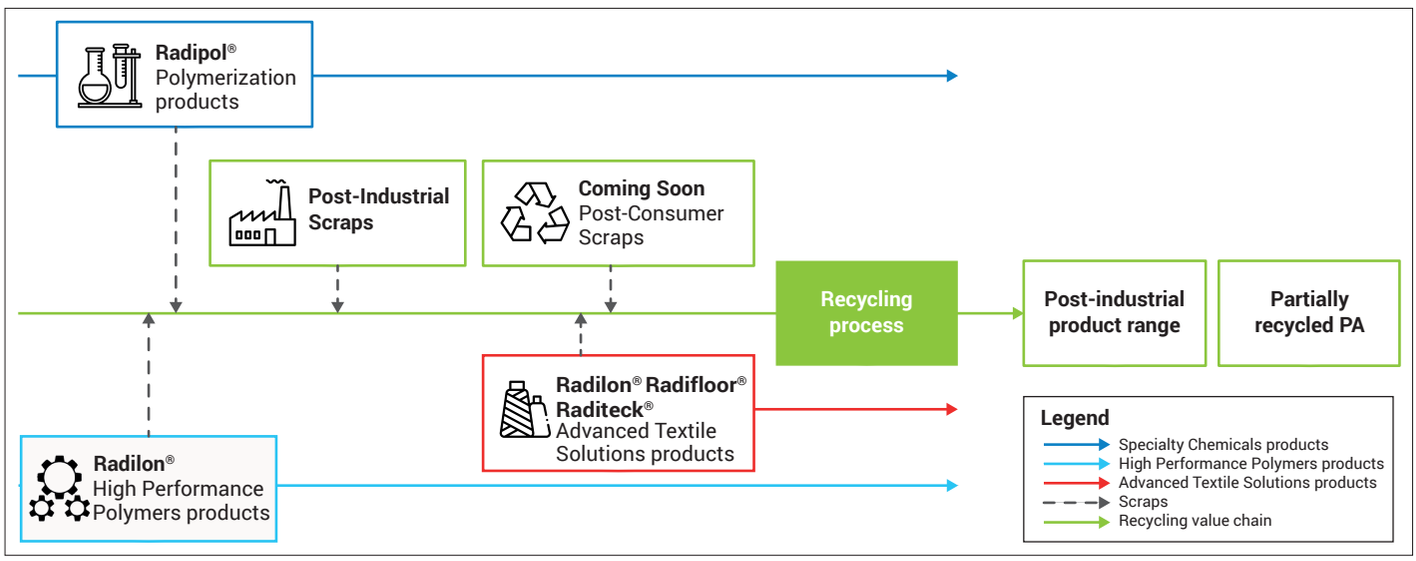

Figure 1: Integration of PA6 and PA6.6

Post-industrial recycled polyamides: Important considerations for the selection process

In general, **products made of recycled polyamides have significantly lower properties** to those of primary raw materials. For application purposes, this aspect must be given due consideration and the design of components must take into account the actual properties of these secondary materials, including their behaviour in case of prolonged exposure to cooling fluids or hot air, for example.

Figure 2 presents the stress-strain curve comparison between Radilon® A RV300W 333BK, a primary PA6.6-GF30 material, in dry conditions and Heramid® A NER GF030/1K, a product made from 100% recycled materials. From Table 1, it can be seen that the tensile modulus of Heramid® A NER GF030/1K is 11.4% lower than the value for the primary material, and, likewise, the impact strength, tensile stress at break and tensile strain at break are 40%, 22.8% and 21.8% lower, respectively. (Table 1 shows the mechanical properties side by side).

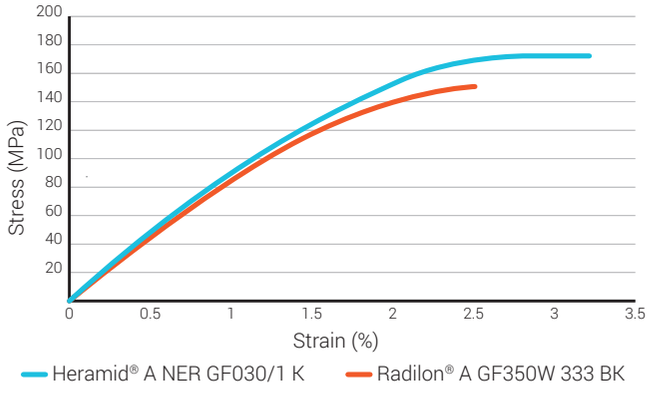

Figure 2: Stress-strain curves comparison

Property	Heramid® A NER GF030/1K	Radilon® A RV300W 333BK
Tensile modulus [MPa]	8500	9600
Tensile stress at break [MPa]	135	175
Tensile strain at break [%]	2.5	3.2
Impact strength [kJ/m²]	45	75

