

**TEIJIN**

*Human Chemistry, Human Solutions*

# Twaron – a versatile high-performance fiber



**Twaron<sup>®</sup>**

The power of Aramid

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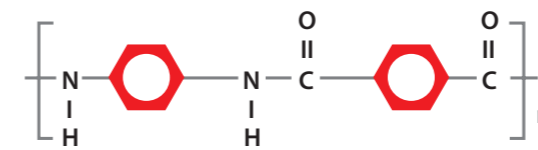
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Twaron is Teijin Aramid's flagship para-aramid, a high-performance man-made fiber. Offering well-balanced performance in terms of mechanical properties, chemical resistance and thermal stability, it is widely recognized in many industries as an extremely valuable component with excellent durability. Our experience of more than 30 years, not only guarantees a technically mature product, it is also the basis for developments – often in close cooperation with our customers to tailor Twaron to the specific requirements in various applications.

Twaron is suitable for a virtually unlimited range of challenging applications, including ballistic protection, heat and cut protection, the oil and gas industry, the automotive industry and optical fiber cables to name just a few of its many uses.

Twaron combines the following characteristics, which distinguishes it from other synthetic fibers:

- High strength (excellent strength-to-weight properties)
- High modulus
- High dimensional stability
- Excellent heat, cut and chemical resistance
- No melting point
- Low flammability
- Non-conductivity



These unique characteristics are the result of a 100% paracrystalline structure with molecular chains preferentially oriented along the fiber axis.



*"Our customers expect the highest quality, so I make sure they get it",  
Jan Oldenburger, operator*


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# How is Twaron produced?

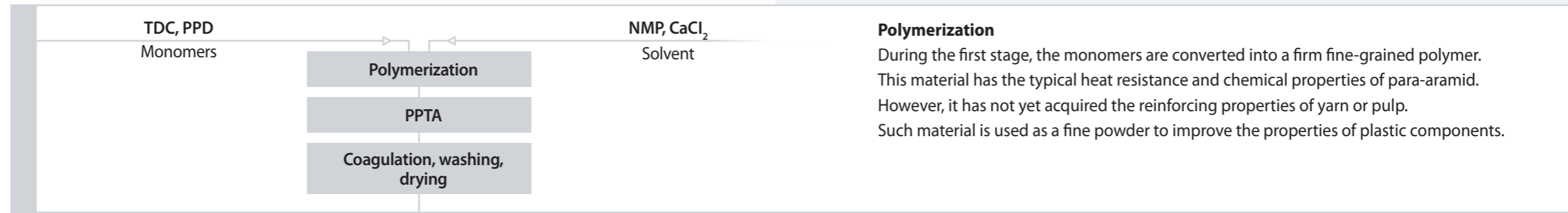
Dedicated specialists in our manufacturing departments continually monitor the production of Twaron, which is made from monomers in three stages. These stages are polymerization, filament yarn spinning and converting.

## Spinning solution

- liquid crystalline solution
  - local orientation of molecules in domains
- 

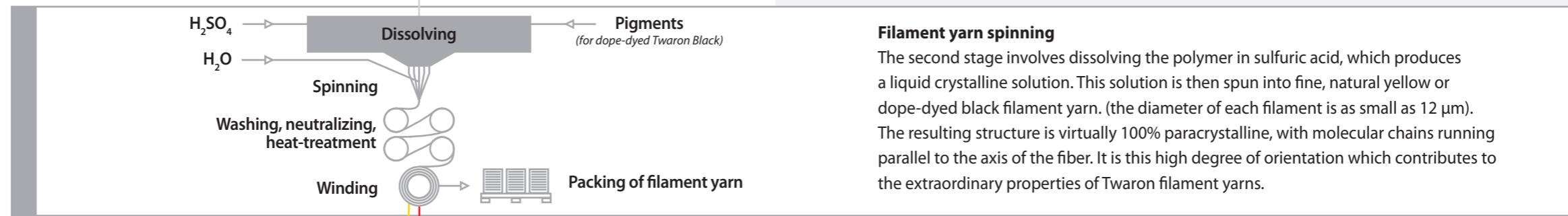
## Yarn structure

- highly crystalline structure
  - molecules are highly oriented
  - fibrillar morphology
- 



