

GRIVORY®
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Grilamid TR®
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GRILON®
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**The leading manufacturer of
high-performance polyamides**

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About us

EMS-GRIVORY is part of the High Performance Polymer business area of the EMS Group and employs around 1000 people worldwide. The largest development center and production site is located at Domat/Ems, Switzerland with further production sites in Germany, China, Taiwan and the USA. We also have development and sales organizations in all major markets in Europe, Asia and America and can quickly reach our customers on site.

We are active worldwide, prompt and customer-oriented

Specific market requirements are satisfied by the independent but closely cooperating business units EMS-GRIVORY Europe, EMS-GRIVORY Asia und EMS-GRIVORY America. Customers worldwide benefit from the locally competent and close global cooperation of these business units in application development, marketing and sales, research and development and manufacturing.



The proven material for metal replacement

Grivory® is the trade name for a group of technical thermoplastics manufactured and distributed by EMS-GRIVORY. Grivory GV is based on semi-crystalline polyamides with partially aromatic content. It is supplied in granulate form for further processing in injection-moulding or extrusion processes using conventional, commercially-available equipment and moulds.

Grivory GV is used in the manufacture of technical components which are characterised by:

- high levels of stiffness and strength
- little change in property values after absorption of moisture
- low dampness and water absorption
- good dimensional stability and low warpage
- good chemical resistance, typical of polyamides
- good surface quality
- efficient and economical production

The following Grivory G grades are available:

Grivory GV:	reinforced with glass fibres, very stiff
Grivory GVX:	highest stiffness and strength values with very low warpage
Grivory GM:	mineral reinforcement, low warpage
Grivory GVN:	reinforced with glass fibres, impact resistant
Grivory GC:	reinforced with carbon, very stiff
Grivory G4V:	reinforced with glass fibres, good surface quality
Grivory GVS:	reinforced with glass fibres, very good flow properties
Grivory GV FWA:	reinforced with glass fibres, for contact with foodstuff and drinking water

These grades are also available in a range of different modifications, which vary in terms of the concentration of the reinforcing agents used, the stabilisers and the processing aids.

Grivory FWA products are physiologically harmless and are also used in sensitive application areas with direct contact to drinking water and foodstuffs.

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You can find more information about Grivory GV online:



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Grivory GV
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Our metal is called Grivory

With the high-performance polymer Grivory GV, EMS-GRIVORY has been market leader in the field of metal replacement for many years. The new material Grivory GVX now takes us a step further. With clearly improved mechanical properties, the range of metal replacement applications has been significantly widened. The exceptional performance provided by Grivory GVX is convincing in every detail!

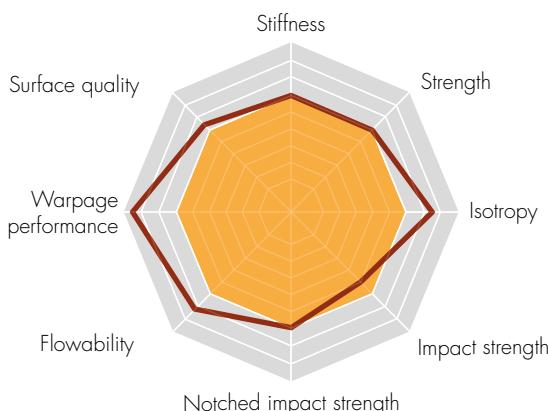
Grivory GVX is characterised in particular by:

- highest stiffness and strength values
- very low warpage
- simple processing

Added performance

With its exceptional property specification profile, Grivory GVX opens up a completely new chapter in the field of metal replacement.

If all property values of Grivory GV-5H are compared with those of the new material Grivory GVX 5H, the consistent increase in performance is clearly apparent. The further development of Grivory GVX is particularly visible in its low warpage values, more isotropic material properties and flowability.



■ **Grivory GVX-5H**

■ **Grivory GV-5H**

Die-cast metals under pressure

The advantages of Grivory GVX compared to diecast metals are, above all, their lower density, simple processability and efficient production with up to 40% lower manufacturing costs.

