TEIJIN

Human Chemistry, Human Solutions

Twaron – a versatile high-performance fiber

Twaron®

The power of Aramid

Contents

page

What is Twaron?

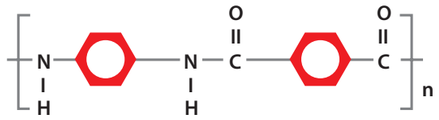
"Our customers expect the highest quality, so I make sure they get it",
Jan Oldenburger, operator

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.

Twaron®

The power of Aramid

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.

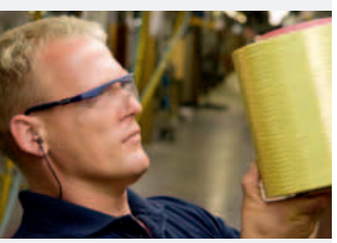
Spinning solution

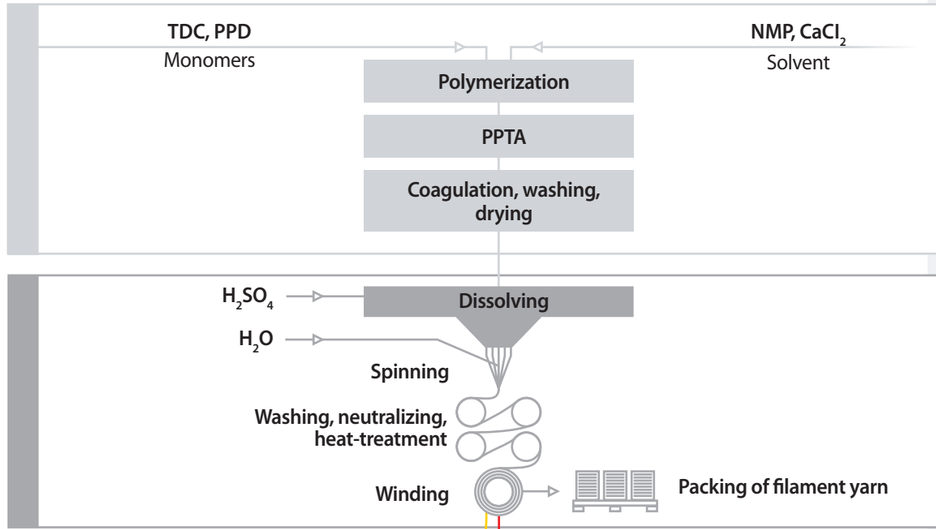
- *liquid crystalline solution*
- *local orientation of molecules in domains*

Yarn structure

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

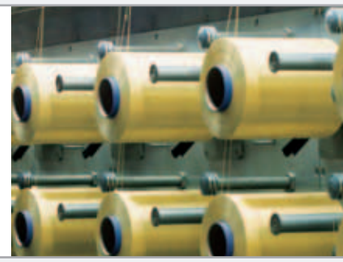
"I feel proud when I see the results of my work", ***Michel Vinke, operator***