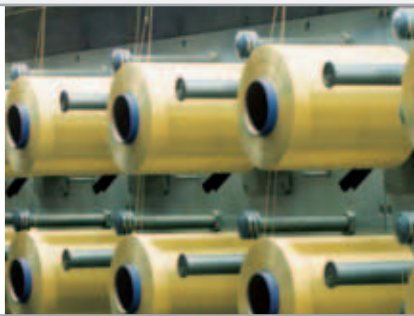
### Polymerization

During the first stage, the monomers are converted into a firm fine-grained polymer. This material has the typical heat resistance and chemical properties of para-aramid. However, it has not yet acquired the reinforcing properties of yarn or pulp. Such material is used as a fine powder to improve the properties of plastic components.



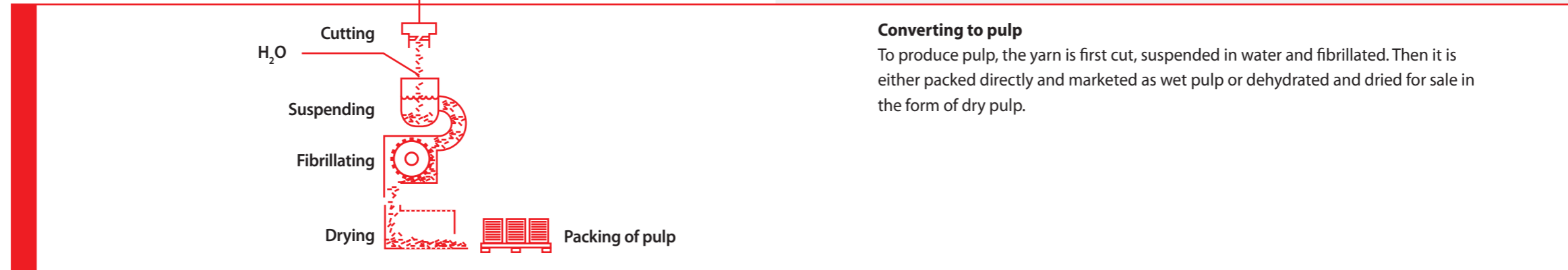
### Filament yarn spinning

The second stage involves dissolving the polymer in sulfuric acid, which produces a liquid crystalline solution. This solution is then spun into fine, natural yellow or dope-dyed black filament yarn. (the diameter of each filament is as small as 12 μm). The resulting structure is virtually 100% paracrystalline, with molecular chains running parallel to the axis of the fiber. It is this high degree of orientation which contributes to the extraordinary properties of Twaron filament yarns.



### Converting to staple and short-cut fiber

To produce staple or short-cut fibers, the yarn is crimped and treated with a finishing agent. After drying, the fibers are cut to the desired length and packaged.



### Converting to pulp

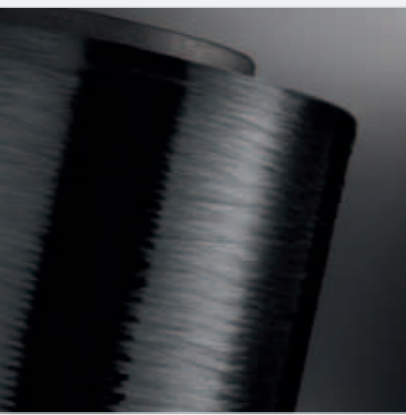
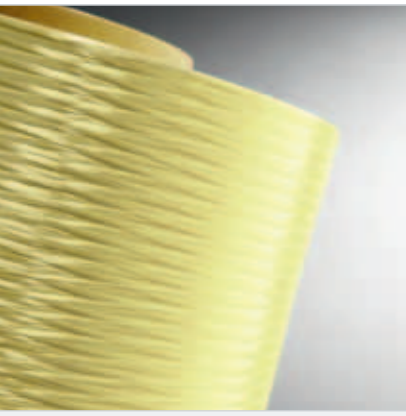
To produce pulp, the yarn is first cut, suspended in water and fibrillated. Then it is either packed directly and marketed as wet pulp or dehydrated and dried for sale in the form of dry pulp.