With a modulus of elasticity of up to 300 MPa, Grivory GVX is leader among thermoplastic materials and does not need to avoid direct comparison with property profiles of metals. At high temperatures for example, it exhibits much better performance than die-cast zinc. When combined with a component design suitable for plastic materials, structural rigidity values comparable to those of metal components, can be achieved.

The future for metal replacement

Due to its exceptional mechanical properties and simple processing, Grivory GVX expands the limits of metal replacement. The well-known advantages of weight reduction, freedom of design, functional integration and, above all cost savings, make polyamide materials much in demand as an alternative to more expensive metals.

Grivory GVX - metal replacement at the highest level!

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You can find more information about Grivory GVX online:



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Enhanced Performance at High Temperatures

Grivory HT is a semi-crystalline thermoplastic construction material based on polyphthalamide (PPA).

EMS-GRIVORY, based in Domat/Ems (Switzerland), developed its own innovative process to manufacture, polymerise and compound Grivory HT. Production capacity has been adjusted to meet strong demand. In the meantime, EMS-GRIVORY has become one of the world's leading suppliers of polyphthalamides and is market leader in Europe.

Grivory HT is characterised by its high-performance properties. Technical injection-moulded parts made from Grivory HT retain their shape even at high operating temperatures. Thanks to its properties, Grivory HT is undoubtedly a high-performance plastic. In terms of characteristics such as stiffness and strength, most important for metal replacement, Grivory HT outperforms materials such as PPS or PEEK at operating temperatures up to 120°C.

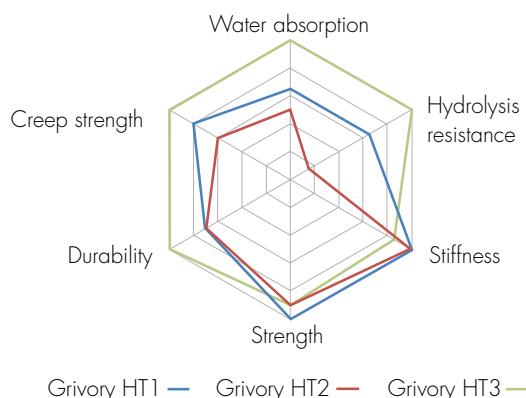
Grivory HT is supplied in granulate form for injection moulding and now also for extrusion methods, and can be processed using conventional, commercially available machinery and tools. Grivory HT is used for the efficient manufacture of high-quality technical components that are characterised by:

- stiffness and strength at high operating temperatures
- little change in property values after absorption of water
- good dimensional stability and low warpage
- good chemical resistance
- good surface quality
- economic production

The Grivory HT grades

The Grivory HT product range includes a number of groups with different base polymers.

- Grivory HT1: PA6T/6I
- Grivory HT2: PA6T/66
- Grivory HT3: PA10T/X



Grivory HT products are supplied ready for injection-moulding processing. The Grivory HT3 product range also includes extrusion grades.

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■ **Grilamid L PA12**



High-performance polymers for highest demands

The Grilamid product family from EMS-GRIVORY is made up of four sub-groups of long-chain aliphatic polyamides.

- Grilamid L (Polyamide 12)
- Grilamid 1S (Polyamide 1010)
- Grilamid 2S (Polyamide 610)
- Grilamid 2D (Polyamide 612)

Grilamid L

Grilamid L polyamide 12 (PA12) is formed by the polymerisation of laurolactam, a ring-shaped, long-chain monomer with 12 carbon atoms. Laurolactam, often called lactam 12, is obtained in a complex, multiple-step process from the basic raw material butadiene. EMS is backward integrated for lactam 12 and produces it in a joint-venture where EMS holds a two-third majority.

Depending on formulation and viscosity, Grilamid L PA12 can be processed using a range of different methods such as injection-moulding, pipe extrusion, film extrusion or blow-moulding.