Table 1: Mechanical properties comparison

The products with post-industrial recycled content offered by RadiciGroup for critical applications come with a **certificate attesting to lot-to-lot qualitative consistency.** Special attention is paid to the control of metal and non-metal pollutants through systematic checks on the production line.

Heramid® products exhibit a lower environmental impact. The ready availability of sorted scraps and long experience in developing new formulations has made the use of these materials possible for automotive applications.

The net result is a sizeable reduction in the environmental impact of end products. The contribution to global warming of Heramid® A NER GF030 1/K is equal to about one-tenth of the contribution of the products made solely with primary raw materials, such as Radilon® A RV300. The same can be said of energy consumption during the production process. **CO_2 equivalent emissions** are reduced by **89%** (see Figure 3) and **MJ consumption** (see Figure 4), by **91%.**

For some applications, particularly **automotive**, RadiciGroup High Performance Polymers has developed **materials with a limited recycled content,** in order to avoid an excessive drop in the mechanical properties.

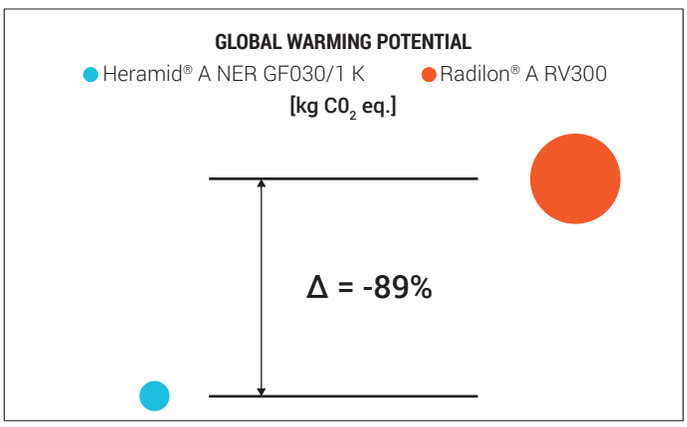

Figure 3: Global warming potential

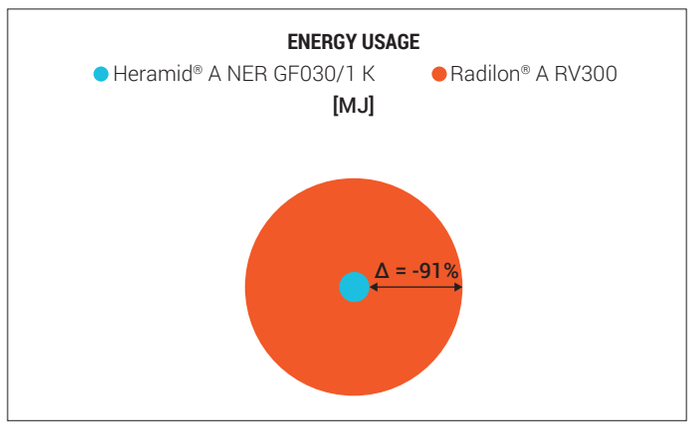

Figure 4: Energy usage

For more detailed information, please refer to the Environmental Product Declaration for RadiciGroup High Performance Polymers Radilon® A RV300 (Reg. No. S-P-00554) and Heramid® A NER GF030 1/K (Reg. No. S-P-00707) freely accessible on www.environdec.com.

Typical automotive applications

Automotive is one of the most important markets where post-industrial materials are used.