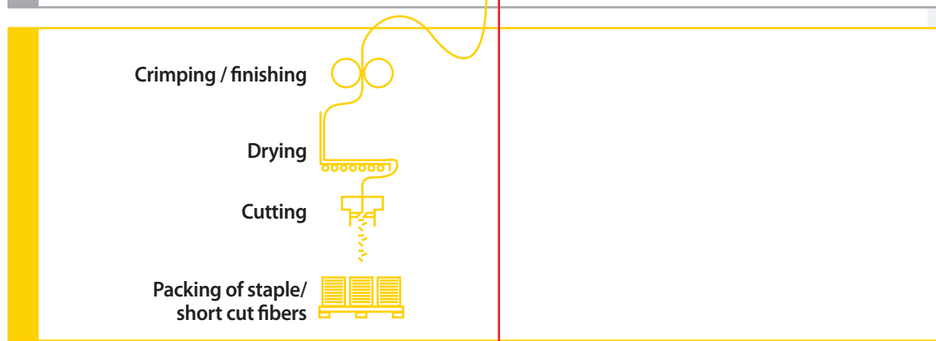




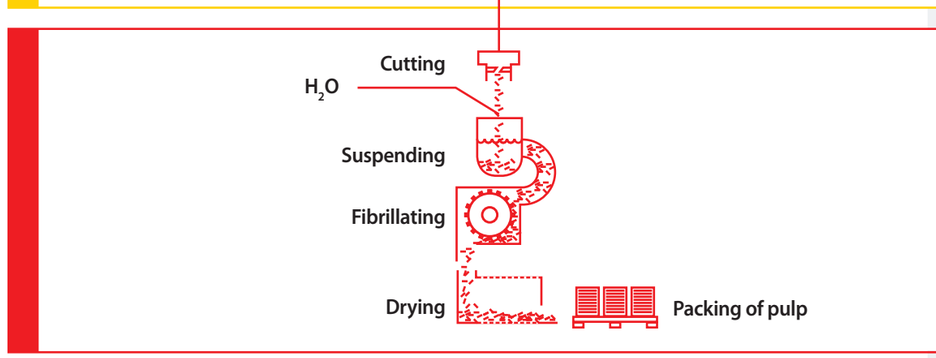
Polymerization
During the first stage, the monomers are converted into a firm fine-grained polymer. This material has the typical heat resistance and chemical properties of para-aramid. However, it has not yet acquired the reinforcing properties of yarn or pulp. Such material is used as a fine powder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



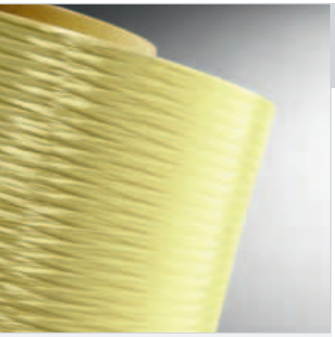


Converting to staple and short cut fiber
To produce staple or short cut fibers, the yarn is crimped and treated with a finishing agent. After drying, the fibers are cut to the desired length and packaged.



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.

What types of Twaron are available?



Twaron 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 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 staple fiber
Twaron staple fibers are used in many heat- and cut protective applications.

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

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 pulp
There are two kinds of pulp: a dry and a wet type with different fiber lengths and degrees of fibrillation. Typical applications are friction materials, gaskets or specialty papers.

Twaron jet-spun fibrids
Twaron jet-spun fibrids are produced in another patented production process for use in e.g. specialty papers.

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

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^3)	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 [1]	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 [1]	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	78	52-132	230-540	72	5.1	7-11	-	-	-	-
Elongation at break	(%)	2.2-4.4	4.6	3-4	0.7-2.0 [1]	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) (°F)	- -	- -	- -	- -	1140 2084	>400 >752	- -	280 536	82 180	50 122	50 122
Decomposition or Melting	(°C) (°F) (°C) (°F)	500 932 - -	500 932 - -	- - 144-152 291-306	3700 6692 - -	- - 825 1517	450 842 - -	- - - -	400 752 - -	- - 255 491	- - 223 433	- - 260 500
LOI	(%)	29 [2] - 37 [3]	25 [2]	<20	-	-	>41	55	29-32	18-21	20-21	20-21

[1] in a matrix structure
[2] fabric measurement
[3] 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.

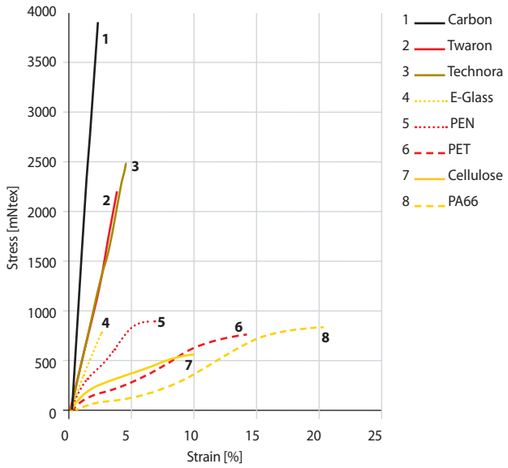
Twaron – a unique combination of properties

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.

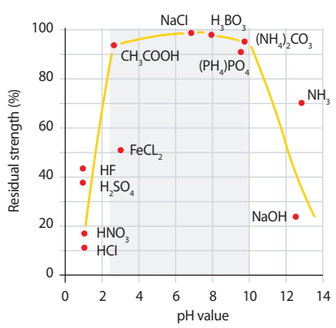
The stress/strain curves are visualized in the graph below.

Stress/strain curves



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.



Twaron resistance to chemical attack, exposure time: 3 months in water at room temperature.