Through use of additives, fillers, pigments, plasticisers, modifiers or processing aids, Grilamid products are adjusted precisely to suit customer requirements and specific applications. EMS-GRIVORY offers a very wide range of speciality grades from very flexible to highly rigid in order to always supply customers with an optimal product solution.

Grilamid L PA12 has a series of exceptional properties such as:

- very low water absorption and excellent dimensional stability
- very good resistance to chemicals and weathering
- very good hydrolysis resistance
- lowest density of all polyamides
- high impact strength down to -40°C
- wide processing window, problem-free processing

The Grilamid L ... "FWA" (food and water contact approved) series was created especially for applications in direct contact with foodstuffs or drinking water. The tailor-made, reinforced and non-reinforced products correspond to international requirements and legislation in this field of application.

Important applications for Grilamid L PA12 are feed lines and connectors for media and compressed air systems in the fields of automotive, industrial goods, sports and leisure, sanitary components (replacement of brass), pneumatic pipes, cables and cable protection, housings for high-quality electronic devices, components for household appliances.

Grilamid 1S

Grilamid 1S polyamide 1010 (PA1010) is created through poly-condensation of decanediamine and sebacic acid.

Both monomers are obtained through a multiple-step chemical process from the renewable bio raw material castor oil. Polyamide 1010 is based to nearly 100 per cent on renewable raw materials. Bio-based products in the Grilamid 1S series are sold by EMS-GRIVORY under the general term GreenLine.

Special features of Grilamid 1S PA1010 are:

- nearly 100% use of renewable basic raw materials (in relation to the polymer)
- very low water absorption and excellent dimensional stability
- good resistance to chemicals and weathering
- low density
- wide processing window, problem-free processing
- a direct bio-alternative to PA12

Important application areas for Grilamid 1S PA1010 are feed lines in automotive and industrial applications, especially lactam-free fuel lines, cable sheathing, sports & leisure articles and housings for portable electronic devices.

**Grilamid 2S**

Grilamid 2S polyamide 610 (PA610) is created through poly-condensation of hexamethylene diamine and sebamic acid.

Hexamethylene diamine is obtained from crude oil, while sebamic acid is obtained following a multiple-step chemical process from the renewable bio-raw material castor oil. This means the polyamide 610 polymer is made to 62% of renewable raw materials. Bio-based Grilamid 2S products are sold by EMS-GRIVORY under the general term GreenLine.

Special features of Grilamid 2S PA610 are:

- use of 62% renewable basic raw materials (in relation to the polymer)
- low water absorption and good dimensional stability compared to PA6 or PA66
- good resistance to chemicals and weathering
- high melting point of 220°C
- problem-free processing

Due to its high melting point, Grilamid 2S PA610 is especially well suited for pipes, connectors and other under-the-hood automotive applications which are exposed to high temperatures. Further preferred applications are industrial pipes for pneumatic and hydraulic systems as well as sports and leisure articles.

Grilamid 2D

Grilamid 2D polyamide 612 (PA612) is created through poly-condensation of hexamethylene diamine and dodecanedioic acid.

Special features of Grilamid 2D are:

- low water absorption and good dimensional stability compared to PA6 or PA66
- good resistance to chemicals and weathering
- very good resistance to hydrolysis
- high melting point of 215°C
- problem-free processing

Due to its high melting point, Grilamid 2D PA612 is especially well suited for pipes and connectors in automotive applications which are exposed to high temperatures. Preferred applications are feed lines for cooling, heating and climate control systems in cars, compressed air lines of heavy-duty trucks exposed to high temperatures, feed lines for hot diesel fuel and individual layers with high barrier properties in multiple-layer petrol lines.

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You can find more information about Grilamid L PA12 online:



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Approved for contact with food and water

Grilamid PA12 FWA products open up new opportunities for applications in direct contact with drinking water or food.