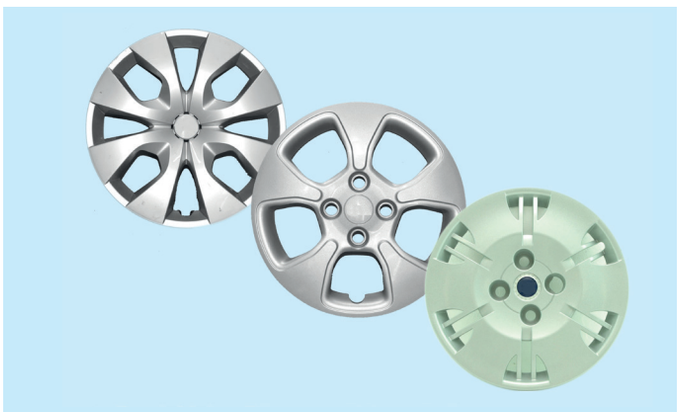

Figure 5: Wheel covers [*]

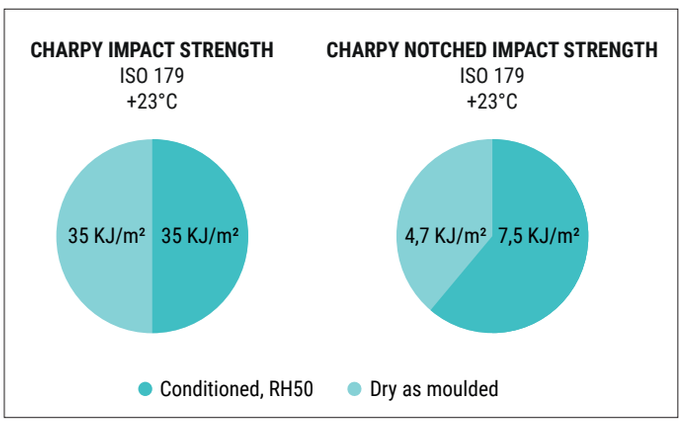

Figure 6: Impact strength comparison

Wheel covers (Figure 5). These wheel covers are made of **Heramid® A GRI 7645 AGF020**, a compound produced with **PA6.6** obtained from **100% post-industrial recycled** raw material. The formulation has been optimized to ensure:

1. Consistent colour shade.
2. Successful passing of the paint adhesion test, after immersion in water and prolonged exposure to high humidity and high temperatures.
3. Successful passing of mechanical tests, including impact tests. Figure 6 shows the impact strengths comparison for Heramid® A GRI 7645 AGF020 at 23°C in dry-as-moulded and RH50 conditions.

Fan shrouds (Figure 7a and Figure 7b). The fan shrouds pictured are made of partially recycled **Radilon® A NER GF250W** (PA6.6-GF25) and 100% recycled **Heramid® A NER GF030/1K** (PA6.6-GF30), respectively.

These heat-stabilized materials contain recompounded base polymer from high-quality post-industrial feedstock.

This assures a limited property drop compared to the primary grade. Figure 8 gives the stress-strain curves of Radilon® A NER GF250W compared to Heramid® A NER GF030/1K, at 23°C in dry-as-moulded conditions.

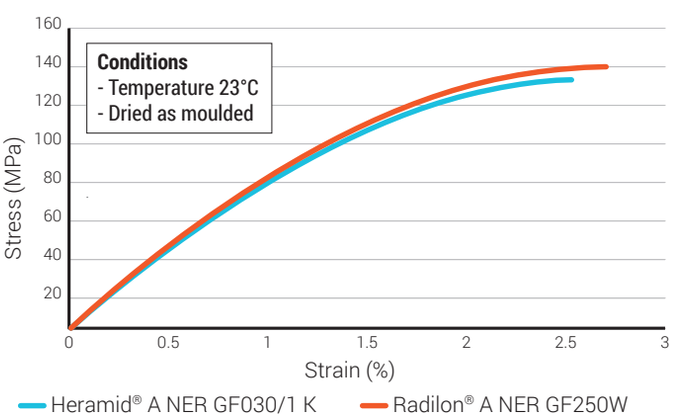

Figure 8: Stress-strain curve

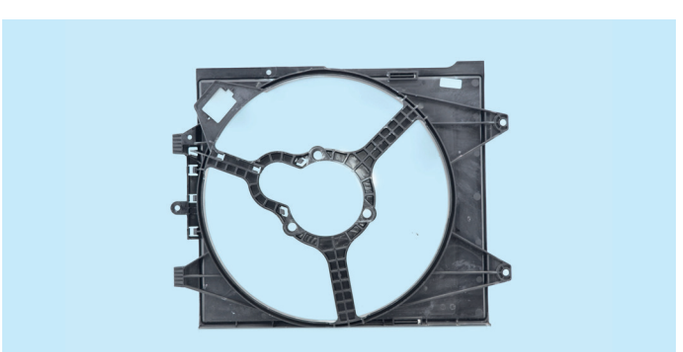

Figure 7a: Fan shroud (Radilon® A NER GF250W) [*]

