MAGRIStalc

Reinforcement of Polyamide 6

- Partial glass fiber replacement
- Cost saving Magris Talc solutions
- Decreased warpage
- Increased crystallization temperature
- Improved melt flow
- Improved part appearance

Performance Additives

Performance Additives are commonly used in the formulation of polyamides and other engineering thermoplastics to provide reinforcement, improve rheology or contribute to other mechanical properties.

Chopped glass fiber and mineral additives are among the most common reinforcing additives used in polyamide formulations.

Typical examples are the highly filled Polyamide 6 (PA6) formulations used in E&E (electrical and electronics) and in automotive applications. Despite its desirable performance enhancement, the application of chopped glass fiber (GF) reinforced PA6 is associated with rheology, appearance and surface aesthetic limitations. Warpage and anisotropy of mechanical properties also limit the application and desirability of many GF-filled PA6 formulations.

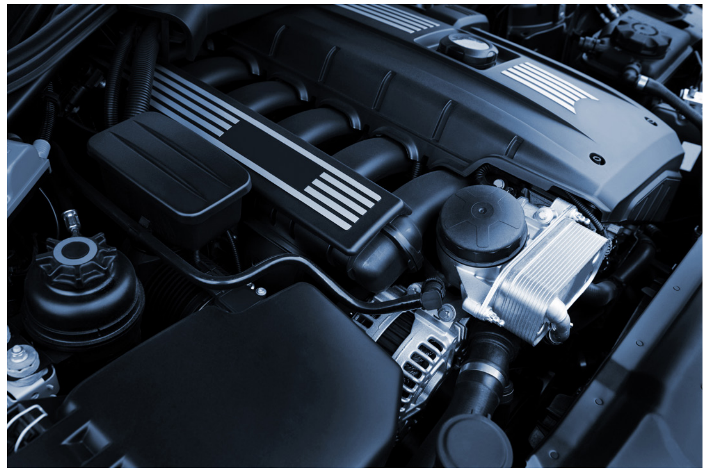
The purpose of this technical bulletin is to compare the effect of GF and Magris Talc products on rheology, appearance, and mechanical properties of Polyamide 6 (PA6). Also investigate how partial replacement of GF with Magris Talc could help alleviate some of the difficulties associated with GF reinforced PA6.

Performance comparisons have been conducted at the total Magris Talc loading of 30% by weight, also compounds with 1/3 (or 10 wt%) of GF replacement with Magris Talc. Both 20 and 30 wt% GF-filled PA6 have been used as "control".

Two typical Magris Talc grades are compared in graphical presentation of the results, one representing the highest aspect ratio (HYPERPLATE™ (T77, H92, Mistron®)) and the other representing the lower aspect ratio (Microcrystalline Talc (Nicron® 674/674C/674DT, Mistron® Vapor R/RE)) form.

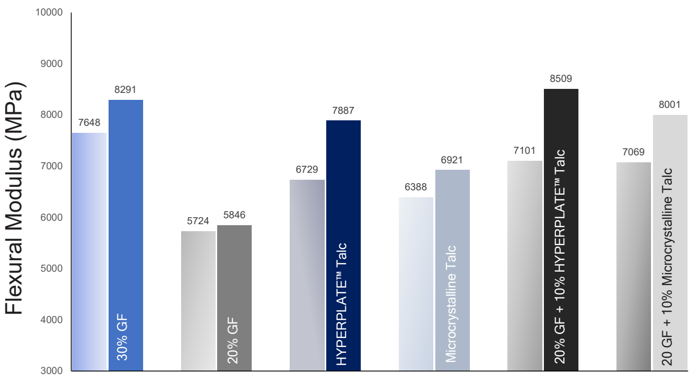
The main performance indicators are measured and presented using both ASTM and ISO standards, where lighter and darker shades of color, respectively show ASTM and ISO test results. Differences observed in values of properties measured by ASTM and ISO tests are due to differences in specimen size, measurement rate/speed, and other specifics of each test as shown on the graphs or under the experimental procedure at the end of this bulletin.

If different specimen types (e.g. double gated vs. single gated specimens) or test conditions (e.g. flow vs. cross-flow directions, angle of gloss measurement, etc.) are compared, dark, and light bars are used to differentiate the results.