Grilamid PA12 products have unique properties such as:

- Very low water absorption
- High dimensional stability
- Excellent chemical and UV resistance
- Strong hydrolysis resistance
- High impact strength in combination with high elongation compared to other technical polymers with identical stiffness values
- Very favourable processing parameters due to low mould and material temperatures compared to most other engineering plastics

Grilamid FWA products are available in two different series with 30% to 65% glass fibres depending on the maximum application temperatures in contact with drinking water and according to existing approvals.

In water up to 60°C	In water up to 85°C
Grilamid LV-30H FWA	Grilamid LBV-30H FWA
Grilamid LV-50H FWA	Grilamid LBV-50H FWA
Grilamid LV-65H FWA	Grilamid LBV-65H FWA

Besides the standard Grilamid FWA grades in natural and black, specific custom colours are possible on request, even for small order quantities.

In addition, non-reinforced and glass-bead reinforced products are also available to customers.

Grilamid FWA products satisfy the requirements of the most important standards and regulations in Europe and North America, such as WRAS, ACS, KTW, NSF and FDA. Detailed information is available in each product-specific datasheet.

For further details such as long term behaviour in water according to ISO 9080, please contact your nearest EMS-GRIVORY sales office.

Grilamid FWA products have been especially developed for the replacement of more costly metal and other high performance polymers. Their favourable moulding conditions make them particularly suitable for thick-walled or very thin-walled components which are difficult or impossible to mould with other polymers.

Grilamid FWA products excellently complement the Grivory GV...FWA and Grivory HT...FWA product lines which are also approved for applications involving direct contact with drinking water and food.

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You can find more information about Grilamid FWA online:



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Transparent polyamide for the most exacting requirements

Grilamid TR grades are amorphous thermoplastics which, due to their composition, combine the excellent properties of semi-crystalline polyamide 12 grades with those of an amorphous thermoplastic in a unique way.

Compared to the known semi-crystalline polyamides, crystallisation of the macromolecules is prevented by careful selection of monomers, resulting in polymers with an amorphous structure giving a strikingly high level of transparency.

In addition to transparency, other outstanding properties include excellent flexural fatigue strength, which facilitates applications under dynamic loading, and high resistance to chemicals, resulting in low susceptibility to stress cracking when in contact with media.

The well known tendency of amorphous thermoplastics to suffer from stress cracking, which is very often the root cause of component failure, is a rare phenomenon in the case of Grilamid TR.

Cycloaliphatic Grilamid TR 90 grades also offer excellent weathering and UV resistance.

The main features of Grilamid TR are:

- high transparency, even with thick walled components
- clear and light inherent colour
- resistance to chemicals and stress cracking
- very high flexural fatigue strength
- very good toughness, even at low temperatures
- dimensional stability and dynamic strength
- light weight due to low density
- low water absorption compared to standard polyamides
- high heat deflection temperature thanks to high glass transition temperatures
- low and mainly isotropic shrinkage
- easy processing
- easy colourability

Grilamid TR is a transparent polymer, which combines a variety of excellent properties and where specific property requirements can be achieved through modification. A noble polymer with unlimited possibilities.

Dynamic strength of Grilamid TR – flexural fatigue strength

Dynamic, long-term stress can lead to the failure of a thermoplastic material. Depending on the level of the cyclic mechanical stress, breakage occurs after a certain number of load cycles. The fatigue strength is shown here by the almost horizontal part of the Wöhler curve. This is the maximum load which a dynamically loaded material can withstand without any notable signs of fatigue.

Grilamid TR 90 exhibits exceptionally good dynamic strength. The material has fatigue strength values in excess of 30 MPa, and even with flexural fatigue loading of ± 50 MPa it still achieves one million flexural cycles (load changes). This means that Grilamid TR 90 is the preferred transparent plastic material for applications with stringent requirements for dynamic strength.

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Premium polyamide

Grilon® is the brand name for engineering plastics based on polyamide 6 and polyamide 66 manufactured by EMS-GRIVORY.