"I feel proud when I see the results of my work", Michel Vinke, operator



## What types of Twaron are available?



### Twaron yellow filament yarn

As filament yarn, Twaron can be supplied in the following forms:

- Standard modulus filament yarn (twisted or untwisted) with 250-10,000 filaments
- High-modulus filament yarn with 250-15,000 filaments
- High-tenacity filament yarn with 500-2,000 filaments

As filament yarn, the power of Twaron has proven itself in numerous applications, including optical fiber cables, hoses, tires, rubber products, ballistic protection, linear tension members, composites and belts. To help our customers find optimal solutions, our Research & Development experts have also developed special surface treatments such as water-blocking finishes for optical fiber cables or adhesion activation finishes for rubber products in order to further improve product properties and/or processability.

Twaron yellow yarn types	Linear density (dtex)	Tenacity (mN/tex)	Modulus (GPa)	Elongation at break (%)
Standard	420 - 3,360	1,650 - 2,200	60 - 80	3.0 - 4.4
High-modulus	420 - 24,150	2,100 - 2,300	100 - 120	2.2 - 3.0
High-tenacity	420 - 3,360	2,350 - 2,500	85 - 95	3.3 - 4.0

### Twaron black filament yarn

Twaron black filament can be supplied as high modulus filament yarn which is optimized for composite applications in two linear densities: 1210 dtex and 1610 dtex. For heat protective applications it is also available in standard modulus and 3360 dtex. Both types are dope-dyed and therefore offering a good color fastness.

Twaron black yarn types	Linear density (dtex)	Tenacity (mN/tex)	Modulus (GPa)	Elongation at break (%)
Standard	3,360*	1,828 - 1,950*	64 - 81*	3.2 - 3.8*
High-modulus	1,210 - 1,610*	2,000*	100*	2.8*

\* preliminary values

### Twaron yellow staple fiber

Twaron staple fibers are used in many heat- and cut protective applications. In its natural yellow color Twaron staple fibers are available in a range of yarn counts and fiber lengths for textile applications in protective apparel and for industrial applications.

Twaron staple fiber length (mm)	Linear density (dtex)
40, 50, 60	1.7
50	0.9
60	2.5

### Twaron black staple fiber

To support our customers to develop solutions providing the optimum protection combined with comfort for heat and flame protection we also offer Twaron black staple fiber in 1.7 dtex and 50 mm fiber length.

### Twaron short-cut fiber

Twaron filament yarn can also be converted into chopped fibers or dipped chopped fibers with fiber lengths from 0.25 – 12 mm for use e.g. in engineering plastics applications.

### Twaron powder

Twaron is available in different powder forms, differentiated by particle size. These products are used amongst others in engineering plastics, specialty coatings as well as rubber compounds.

### Twaron pulp

To produce pulp, Twaron filament yarn is first cut, suspended in water and then fibrillated. The characteristic properties of the pulp are determined by the fiber length and the specific surface area (degree of fibrillation).

Due to its chemical and physical properties, Twaron pulp improves stability and increases the strength of compounds in which it is used.

To help our customers find optimal solutions, we provide both dry and wet pulp in different fiber lengths and degrees of fibrillation. With the broadest product range on the market, we offer tailor-made solutions for many different applications such as friction products, sealing materials and specialty paper products.