Stiffness (Flexural/Tensile Modulus)

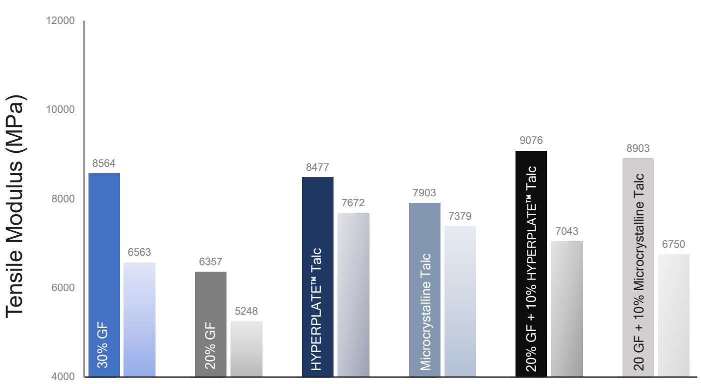
A desired performance of reinforcing additives in Polyamide 6 is their effect on increasing material stiffness, i.e. flexural or tensile modulus. While GF is the typical standard for reinforcing PA6, our results show that HYPERPLATE™ talc closely matches GF performance. The performance of Microcrystalline talc also falls within the performance of 20 and 30 wt% GF filled PA6.



ASTM D790: Light Bars - Rate = 1.27mm/min
ISO178: Dark Bars - Rate = 2.00mm/min

While above stiffness results are valid for single gated injection molded specimens without a weldline, the replacement of 10% GF with HYPERPLATE™ and Microcrystalline Talc clearly improves stiffness for double-gated injection molded specimens with weldlines. The stiffness comparison is based on tensile modulus data obtained using ASTM standard specimens that are injection molded with either a single gate (no weldline) or double gate (a single weldline in the middle of the bar).

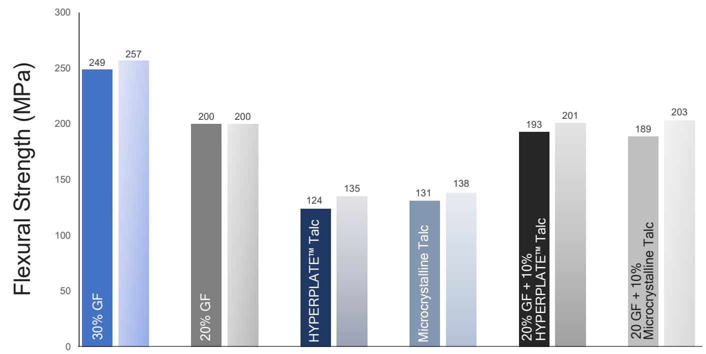
ASTM tensile tests allow for preparing standard specimens using either a single injection molding gate that creates no weldline or a double gated design that results in a weldline in the center of the part. Tensile modulus test results for specimens with weldline (light bars below) show a clear advantage for both talc products. The tensile modulus without a weldline follows a similar trend to flexural modulus.



Single Gated (no weldline) - Dark Bars
Double Gated (with weldline) - Light Bars
ASTM D638: Rate 0.51 mm/min

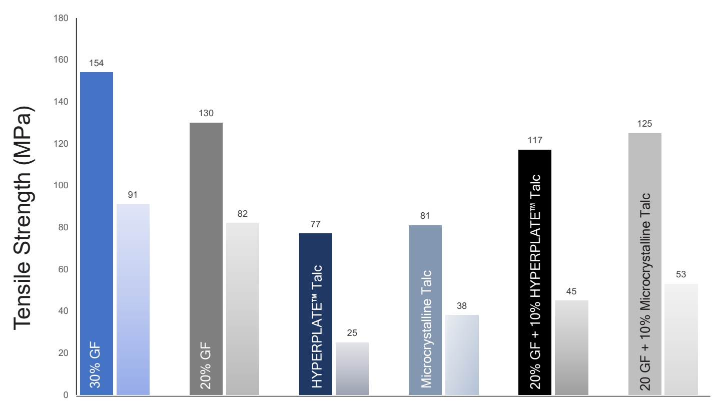
Flexural/Tensile Strength

Glass fiber is known for its strong performance in improving the flexural/tensile strength of thermoplastic polymers. Since functional minerals by themselves produce lower strength performance, the combination of GF and functional minerals is advantageous in applications requiring high strength performance. Test results show that flexural strength of PA6 formulations containing 20% GF and 10% Magris Talc is maintained at about the strength performance of 20% GF filled PA6.



ASTM D790: Light Bars - Rate = 1.27 mm/min
ISO178: Dark Bars - Rate = 2.00 mm/min

Tensile strength for single-gated specimens (no weldline) of 20% GF and 10% Magris Talc filled PA6 also appears to be maintained at about 20% GF-filled PA6 level.