With the manufacture of special polyamide 6 and polyamide 66 alloys, EMS-GRIVORY has succeeded in further improving the already outstanding properties of Grilon.

The products in this group are semi-crystalline polyamide materials characterised by the following properties:

- high strength and stiffness
- high impact strength
- high heat deflection temperature
- good abrasion and surface slip (friction) properties
- resistance to many chemicals
- good electrical properties
- economic processing

Grilon is perfectly suited for processing using injection moulding, extrusion and extrusion blow-moulding methods.

Due to their excellent properties, these materials can be used in a wide variety of application segments such as the automotive industry, electrical / electronic technology, sport and leisure as well as in mechanical engineering.

The various Grilon grades differ from each other according to the type and composition of the basic polymers as well as their modification with stabilisers, processing aids and reinforcing materials (minerals, glass, carbon and steel fibres).

Grade families

Grilon A	PA 66
Grilon B	PA 6
Grilon TS	PA 66 + 6

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Polyamides with Spine

LFT polyamides from EMS-GRIVORY are long-fibre reinforced structural materials based on the established polyamides Grivory GV and HT1, Grilamid PA12 and Grilon TS.

All products are reinforced with glass or carbon fibres, the length of which corresponds to a typical granulate length of 10 mm. The objective of this is to create a unique web-like fibre structure within the injection-moulded component, which significantly improves the thermal-mechanical properties compared to products reinforced with short fibres.

The products differ by the type of used polyamide as well as the type and quantity of reinforcement. The products are supplied dried and ready to use in bags or octabins. They can be processed using commercially available injection-moulding equipment.

EMS LFT products are used to manufacture structural components with very high requirements. These are characterised in particular by the following properties:

- A combination of high stiffness and exceptional notched impact strength
- Little change in the properties under the influence of temperature or moisture
- Very low tendency to creep
- Excellent permanent strength
- Low warpage

Preferred applications for these LFT polyamides are challenging metal replacement applications. The excellent properties of the proven products supplied by EMS-GRIVORY are increased once again by the reinforcement with long fibres.

The product portfolio of LFT products

Grivory HT1VL	long glass-fibre reinforced, high-temperature polyamides (PPA)
Grivory GVL	long glass-fibre reinforced semi-crystalline polyamides with partially aromatic content
Grivory GVL VO	long glass-fibre reinforced, semi-crystalline, flame-resistant polyamides with partially aromatic content
Grivory GXL	hybrid-fibre reinforced, semi-crystalline polyamides with partially aromatic content
Grivory GCL	long carbon-fibre reinforced, semi-crystalline polyamides with partially aromatic content
Grilamid LVL	long glass-fibre reinforced PA12 products
Grilamid LCL	long carbon-fibre reinforced PA12 products
Grilamid TRVL	long glass-fibre reinforced products based on transparent PA
Grilon TSGL	long glass-fibre reinforced, semi-crystalline polyamides PA66+PA6
Grilon TSGL VO	long glass-fibre reinforced, semi-crystalline, flame-resistant polyamides PA66+PA6
Grilon TSXL	hybrid-fibre reinforced, semi-crystalline polyamides PA66+PA6

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You can find more information about LFT online:



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Under the general term GreenLine, EMS-GRIVORY markets a wide range of bio-based polyamides which are manufactured partially or wholly from renewable raw materials. The „GreenLine“ series is made up of products from the families:

- Grivory HT3 (PA10T/X)
- Grilamid TR (amorphous transparent PA)
- Grilamid 1S (PA1010)
- Grilamid 2S (PA610)

which provide a wide spectrum of special properties from very flexible to extremely rigid, from high heat or hydrolysis resistant to perfectly transparent.

The primary objective of EMS-GRIVORY with GreenLine is to offer customers products based on renewable raw materials, having excellent properties and allowing a proven contribution towards reduction of environmental impact. From a technical point of view, GreenLine products are in no way inferior to crude-oil based polyamides.