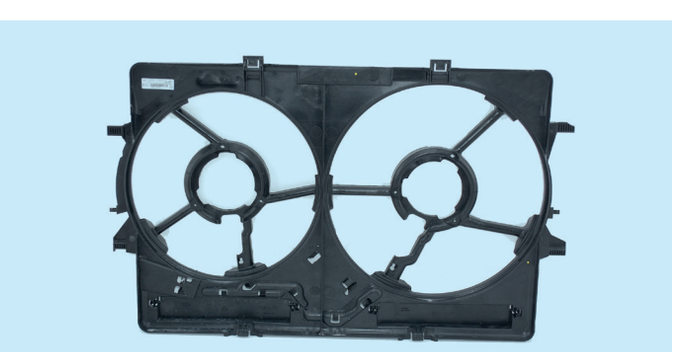

Figure 7b: Fan shroud (Heramid® A NER GF030/1K) [*]

Body-in-white inserts. These inserts are other automotive products that can be made of 100% recycled material. The **Heramid® A NER MP 1/K** and **Torzen® T2021 HSL BK 01** products used here, are toughened, heat-stabilized, black-coloured grade.

This material is a suitable solution for all applications where impact resistance and flexibility are important requirements. Figure 9 shows the stress-strain curve of Heramid® A NER MP 1/K at 23°C in dry-as-moulded conditions.

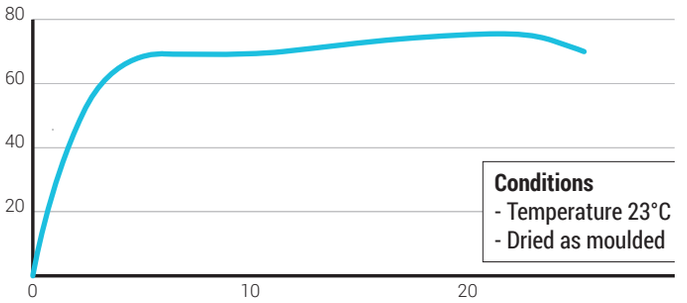

Figure 9: Stress-strain curve

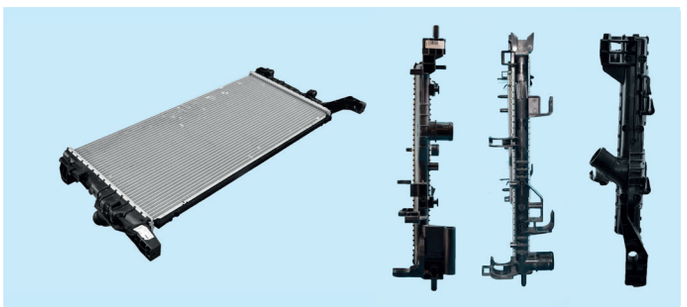

Figure 10: Radiator end tanks [*]

Radiator end tanks (Figure 10). For this application, HPP has developed **Radilon® A NER GF300RKC**, a product consisting of partially recycled content.

The material has been specially formulated to ensure good resistance when directly exposed to engine cooling liquids.

It is a lower environmental impact alternative to glass fibre filled PA6.6s, which, since years, has been the material chosen for this application.

Valve covers (Figure 11). For these automotive parts, as for the radiator end tanks above, RadiciGroup High Performance Polymers has introduced **Radilon® A GF350W 333 BK**, a material with partially recycled content.

Valve covers, a so-called “mature” application, require materials capable of operating at high temperatures under considerable creep and fatigue loads.

Radilon® A GF350W 333 BK is a good solution for reduced environmental impact products that do not entail a compromise in the quality and reliability of the end components.

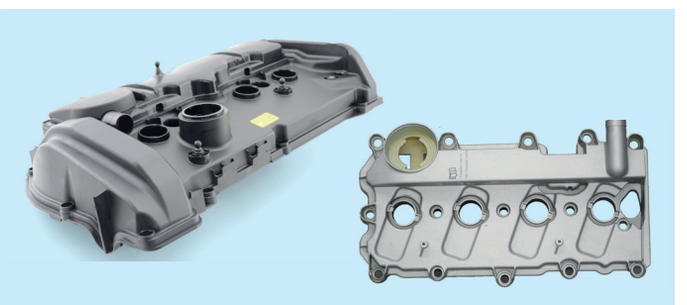

Figure 11: Valve covers [*]

Figure 12: Engine cover [*]

Engine covers (Figure 12). For engine cover applications, glass and glass/mineral filled Heramid® products are a valid alternative to primary materials.