### Twaron jet-spun fibrils or pulp

Twaron jet-spun fibrils and pulp are made by a newly developed and patented manufacturing process. They differ from conventional pulp thanks to their adjustable specific structure from film-like to very fine, which improves network formation and ensures superior binding. Twaron jet-spun fibrils and pulp can be processed on conventional paper machines, e.g. for the production of specialty paper products.

Special product types are available on request. For more detailed information please contact us for the relevant datasheets.

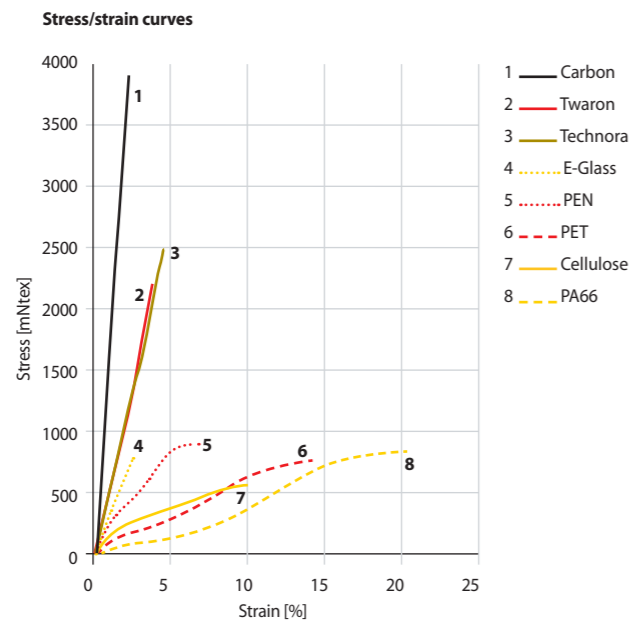


# Twaron – a unique combination of properties

## Mechanical properties

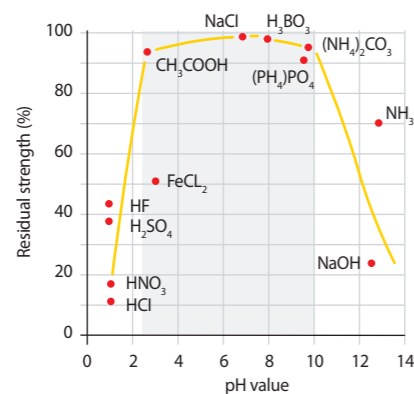
Twaron yarns are very strong, their tensile strength being two to three times higher than that of high-strength polyester and polyamide yarns and five times higher than that of steel (on weight basis). The table on page 7 shows the mechanical properties in detail.

The stress/strain curves are visualized in the graph below.



## Chemical resistance

Twaron's high crystallinity and strong intermolecular interactions prevent chemicals from penetrating the polymer. Resistance to organic chemicals is good to excellent, while resistance to inorganic chemicals varies with their pH value. Highly acidic or alkaline chemicals may cause hydrolytic degradation.



## Thermal properties

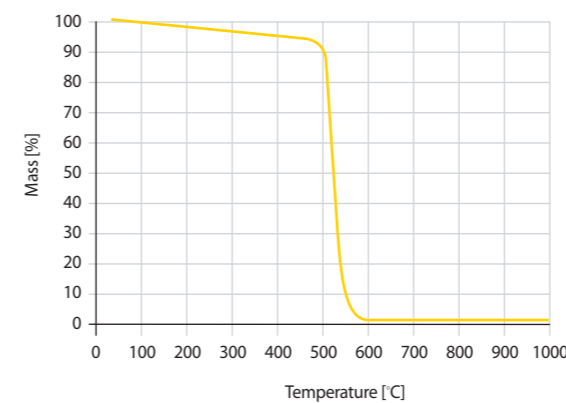
Twaron neither burns nor melts. The graphs below show that Twaron can survive brief exposure to temperatures up to 500°C (932°F) without any significant loss of mass. This is significantly better than the thermal properties of other synthetic fibers. When used as heat resistant material, however, it is not recommended to exceed 250°C. Twaron carbonizes in the absence of oxygen and approximately 30% of its mass is retained.