By using monomers obtained through chemical processes from the renewable raw material castor oil, the environmental impact of GreenLine products is significantly improved from a "cradle to gate" point of view compared to crude-oil based polyamides. The total emission of climate-damaging gases during the whole manufacturing process of the polymer and its precursors can be reduced by up to ¾ depending on the product.

Despite the use of renewable raw materials, GreenLine products are not biologically degradable polymers. Their durability is comparable to that of crude-oil based polyamides.

Key features

Grilamid 1S PA1010 and Grilamid 2S PA610

- high to very high bio-content
- properties similar to those of PA12
- low moisture absorption
- from flexible to high stiffness (reinforced), cold impact resistant
- good UV and chemical resistance
- low density
- for injection and extrusion processing
- good adhesion of Grilamid 1S PA1010 to bio-based Grilamid BTR grades in overmoulding or sandwich moulding processes.

Grilamid TR, transparent polyamide

- high bio-content
- excellent transparency and natural colour
- very good chemical resistance compared to most other amorphous thermoplastics
- high gloss and good scratch resistance
- low density
- good adhesion to Grilamid 1S PA1010

Grivory HT3 PPA (Polypythalamide)

- high bio-content
- very low moisture absorption compared to other PPAs
- high dimensional stability
- excellent resistance to chemicals and hydrolysis
- high peak temperature and heat resistance
- suitable for lead-free soldering
- available as halogen-free flame-retardant compound for E&E applications

The bio content of GreenLine products varies from about 50 up to 99% depending on the type of polymer, when determined according to ASTM D 6866-12 and expressed in percentage of total carbon.

You can find more information about GreenLine online:



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Automotive

Weight and cost-savings through metal replacement in automotive construction

In the automotive industry, EMS-GRIVORY has contributed significantly for more than 40 years to the development of modern vehicle components of the highest quality. Our products always fulfill the increasing demanding requirements. They enable customers to achieve reductions in component weight and economic fuel consumption while satisfying high standards of comfort and safety. Further factors are their economic processing and recyclability.

Our materials are in particularly highly demand for the replacement of metal components in under-the-bonnet applications. For this purpose we have developed high performance polyamides with especially high heat resistance for use in applications such as air ducts and coolers for turbocharged engines, heat exchangers and throttle bodies. Polymers from EMS-GRIVORY are also found in automotive electrical and electronic systems which must ensure trouble-free operation under extreme climatic conditions. In addition, our polyamides are used in chassis and power train components where resistance to motor oils and hydraulic fluids is required. Examples of these applications are clutch, brake or steering systems. In automotive interiors, polyamides from EMS-GRIVORY replace conventional die-cast alloys as materials for functional parts such as arm rests, covers or dashboard brackets. External metal-replacement applications include door handles, wing mirrors or windscreen wiper units. Furthermore, our polyamide materials, which are resistant to chemicals, corrosion and weathering, allow efficient manufacturing of media supply systems such as fuel or cooling water lines.

Electro & Electronics

Highest levels of precision and reliability in electrical and electronic applications

As stiff and yet impact-resistant housings for thin-walled components in mobile telephones, notebooks, Ebook readers and tablets, polyamides from EMS-GRIVORY protect the internal electronic components while satisfying the highest requirements of strength and design. Typical applications are structural frames, housings and display windows.

In miniaturized electronic components such as LEDs or connectors, our materials ensure highest precision in combination with heat resistance at temperatures required for soldering processes.

Increasing miniaturization and more stringent safety requirements also place high demands on mechanical and thermal requirements. Our high-temperature resistant materials, with outstanding strength values and flame retardant modification, help provide new and innovative solutions.



Industry & Consumer goods

Metal and glass replacement in high-quality applications for industrial and consumer goods

In the sanitary market, polyamides from EMS-GRIVORY are used for water meters, water filter housings, filter bowls and pressure reduction valves. In this way, significant cost advantages can be achieved compared to the use of brass.

In coffee machine applications, special products are used which have all necessary approvals for use in direct contact with hot water.