Typical material of choice for this application is **Heramid® S NER GFP3010** (PA6 (GF+MD)30). As in the case of other auto parts, Heramid® solutions provide good planarity and good surface appaerence.

Cable channels (Figure 13). These components are usually manufactured with **Heramid® A NER MP/1K** or other tailor made grades like **Heramid® S NER 233 MP/1K**. Flexibility and excellent thermal resistance are two of the key requirements for this well-established application.

Furthermore, the Heramid® A and S range features a good selection of grades to meet the various component design requirements and the technical specifications of manufacturers.

Figure 13: Cable channel [*]

Applications in other sectors

Thermal breakers (Figure 14). Thermal breakers, also known as heat barriers, installed in window frames are one of the conventional applications of polyamides.

A tailor made **Heramid® A (PA6.6)** can be used to produce the special materials needed for this kind of application, combining the main thermal insulation function with reduced environmental impact.

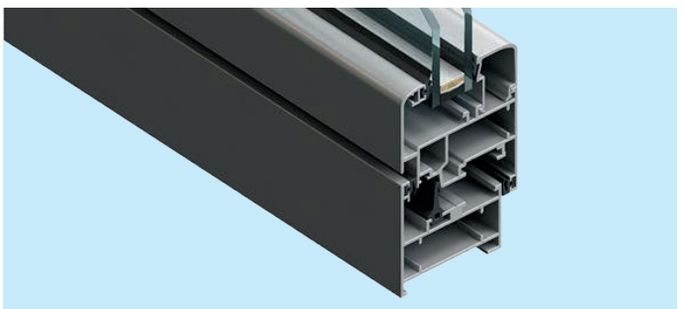

Figure 14: Thermal breakers

Figure 15: Power tools

Power tools (Figure 15): For this type of application, RadiciGroup HPP has developed 100% post-industrial recycled (PIR) specialty products to serve the custom requirements of its customers.

The chief product characteristics requested are UV resistance for exterior exposure, impact resistance, excellent surface appearance and made-to-order colours.

Expansion dowels (Figure 16). Still another use of post-industrial materials is expansion dowels. In this case, the suitable grade is **Heramid® S GRI 7350 MPX** produced with polymer scrap content coming from polymerization, spinning and compounding plants.

The material, formulated with a grey colour, has been modified to increase flexibility, as required by this kind of application. Figure 17 shows the stress-strain curve of Heramid® S GRI 7350 MPX at 23°C in dry-as-moulded conditions.

Figure 16: Expansion dowels

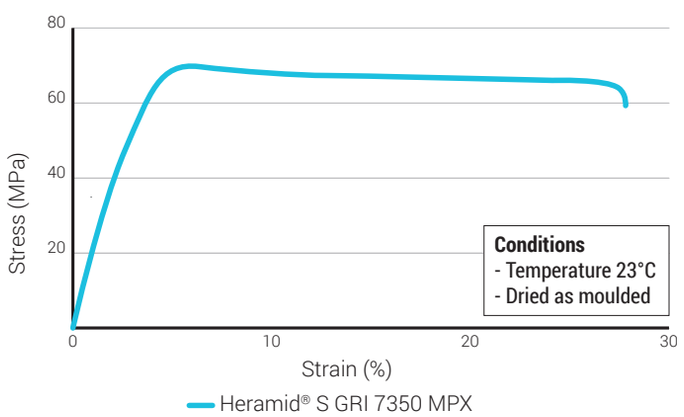

Figure 17: Stress-strain curve

Our experience. Your solutions.

RadiciGroup has expert technical personnel around the globe ready to provide all the needed assistance in choosing the best materials for the most diverse variety of applications. RadiciGroup High Performance Polymers offers assistance in determining the optimal processing conditions (moulding or extrusion) for its polymers, as well as support on many other technical aspects. We have many years' experience in **technical assistance, research and development** and engineering through our **CAE Service**, equipped with the most advanced process and structural simulation software.

The same level of support is also provided from the very initial stages of a project to help select products with the lowest environmental impact. In this case, the choice and the quality consistency of the polymer are crucial elements to ensure that the specifications and reliability of the final product are met.