Thermal properties

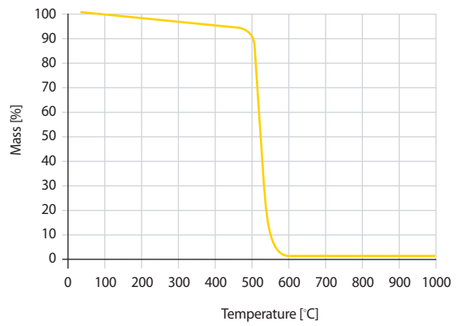
Twaron neither burns nor melts. The graphs below show that Twaron can survive brief exposure to temperatures up to 500°C (932°F) without any significant loss of mass. This is significantly better than the thermal properties of other synthetic fibers. When used as heat resistant material, however, it 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[1] - 37[2]
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 (200°C / 392°F, 48 hrs.)	%	90

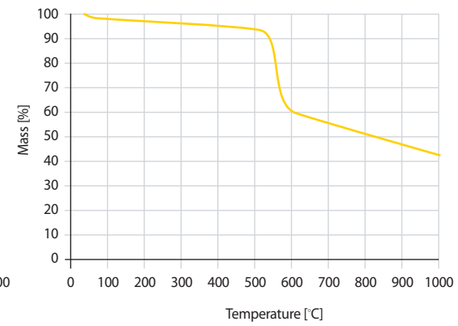
[1] fabric measurement [2] filament yarn measurement

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 recommended to protect aramid from exposure to direct sunlight.

Hydrolysis

Hydrolysis of aramid and other condensation polymers is sensitive to acids and bases.

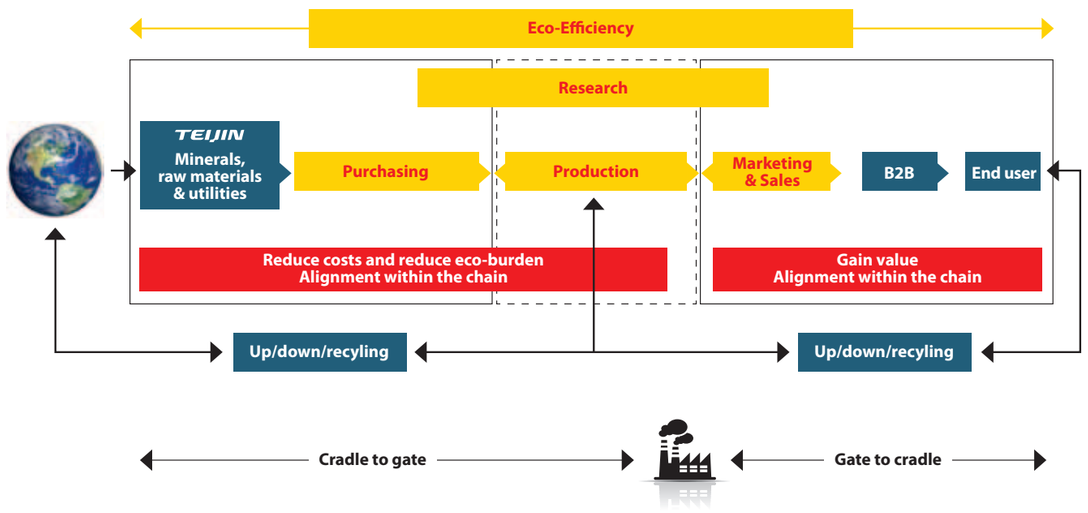
If you're interested in more detailed information about Twaron properties or testing methods, please contact us.

Sustainability is the future

As a company that operates around the globe, we see sustainability and transparency as key elements in doing business worldwide, now and in the future. Our business strategy is perfectly aligned with this trend. Exceptional resistance to extreme conditions make Twaron and our other aramid products intrinsically sustainable. As a result, Twaron is ideally suited for energy-efficient and durable applications. We also operate dedicated, highly automated recycling factories. Most of our products can be recycled, for example crushed and converted into pulp, which is then made into new products.

Eco Efficiency Analyses
We want to be leaders in sustainability by making our products even more sustainable. We also wish to demonstrate the positive effects of our products in our customers' products and applications. We are therefore investing in building up the knowledge and expertise needed to carry out Eco Efficiency Analyses (EEA). EEAs enable us to quantify and demonstrate the value created by our products, taking the entire chain into consideration.

Opportunities in the chain



Partnering on sustainability
Sustainability benefits strongly from innovation and cooperation. We see our role as being a reliable partner for our customers in terms of quality, reliability of supply, accessibility, and openness – the human dimension of a high-tech environment. We would like to know where and how we can improve our performance.

Interaction teaches us a great deal about the markets in which we operate and it's a fruitful source for product development. Social change also encourages us to find new, environmentally friendly solutions in markets where we are not yet involved. In our Central Research Facilities, at the Technical Textile Institute (TTI), as well as in our application laboratories, we are constantly working on innovative solutions and improving our products, often in close cooperation with our customers.

"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

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.

Whether you're looking for less weight, extra strength, greater energy efficiency, heat and chemical resistance, safety or comfort, or any other way to improve the durability and performance of your products, we can create sustainable solutions together. Contact us via info@teijinaramid.com.

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 or e-mail us at: **info@teijinaramid.com**

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