THERMOLYSIS

Carbon Fiber Recycling and Regeneration

Upcycle CFRP Wastes for a Greener Tomorrow

Thermolysis Co., Ltd.

One-stop service for recycling and sourcing,
Enabling the circular economy of carbon fiber

About Thermolysis

Thermolysis, founded in 2016 in Taiwan, specializes in innovative technologies. Our expertise lies in high-temperature pyrolysis equipment, specifically designed for the recycling of advanced carbon materials such as carbon fibers.

Using exclusive microwave pyrolysis technology and equipment, we recycle carbon fiber, refining it into various recycled materials and consumer products. With factories and production lines in Taiwan, we handle large-scale processing of carbon fiber waste to produce high-quality recycled carbon fiber.

Our aim is to offer cost-effective, eco-friendly solutions, leading in global carbon fiber recycling efforts.

1 Thermolysis Established

2016

2 Setting up continuous microwave pyrolysis equipment for production.

2017

3 Developed CFRP recycling technology

2020

4 Mass production of recycled carbon fiber and development of recycled carbon fiber products.

2021

5 UL2809 Certified, Commercialization of RCF Intermediary Products

2022

6

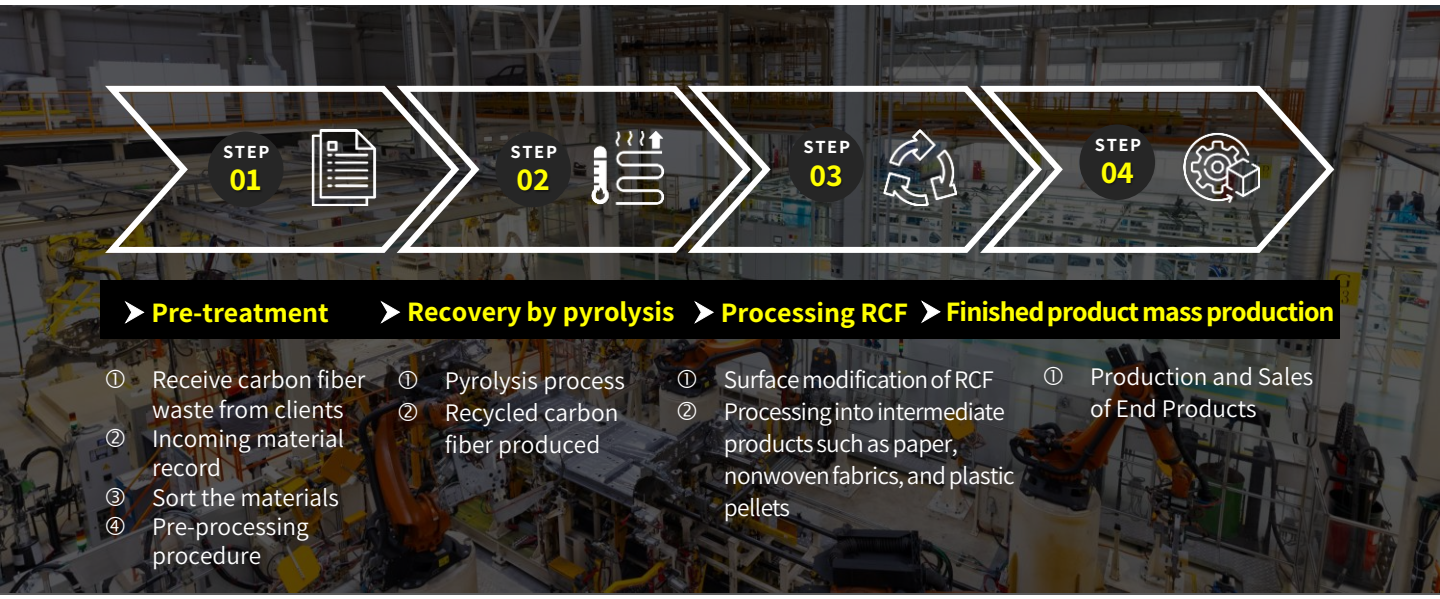
- ISO 14067 carbon footprint certification
- Winning the 20th National Innovation Award in Taiwan

2023

7 Winning Green World Awards-Gold

2024

Carbon Fiber Recycling Process



Types Of Waste We Deal With

Trimming waste

Cured waste

End-of-life products

Carbon Fiber Recycling Process by Thermolysis

Recycled Carbon Fiber (RCF)

- Resin removal rate exceeds 90%, maintaining carbon fiber surface integrity.
- 100% from carbon fiber waste, environmentally friendly.
- Recycled materials verified through UL2809 for content, with traceable source.
- The recycling process is certified to ISO 14067 product carbon footprint standards, with recycled materials emitting only one-fifth of the carbon compared to new ones.
- Various surface-modified recycled carbon fiber products available to meet diverse customer needs.