Properties	Unit	Typical value
Flammability (LOI)	%	29 <sup>1</sup> - 37 <sup>2</sup>
Specific heat	$\frac{J}{kg \cdot K}$	1420
Shrinkage in hot air (190°C / 374°F, 15 min.)	%	0
Decomposition temperature	°C/°F	500/932
Heat resistance (i.e. strength retention) (200°C / 392°F, 48 hrs.)	%	90

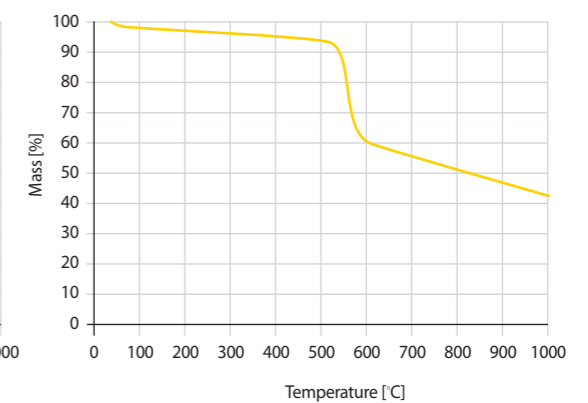
<sup>1</sup> fabric measurement <sup>2</sup> filament yarn measurement

Thermogravimetric analysis of Twaron at a heating rate of 10°C/min.

In air



In nitrogen



## UV resistance/weathering

Twaron is susceptible to UV light. It is necessary to protect aramid from exposure to direct sunlight.

## Hydrolysis

Aramid and other condensation polymers are sensitive to acids and bases.

If you're interested in more detailed information about Twaron properties or testing methods, please contact us.

## Sustainability is our future



"I enjoy my work in research which is my contribution to further enhance the properties of Twaron - tailored to our customers' needs",  
Elona Buckle, research assistant

The scarcity of natural resources and the need for clean energy will be the most important limiting factors regarding the quality of life in the future. Sooner or later, we will reach that tipping point when our current lifestyles and business practices hit the boundary conditions of what the Earth is able to provide. Our current way of living will no longer be viable. We need to take the lead.

### Value throughout the chain

Therefore we see sustainability as a joint responsibility, and we are actively seeking to take responsibility for our part. That's why we're looking for new ways of contacting, interacting and cooperating with our partners in the value chain.

The aramid products in our portfolio are intrinsically capable of enabling sustainability. For example, with its exceptional resistance to extreme conditions, Twaron contributes to global trends in sustainability like saving weight, conserving scarce raw materials and making products that are tougher and more durable. Also, through its extensive recycling program, Teijin Aramid is committed to safeguarding the value of its aramid wherever possible.

Over the past few years, Teijin Aramid has invested in sustainability by executing Eco-Efficiency Analyses (EEAs). Using these analyses, we are able to quantify the potential eco-footprint reductions of certain products and solutions containing Twaron throughout their lifecycle. These can then be compared with other solutions in the market and potentially create value for you, your customer and the customer of your customer.

### Partnering on sustainability

Sustainability benefits strongly from innovation and cooperation. In our Central Research Facilities, at the Technical Textile Institute (TTI), as well as in our Application Competence Center, we are constantly improving our products and working towards innovative and environmental friendly solutions. For existing markets and for new markets. We aim to do these developments together with our customers and other partners in the value chain.

### Quality, Health, Safety and Environment (QHSE)

Teijin Aramid has been certified to ISO 9001 (Quality) since 1993, to ISO 14001 (Environment) since 1996, and to OHSAS 18001 (Health & Safety) since 2002. Operations at our sites are governed by procedures documented in our QHSE management system. We make continuous improvements and carry out several audits each year. In 2009 Lloyds Register Quality assurance certified that our operations meet the requirements of the new (2008) version of the ISO 9001 standard.