In the construction and furniture industries as well as mechanical engineering, our products are used in a wide variety of applications demanding high requirements with regard to long life cycles and safety.

Optics

Global market leader in eyewear

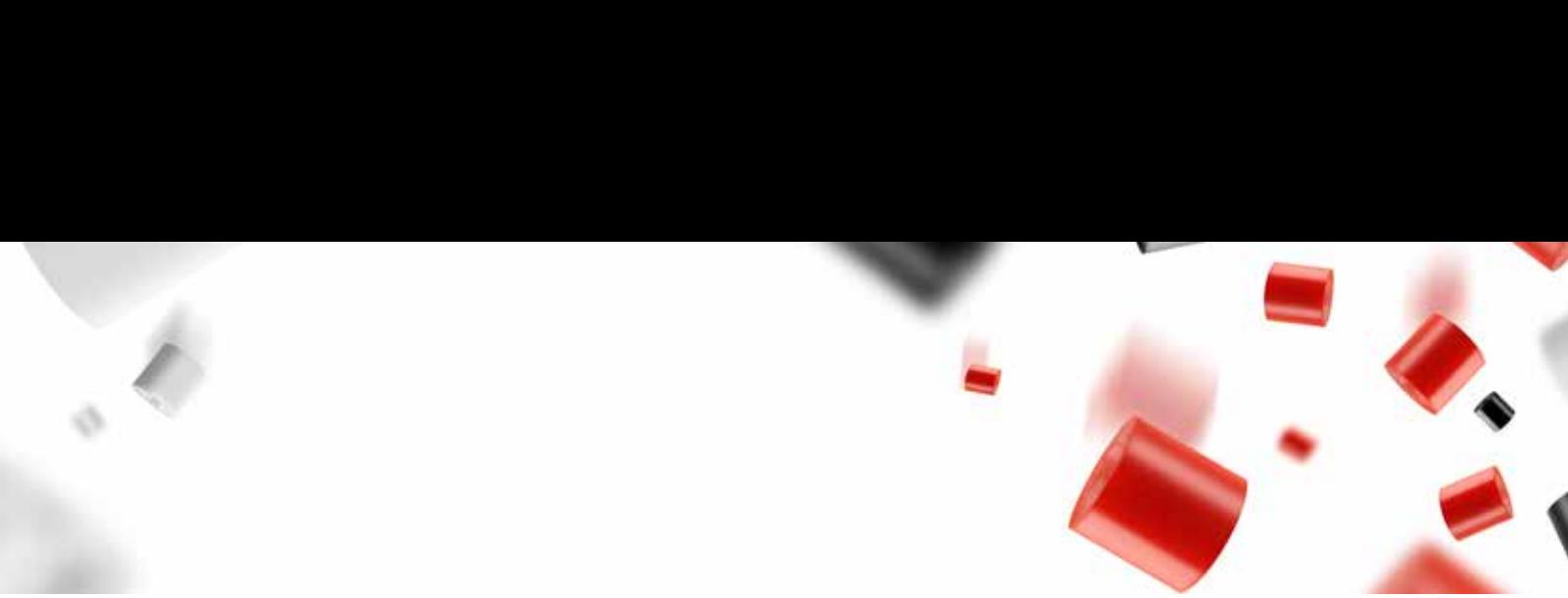
Polyamides from EMS-GRIVORY enable the perfect combination of functionality and unlimited individual possibilities in design, color and UV protection for sun and sports glasses. Our polyamides are also used to make ultra-lightweight and practically unbreakable frames for corrective glasses. For safety glasses, our products provide highest levels of safety through impact strength and break resistance.

Thanks to outstanding resistance to chemicals and stress-cracking, as well as excellent optical and mechanical properties, EMS-GRIVORY is world market leader for transparent polyamides with Grilamid TR 90.

Packaging

Optimally packaged with polyamides from EMS-GRIVORY

Packagings and containers made of our polyamides have excellent barrier properties against oxygen, carbon dioxide and flavors so that food and beverages as well as cosmetics and medicines remain fresh for longer. Our products fulfill the strict safety regulations demanded by governmental health authorities and have all corresponding approvals.