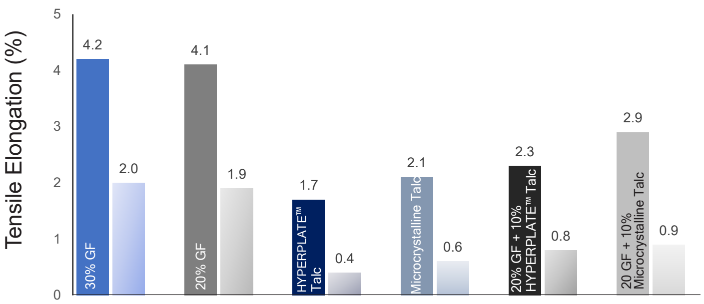


Single Gated (no weldline) - Dark Bars
Double Gated (with weldline) - Light Bars
ASTM D638: Rate 0.51mm/min

For PA6 parts with no weldline that require high strength performance, partial replacement of GF with Magris Talc allows a major portion of the strength contributed by GF to be maintained. Weldlines are unavoidable in the production of many plastic parts. Superior stiffness along with similar strength performance to chopped glass fiber is difficult to achieve. Partial replacement of 10% GF with Magris Talc also results in a small reduction in elongation at break.

Tensile Elongation

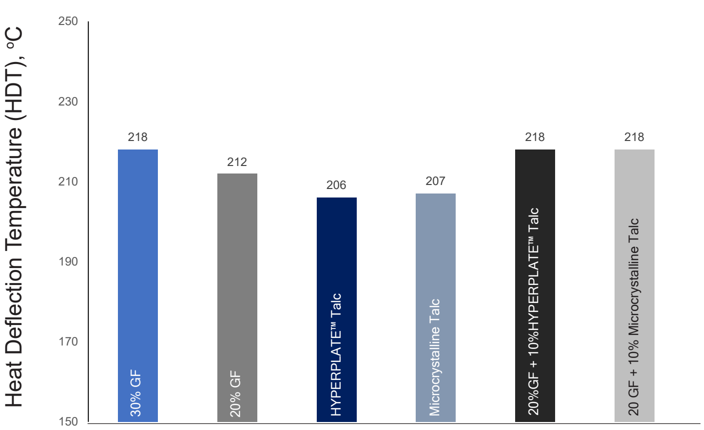
SEM analyses of the failed specimens show GF tends to align itself parallel to weldline, causing weak interlayer bonding. Similar to GF, talc platelets also align parallel to weldline causing a relatively weak point at the weldline.



Single Gated (no weldline) - Dark Bars
Double Gated (with weldline) - Light Bars
ASTM D638: Rate 0.51mm/min

Heat Deflection Temperature

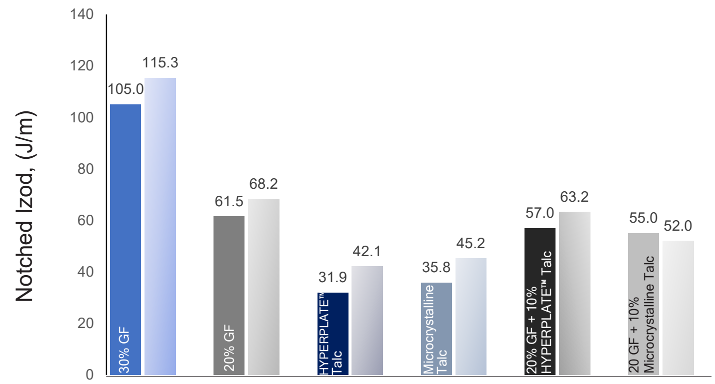
HDT test results at 0.45 MPa show that there is no practical effect on HDT of the PA6 formulations when 10% of GF is replaced with either of the Magris Talc grades used in this study. Small variations recorded are within typical variations of HDT measurement.



ISO 75 at 0.45 MPa
Edgewise, 100mm Span

Notched Izod Impact

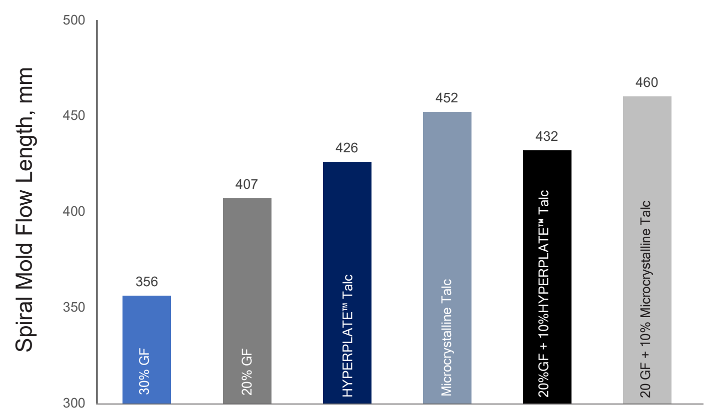
Similar to strength, GF also provides an advantage in notched Izod impact performance as shown by an increase in Izod impact with increasing GF loading in PA6. Using a combination of GF and Magris Talc reinforcement allows partially maintaining this benefit of GF to achieve higher Izod impact performance compared to a Talc filled PA6. Test results show that HYPERPLATE™ Talc gives the best Izod impact performance when used for partial replacement of 10% GF, where the Izod impact is similar to that for 20% GF-filled PA6.