If you are interested in cooperating with us or would like to discuss issues regarding sustainability, please don't hesitate to contact us via [sustainability@teijinaramid.com](mailto:sustainability@teijinaramid.com)

## How does Twaron compare to other fibers?

Twaron's unique combination of properties makes it the fiber of choice in numerous applications.

		Twaron	Technora	UHMW PE	Carbon (PAN-based)	E-Glass	PBI	Oxidized PAN	Teijin-conex	PET	PA-6	PA-66
Density	(g/cm <sup>3</sup> )	1.44-1.45	1.39	0.97-0.98	1.78	2.55	1.43	1.35-1.40	1.38	1.37-1.4	1.13	1.13
Tensile strength	(GPa)	2.4-3.6	3.4	2.2-3.9	3.5-7 <sup>1</sup>	1.5-3	0.32	0.2-0.3	0.62-0.69	1.1	0.9	0.9
Tenacity	(N/tex)	1.65-2.5	2.5	2.3-4.0	2.0-3.9 <sup>1</sup>	0.6-1.2	0.24	0.15-0.2	0.45-0.5	0.6-0.8	0.7-0.75	0.75
Modulus	(GPa)	60-120	74	52-132	230-540	72	5.1	7-11	-	-	-	-
Elongation at break	(%)	2.2-4.4	4.5	3-4	0.7-2.0 <sup>1</sup>	1.8-3.2	27	15-23	35-45	10-15	20-25	18-25
Moisture	(wt%)	3.2-5	1.9	< 0.1	0	0.1	15	10	5-5.5	0.4	3.5-4.5	4-6
Glass transition	(°C)	-	-	-	-	1140	>400	-	280	82	50	50
	(°F)	-	-	-	-	2084	>752	-	536	180	122	122
Decomposition or Melting	(°C)	500	500	-	3700	-	450	-	400	-	-	-
	(°F)	932	932	-	6692	-	842	-	752	-	-	-
	(°C)	-	-	144-152	-	825	-	-	-	255	223	260
	(°F)	-	-	291-306	-	1517	-	-	-	491	433	500
LOI	(%)	29 <sup>2</sup> -37 <sup>3</sup>	25 <sup>2</sup>	<20	-	-	>41	55	29-32	18-21	20-21	20-21

<sup>1</sup> in a matrix structure

<sup>2</sup> fabric measurement

<sup>3</sup> filament yarn measurement

N.B. As these data originate from a variety of sources, they may be subject to deviations resulting from different test methods and/or conditions.

We do not accept any liability for the results of the use of these products. The technical data in this brochure reflects our best knowledge at the time of publication. The content of this leaflet is subject to change, depending on new developments and findings, and a similar reservation applies to the properties described in it.

# TEIJIN

## About Teijin Aramid

We are Teijin Aramid, a subsidiary of the Teijin Group with a passion for aramid. Our commitment both to our products and to our customers has made us a global leader in aramids. Wherever strength, safety, heat or flame resistance, low weight or sustainability is required, you will find our Twaron®, Sulfron®, Teijinconex® or Technora®. Our products are used worldwide in many different applications and markets, including automotive, ballistic protection, marine, civil engineering, protective clothing, optical fiber cables, and oil & gas. With our four high performance aramids – produced at our plants in The Netherlands and Japan – we offer the widest range of products. And, with unrivalled expertise and experience we are able to continuously work on further innovations. Often in cooperation with customers and partners through our worldwide sales and marketing organization. That's the power of aramid. If you would like to learn more about the world of aramid or to exchange ideas on developing new solutions, please go to:

[www.teijinaramid.com](http://www.teijinaramid.com) or e-mail us at: [info@teijinaramid.com](mailto:info@teijinaramid.com)

# Twaron®

The power of Aramid