[*] – Images from https://portal.a2mac1.com/

RadiciGroup High Performance Polymers post-industrial product range

Legend:
IM: Impact Modified; HS: Heat Stabilized; GF: Glass Fibre content; GB: Glass Bead content; MD: Mineral filler content; HR: Hydrolysis Resistant

	BASE POLYMER AND SHORT DESCRIPTION (SEE LEGEND ABOVE)	MECHANICAL – DRY AS MOULDED					PHYSICAL		
		TENSILE STRESS AT BREAK	TENSILE STRAIN AT BREAK	TENSILE MODULUS	FLEXURAL MODULUS	CHARPY NOTCHED IMPACT STRENGTH	HEAT DEFLECTION TEMPERATURE	MELTING TEMPERATURE	DENSITY
ISO Standard		527	527	527	178	179\1eA	75	3146	1183
Test Conditions		23°C	23°C	23°C	23°C	23°C	1.8MPa	DSC	23°C
Unit		MPa	%	MPa	MPa	kJ/m²	°C	°C	g/cm³
Heramid® S Ner	PA6	70	-	2750	2500	8	60	220	1.13
Heramid® S Nat	PA6	70	-	2750	2500	7	60	220	1.13
Heramid® A Ner	PA6.6	70	18	2600	2300	9	70	260	1.12
Heramid® A Nat	PA6.6	75	15	3000	2500	6	70	260	1.13
Heramid® A Ner MPT	PA6.6 – IM	54	50	2000	1800	60	70	260	1.10
Heramid® A Ner MPX/1	PA6.6 – IM	70	-	2700	2400	5	65	260	1.10
Heramid® S Ner 233 MP/1K	PA6 – IM – HS	60	-	2500	2100	13	60	220	1.12
Heramid® S Ner FV030	PA6 GF30	120	3	8000	7000	7	190	220	1.35
Heramid® A Ner FV030	PA6.6 GF30	125	3	8000	7000	5	200	260	1.35
Heramid® S Nat SV030	PA6 GB30	70	5.5	4000	3600	3.7	85	220	1.35
Heramid® A Ner SV030	PA6.6 GB30	65	6.5	3850	3750	3.5	80	260	1.33
Heramid® S Ner GF030/1 K	PA6 GF30 – HS	130	2.5	8000	7500	7	190	220	1.36
Heramid® A Ner GF030/1 K	PA6.6 GF30 – HS	135	2.5	8500	7500	6.5	230	260	1.36
Heramid® A Ner MP/1K	PA6.6 – IM – HS	60	33	2400	2200	13	65	260	1.12
Heramid® A EGF 015W 3733BK	PA6.6 GF15 – IM – HS	90	4.5	4800	4300	13	225	260	1.21
Heramid® S NER GFP3010	PA6 (GF+MD)30	85	2.5	6500	6000	6	190	220	1.35
Heramid® S Ner GFP3015/2	PA6 (GF+MD)30	130	2.5	9500	8500	7	200	220	1.43
Heramid® A GRI 7645 AGF020	PA6.6 (GF+MD)20 – IM	95	3.5	5500	4500	4.7	190	260	1.22
Heramid® A Ner GF050/1	PA6.6 GF50	175	2	14000	13200	10.5	230	260	1.56
Heramid® S Ner 233 MPX	PA6 – IM	60	-	2500	2500	8.5	65	220	1.12
Heramid® S GRI 7350 MPX	PA6 – IM	70	18.6	2700	2500	10	65	220	1.13
Heramid® A Ner GF035/1	PA6.6 GF35	140	2.5	10000	8500	7.5	230	260	1.39
Radilon® A Ner GF250W	PA6.6 GF25 – HS	148	2.7	8000	6800	7	230	260	1.32
Radilon® A Ner GF300 K	PA6.6 GF30 – HS	165	3	9000	8000	9	235	260	1.35
Radilon® A Ner GF 300 RKC	PA6.6 GF30 – HR	170	3	9000	8000	7.5	240	260	1.35
Radilon® A GF350W 333 BK	PA6.6 GF35 – HS	169	2.6	10300	9740	11	250	260	1.39
Torzen® G4001 HSL BK	PA6.6 GF40 – HS	205	2.8	12100	10100	10	248	262	1.47
Torzen® T2021 HSL BK 01	PA6.6 – IM – HS	65	-	2400	2260	17	65	260	1.10

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