ASTM D256 at 23°C - Light Bars
ISO 180 at 23°C - Dark Bars

Rheology Improvement

Melt flow limitations and the associated injection molding and surface aesthetic issues are known deficiencies of glass fiber filled PA6 formulations. Partial replacement of 10% GF with Magris Talc improves the formulation rheology as shown by the spiral mold flow length. Exceptional performance is obtained when Magris Talc is used, where the spiral flow length is greater than that for 30% or even 20% GF-filled PA6.



ASTM D256 at 23°C - Light Bars
ISO 180 at 23°C - Dark Bars

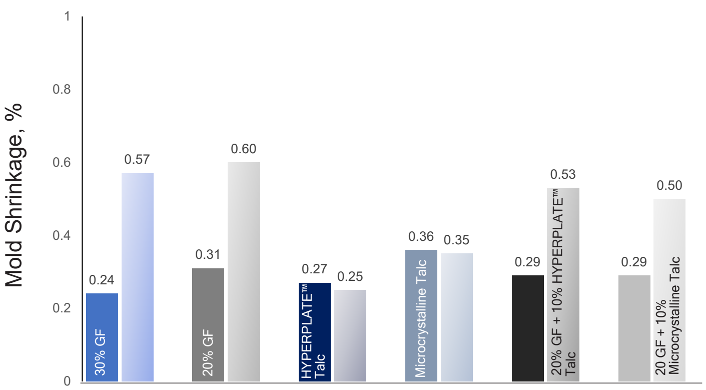
Magris Talc significantly improve the rheology of PA6 formulations compared to chopped glass fiber and can be used to improve the rheology and aesthetics of GF-filled PA6 especially for injection molded parts.

Dimensional Stability and Isotropy

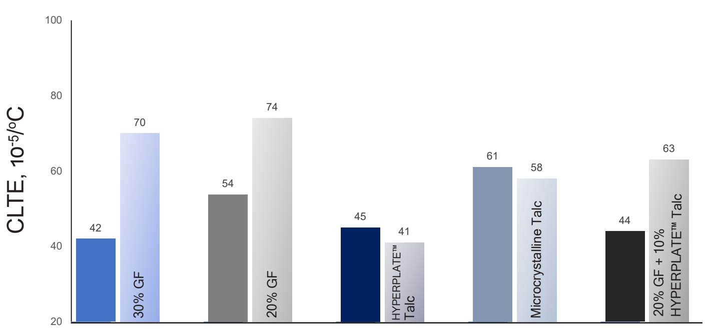
Improving dimensional stability as in reduced mold shrinkage and CLTE (Coefficient of Linear Thermal Expansion) is a desirable performance in polyamide formulations; both glass fiber and Magris Talc improve dimensional stability of semi-crystalline PA6. However, the performance of GF is non-isotropic, which often results in part warpage.

Mold shrinkage measurements show that partial replacement of 10% GF with HYPERPLATE™ improves dimensional isotropy and part warpage by reducing cross-flow shrinkage.

Measurement of CLTE (Coefficient of Linear Thermal Expansion on HYPERPLATE™ also confirms a lower CLTE for cross-flow direction and improved isotropy resulting in a lower average CLTE and improved isotropy.



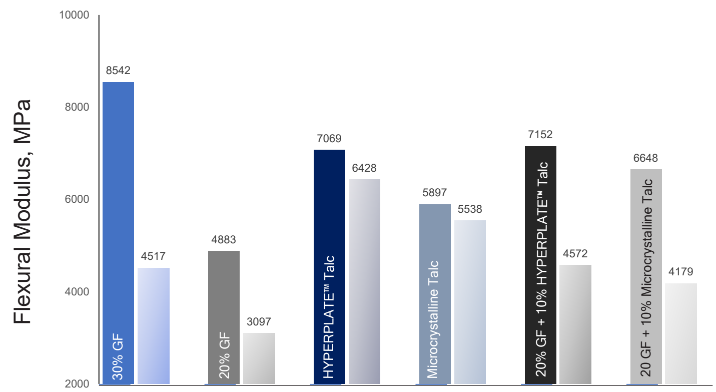
Flow Direction - Dark Bars
Cross Flow Direction - Light Bars
Internal Method / Measurement Fixture



Flow Direction - Dark Bars
Cross Flow Direction - Light Bars
Internal Method/Measurement Fixture