EMS-GRIVORY worldwide

www.emsgrivory.com

EMS-GRIVORY - The leading manufacturer of high-performance polyamides

EMS-GRIVORY is the leading manufacturer of high-performance polyamides and the supplier with the widest range of polyamide materials. Our products are well-known throughout the world under the trademarks Grilamid, Grivory and Grilon.

We offer our customers a comprehensive package of high-capacity and high-quality products along with segment-specific advisory competence in distribution and application development. We maintain our market leadership through continual product and application development in all segments.

EMS-GRIVORY Europe

Switzerland

EMS-CHEMIE AG
Business Unit EMS-GRIVORY Europe
Via Innovativa 1
7013 Domat/Ems
Switzerland
Phone +41 81 632 78 88
Fax +41 81 632 76 65
welcome@emsgrivory.com

Germany

EMS-CHEMIE (Deutschland) GmbH
Warthweg 14
64823 Gross-Umstadt
Deutschland
Phone +49 6078 783 0
Fax +49 6078 783 416
welcome@de.emsgrivory.com

France

EMS-CHEMIE (France) S.A.
73-77, Rue de Sèvres
Boîte postale 52
92105 Boulogne-Billancourt Cedex
France
Phone +33 1 41 10 06 10
Fax +33 1 48 25 56 07
welcome@fr.emsgrivory.com

Great Britain

EMS-CHEMIE (UK) Ltd.
Darfin House, Priestly Court
Staffordshire Technology Park
Stafford ST18 0AR
Great Britain
Phone +44 1785 283 739
Fax +44 1785 283 722
welcome@uk.emsgrivory.com

EMS-GRIVORY,
a business unit of the EMS Group

Italy

EMS-CHEMIE (Italia) S.r.l.
Viale Innocenzo XI n. 77
22100 Como (CO)
Italia
Phone +41 81 632 75 25
Fax +41 81 632 74 54
welcome@it.emsgrivory.com

EMS-GRIVORY Asia

China

EMS-CHEMIE (China) Ltd.
227 Songbei Road
Suzhou Industrial Park
Suzhou City 215126
Jiangsu Province
P.R. China
Phone +86 512 8666 8180
Fax +86 512 8666 8210
welcome@cn.emsgrivory.com

EMS-CHEMIE (Suzhou) Ltd.
227 Songbei Road
Suzhou Industrial Park
Suzhou City 215126
Jiangsu Province
P.R. China
Phone +86 512 8666 8181
Fax +86 512 8666 8183
welcome@cn.emsgrivory.com

Taiwan

EMS-CHEMIE (Taiwan) Ltd.
36, Kwang Fu South Road
Hsin Chu Industrial Park
Fu Kou Hsiang
Hsin Chu Hsien 30351
Taiwan, R.O.C.
Phone +886 3 598 5335
Fax +886 3 598 5345
welcome@tw.emsgrivory.com

Korea

EMS-CHEMIE (Korea) Ltd.
#817, Seo-Gwan,
Doosan Venturedigm,
126-1, Pyeongchon-dong,
Dongan-gu, Anyang-si,
Gyeonggi-do, 431-070
Republic of Korea
Phone +82 31 478 3159
Fax +82 31 478 3157
welcome@kr.emsgrivory.com

Japan

EMS-CHEMIE (Japan) Ltd.
EMS Building
2-11-20 Higashi-koujiya
Ota-ku, Tokyo 144-0033
Japan
Phone +81 3 5735 0611
Fax +81 3 5735 0614
welcome@jp.emsgrivory.com

EMS-GRIVORY America

United States of America

EMS-CHEMIE (North America) Inc.
2060 Corporate Way
P.O. Box 1717
Sumter, SC 29151
USA
Phone +1 803 481 61 71
Fax +1 803 481 61 21
welcome@us.emsgrivory.com