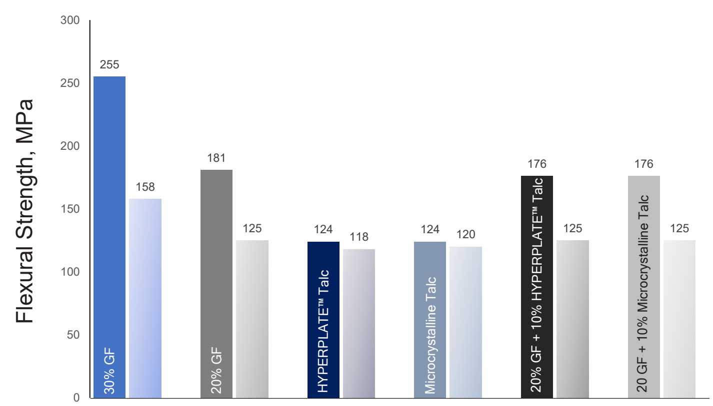
The difference in dimensional stability in flow and cross-flow directions cause dimensional anisotropy that results in warpage of injection molded parts, which is especially evident in thinner and larger parts. Acicular additives such as GF cause anisotropy due to their one dimensional aspect ratio, while Magris Talc products are isotropic in two dimensions.

The anisotropy of GF expands beyond dimensional stability into mechanical properties. Flexural modulus and strength measurements conducted on standard ISO plaques show significantly weaker performance in cross-flow direction for GF, while Magris Talc products provide isotropy and the best stiffness and strength performance balance in both directions.



Flow Direction - Dark Bars
Cross Flow Direction - Light Bars
ASTM D790: Rate = 0.51 mm/min

HYPERPLATE™ is shown to be very effective in increasing cross-flow flexural modulus (stiffness) by outperforming 30% GF-filled PA6, and maintaining or increasing cross-flow flexural strength compared to 20 wt% GF-filled PA6.

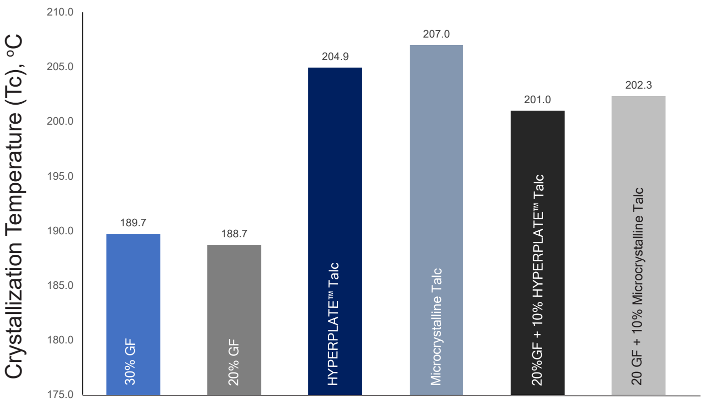


Flow Direction - Dark Bars
Cross Flow Direction - Light Bars
ASTM D790: Rate = 0.5mm/min

Industrial parts are designed based on the weakest mechanical properties of materials/formulations, so isotropy or strong performance in cross-flow direction are desirable for many parts. Magris Talc products provide the best isotropy and optimum balance of properties in two dimensions.

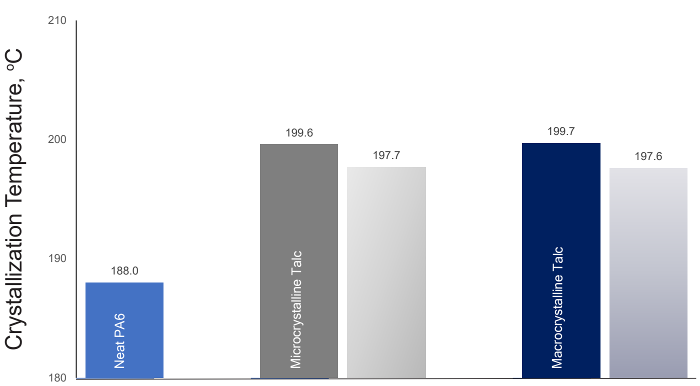
Polyamide Nucleation

As a semicrystalline polymer, the performance and properties of PA6 are affected by its degree of crystallization. Differential Scanning Calorimetry (DSC) analyses conducted on Magris Talc and glass fiber filled PA6 formulations show that their crystallization temperature varies with the type of additives used. Both Microcrystalline and HYPERPLATE™ talc increase the crystallization temperature of PA6 by as much as 15-17°C compared to GF at 30 wt% loading. Data also shows that partial replacement of 10% GF with Magris Talc in PA6 results in about 11-12°C increase in crystallization temperature Tc).



Tc for Neat PA6 = 188°C

Additional measurements show that talc is an effective nucleating agent starting at much lower loading levels of 3%, 0.5% or even lower. This suggests that talc could also be used at low loading levels in PA6 formulations filled with GF, other minerals, or their combination to impart a desired increase in crystallization temperature (Tc). An increase in Tc could be beneficial in improving throughput of industrial processes, including injection molding cycle time.



3.0% Additive Loading - Dark Bars
0.5% Additive Loading - Light Bars

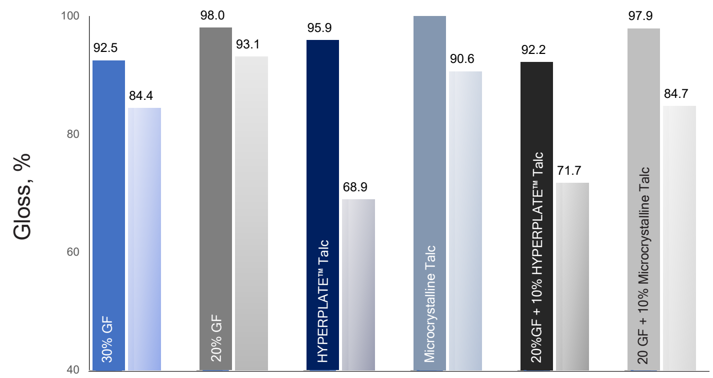
Incorporating Magris Talc in PA6 formulations either as the primary reinforcing additive or in combination with glass fiber and/or other mineral additives increases the crystallization temperature proportionately to the Magris Talc loading in the formulation. This improves processing throughputs including the reduction of injection molding cycle time.

Appearance

Minerals are naturally occurring, so their color and appearance can vary even within the same ore body. In general, Magris Talc products can be white to off-white with differing hues.

Small variations were also observed in the gloss values of injection molded parts, indicating increased gloss with reduced GF loading and with reduced particle size of Magris Talc.

Magris Talc also showed some matting effect on 60° gloss values. So, partial replacement of GF with talc may alter the color and appearance of PA6 formulations.



85° Gloss - Dark Bars
60° Gloss - Light Bars

Conclusions and Product Recommendation

Partial replacement of glass fiber with Magris Talc products can be utilized to preserve the benefits of glass fiber in increasing the tensile/flexural strength and Izod impact performance of PA6 formulations, while making use of the especial attributes and benefits of this functional additive.

Magris Talc products provide superior balance of properties for parts that require similar performance in two dimensions as they provide isotropic mechanical properties and dimensional stability, especially HYPERPLATE™ for these applications.

Magris Talc products have a unique efficacy to nucleate PA6 and increase its crystallization temperature. We recommend using microcrystalline talc by itself or in combination with GF to increase crystallization temperature and reduce industrial processing times.

Magris Talc products offer superior performance for improving isotropy and cross-flow mechanical performance. We recommend using Magris Talc products in combination with GF to improve isotropy.

HYPERPLATE™ provides the highest stiffness reinforcement that competes with chopped GF, so it is recommended for applications requiring enhanced stiffness.

For Parts with a Weldline

Magris Talc products increase crystallization temperature and stiffness, improves rheology, but does not maintain tensile strength and elongation.

For Parts without a Weldline

Magris Talc products: increase crystallization temperature, maintain stiffness and HDT, synergistically increase spiral melt flow length, reduce cross-flow shrinkage and CLTE, increase cross-flow stiffness, and maintain cross-flow strength performance.

Experimental Procedure

Materials used:

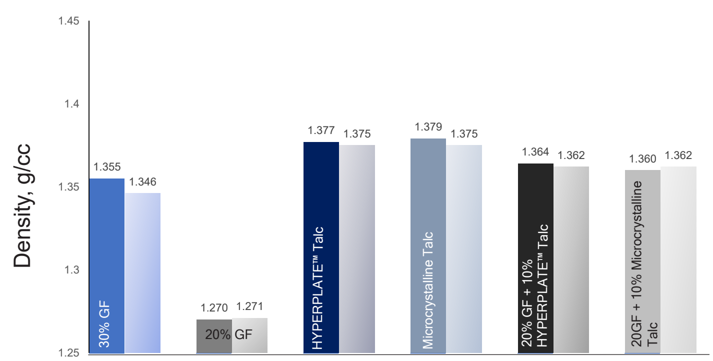
- PA6: Ultramide B27E (BASF)
- Glass Fiber: EC10-675, 4mm (Johns Manville)
- Magris Talc as listed in the text
- Compounding: Bernstorff ZE 25A x 46D UTZXi twin-screw extruder D-25mm, L/D=46, 250rpm, 15 kg/hr
- GF feed-port: downstream side-feeder at Barrel Zone 5
- HYPERPLATE™ Talc feed-port: side-feeder at Barrel Zone 3
- Microcrystalline talc feed-port: extruder throat
- Drying PA6 to <0.4% moisture
- Injection Molding: - Arburg Allrounder 370E 600-170 IM press
- Drying the compound to <0.2% moisture
- ISO and ASTM standard specimen molds
- Spiral-flow mold

Testing:

- Flexural properties: ASTM D790 (at 0.05 in/min. and 2 in. span) and ISO 178 (at 2 mm/min. and 64 mm span)
- Tensile properties: ASTM D638 (at 0.2 in./min speed) and ISO 527 (Type 1A) at 5 mm/min
- Notched Izod impact: ASTM D256 and ISO 180 and 23°C
- HDT: ISO-75 at 0.45 and 1.82 MPa in edgewise orientation and 100 mm span
- Shrinkage: internal method using 60x60 mm injection molded plaques and a specially designed measurement fixture
- Crystallization temperature: ASTM D3418-15 - heating/cooling/heating cycle at 20°C/min using DSC-25 TA instruments
- Coefficient of Linear Thermal Expansion (CLTE): in-house fixture and method (23-70°C)
- Ash content: internal method using microwave ash oven
- Density: Mettler Toledo MS semi-micro balance and density kit
- Moisture: Computrac Vapor Pro Moisture Analysis
- Color (CIE L* a* b*): Konika Minolta Chroma Meter / Colorimeter CR-400
- Gloss: Gardner micro-Tri-gloss meter
- SEM: Hitachi S4300

Compositional Accuracy

To verify the accuracy of composition and quality of molded specimens obtained in the compounding and injection molding process, the density of specimens were compared with the theoretical formulation density.



Measured - Dark Bars
Theoretical - Light Bars

Products

Canada Sourced Products	Applications	Median Particle Size Sedigraph µ	Top Size Hegman	Y Brightness
JetWhite® 3CW	Interior & Exterior TPO	1.3	7.5 (~6.25 microns)	91
JetFil® 3CC	Improved Scratch - TPO/PP	0.9	7.5 (~6.25 microns)	88
JetFil® 700C	Exterior TPO	1.5	7.0 (~12.5 microns)	88
JetFil® 625C	Exterior TPO	2.2	6.5 (~18.75 microns)	88
JetFil® 575P / JetFil® 575C	General PP & PVC Applications	3.4	5.75 (~28.13 microns)	87
JetFil® 575C-HB	Color Sensitive Applications	3.0	5.75 (~28.13 microns)	89
JetFil® P500	Appliances	4.5	5.0 (~37.5 microns)	85
JetFil® P350	General Purpose	7.5	4.25 (~46.88 microns)	84
JetFil® P200	General Purpose	8.5	2.0 (~75.0 microns)	83
JetFil® T590	Packaging, UTH*	4.5	5.0 (~37.5 microns)	83
JetFil® T490	Packaging, UTH*	5.5	4.5 (~43.75 microns)	81
JetFil® T390	Under the hood (UTH)	7.5	4.25 (~46.88 microns)	81
JetFil® T290	UTH*, WPC**	8.5	3.0 (~62.5 microns)	78

Houston Production Grades	Applications	Median Particle Size Sedigraph µ	Top Size Hegman	Y Brightness
JetWhite® 1H/HC Series	Nucleation	1.1	7.5 (~6.25 microns)	90
JetWhite® 7H/HC Series	Nucleation	1.9	7.0 (~12.5 microns)	91
JetWhite® 6H/HC Series	Nucleation	2.4	6.0 (~25.0 microns)	91
JetWhite® 4H Series	General Purpose	5.7	4.0 (~50.0 microns)	90
JetWhite® 2H Series	General Purpose	11	2.0 (~75.0 microns)	87
JetWhite® R7	PC/ABS	1.8	7.0 (~12.5 microns)	91***
Cimpact® 710HS	TPO - Odor Sensitive/Heat Aging	1.8	7.0 (~12.5 microns)	93***
Cimpact® 710C / 710D	Interior TPO	1.8	7.0 (~12.5 microns)	93***
Cimpact® 650C / 650D	Exterior TPO	2.2	6.5 (~18.75 microns)	92***
Cimpact® 610C / 610D	Exterior TPO	3.2	6.0 (~25.0 microns)	91***
Cimpact® 550C / 550D	Appliances	3.4	5.75 (~28.13 microns)	88***
JetWhite® 3CH	Interior and Exterior TPO	1.2	7.5 (~6.25 microns)	94
JetFil® 3CHE	Exterior TPO	1.2	7.5 (~6.25 microns)	82
JetFil® T1H	Exterior TPO	1.8	7.0 (~12.5 microns)	80
JetFil® T1HB	Interior TPO	1.8	7.0 (~12.5 microns)	89
Mistroblock® 1H/1HT/1HTC Series	Antiblock	1.1	7.5 (~6.25 microns)	91
Mistroblock® 7H/7HT/7HTC Series	Antiblock	1.9	7.0 (~12.5 microns)	91
Mistroblock® 6H/6HT/6HTC Series	Antiblock	2.4	6.0 (~25.0 microns)	91
Mistroblock® H/HT/HTC Series	Antiblock	3.5	5.75 (~28.13 microns)	90
Stellar® 510	Appliances	5	5.5 (~31.5 microns)	88***
Stellar® 420	Appliances	12	4.0 (~50.0 microns)	87***
JetWhite® 8230	Appliances	10	4.0 (~50.0 microns)	92***
JetFil® H590	Packaging, UTH*	5	5.5 (~31.5 microns)	77
JetFil® H390	UTH*, WPC**	8.5	4.5 (~43.75 microns)	74

** Under the hood*

*** Wood Plastic Composites*

**** Brightness measurements in GEB*

Products

MAGRIStalc

Montana Sourced Products	Applications	Median Particle Size Sedigraph μ	Top Size Hegman	Y Brightness
JetFil® M625C	Exterior TPO	1.3	6.5 (~18.75 microns)	87***
Nicron® 674 DT2 / Nicron® 674C	Exterior TPO, Polyamides	1.9	7.0 (~12.5 microns)	87***
JetFil® M700 / JetFil® M700C	Exterior TPO	1.9	7.0 (~12.5 microns)	83
JetFil® M600 / JetFil® M600C	Exterior TPO	2.3	6.0 (~25.0 microns)	83
JetFil® M550 / JetFil® M550C	Exterior TPO/Appliances	2.2	5.5 (~31.5 microns)	83
JetFil® M500	Appliances	3.2	5.0 (~37.5 microns)	81
JetFil® M400	General Purpose, PVC	4.7	4.0 (~50.0 microns)	81
JetFil® M300	General Purpose	7.5	3.0 (~62.5 microns)	79
JetFil® M200	WPC	10	2.0 (~75.0 microns)	78
Nicron® 665	Nucleation	1.2	6.5 (~18.75 microns)	87***
Mistron® ZSC	Foam Nucleation	2	6.0 (~25.0 microns)	87***
MistroFoam™	Foam Nucleation	2.2	5.5 (~31.5 microns)	82
Nicron® 604	PVC Sheet, Antiblock	2.3	6.0 (~25.0 microns)	85***
Mistron® NT / Mistron® NTC	Antiblock	3.5	5.75 (~28.13 microns)	85
Mistron® 400C / 400CT	Antiblock	4	5.5 (~31.5 microns)	88
Silverline® 002	WPC**	9	3.0 (~62.5 microns)	78***
Silverline® 303	WPC**	6.1	3.0 (~62.5 microns)	78***

Vermont Sourced Products	Applications	Median Particle Size Sedigraph μ	Top Size Hegman	Y Brightness
JetFil® V625C	Exterior TPO	2.2	6.25 (~21.88 microns)	84
JetFil® V575C	General PP, PVC	3.3	5.0 (~37.5 microns)	82
JetFil® V390	UTH*, WPC**	8.5	4.0 (~50.0 microns)	77***

Specialty, High Aspect Ratio Grades	Applications	Median Particle Size Sedigraph μ	Top Size Hegman	GEB Brightness
HYPERPLATE™ T77	Exterior TPO, Polyamides, FR†	2	5.25 (~34.63 microns)	79
HYPERPLATE™ H92	Exterior TPO, Color Sensitive, Polyamides, FR†	2	5.25 (~34.63 microns)	92
Mistron® HYPERPLATE™	Exterior TPO, Polyamides, FR,†	1.1	6.5 (~18.75 microns)	80

** Under the hood*

*** Wood Plastic Composites*

**** Brightness measurements in GEB*

† Flame Retardancy

About Magris Talc

Magris Talc is the world's leading talc producer, supplying around 15 percent of world demand from our mines and processing plants in Canada and the United States. We are the acknowledged leaders in product quality, supply reliability and technical support – the services that create value for our customers and set us apart from competitors. With over a hundred years' experience in the extraction and processing of talc, we offer the highest quality talc products on the market today.

About Talc

Talc is a surprisingly versatile, functional mineral which possesses a unique combination of properties. Talc is soft, water repellent, chemically inert and highly platy and has a marked affinity for certain organic chemicals. Our industry experts have harnessed these properties to bring customers improved performance in a wide range of applications such as paper, paints, plastics, rubber, ceramics, agriculture, food, pharmaceuticals, cosmetics and soap.

Meeting Today's Needs. Securing Tomorrow's.

We believe that running a successful business and sustaining quality of life and the environment go hand in hand. From implementing behavior-based safety training to rehabilitating the land, we think it's important that future generations' needs are not compromised by our actions today.

Our Fundamental Sustainability Principles are:

Safety – We promote the health and safety of employees, contractors, customers, neighbors and consumers through active caring.

Partnership – We seek to understand the issues that are important to our neighbors, and to make a lasting contribution to the communities in which we operate.

Environmental Protection – We work to minimize our environmental footprint by using natural resources efficiently, preventing pollution, complying with applicable laws and regulations and continually improving our performance.

Accountability – We conduct business in an accountable and transparent manner, relying on external auditing and reporting to understand and reflect our stakeholders' interests.

Magris Talc
www.magristalc.com
For more information, contact our team at sales@magristalc.com
TB_EngineeredPlastics_en_September2021