Product Specifications

Item	Unit	RCF	RCF-PT#1	RCF-CM#2
Fiber Grade	-	Mix Grade		
Fiber Length	mm	Customization	6-10 mm	6-10 mm
Length Tolerance	%	± 20		
Color	-	Black		
Moisture	Wt. %	< 3		
Bulk Density	-	0.08-0.1		
Fiber Purity	%	≧ 99		
Sizing Content	Wt. %	-	2±1	-
Sizing Type	-	-	PC、TPU、PP	Specific modification
Application	-	Needle-punch nonwoven, Wet-laid nonwoven, BMC process, etc.	TP-pellet Compounding process, etc.	Cement reinforced material, etc.

#1 PT represents suitability for blending with RCF to produce plastic pellets.
#2 CM represents suitability for blending with RCF to produce cement.
※ The product data is based on our analysis for reference. Accurate values depend on the production equipment and processes.

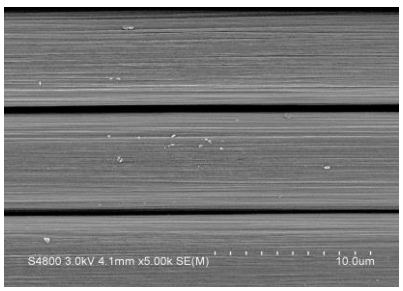
Recycled Carbon Fiber (RCF)

Applicable Processing Techniques

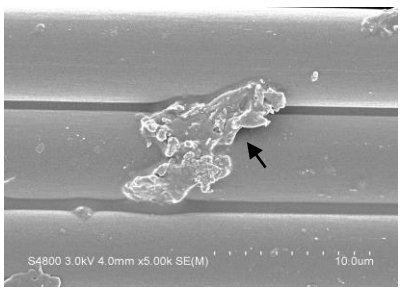
RCF	RCF-PT	RCF-CM
‣Suitable for Needle-punch nonwoven process. ‣Suitable for Wet-laid nonwoven process.	‣Suitable for plastic pellet compounding process.	‣Suitable for manufacturing cement-reinforced materials.

High-Quality Recycled Carbon Fiber

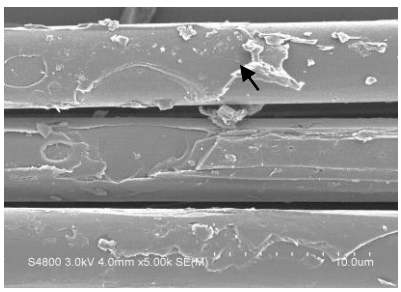
- **Comparison of recycled carbon fiber surface analysis under SEM**



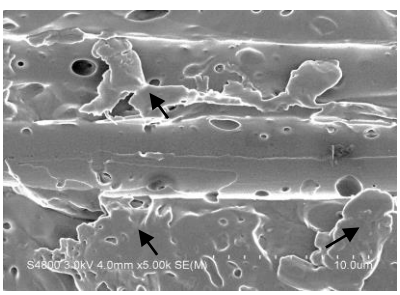
THERMOLYSIS 's RCF



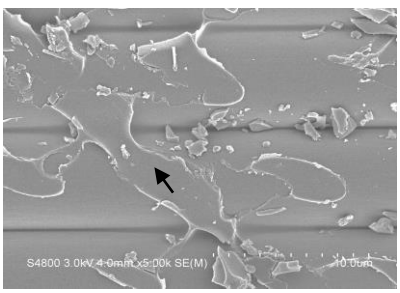
A company's RCF



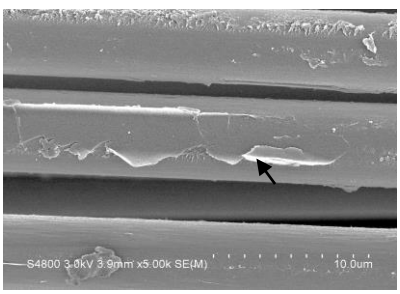
B company's RCF



C company's RCF



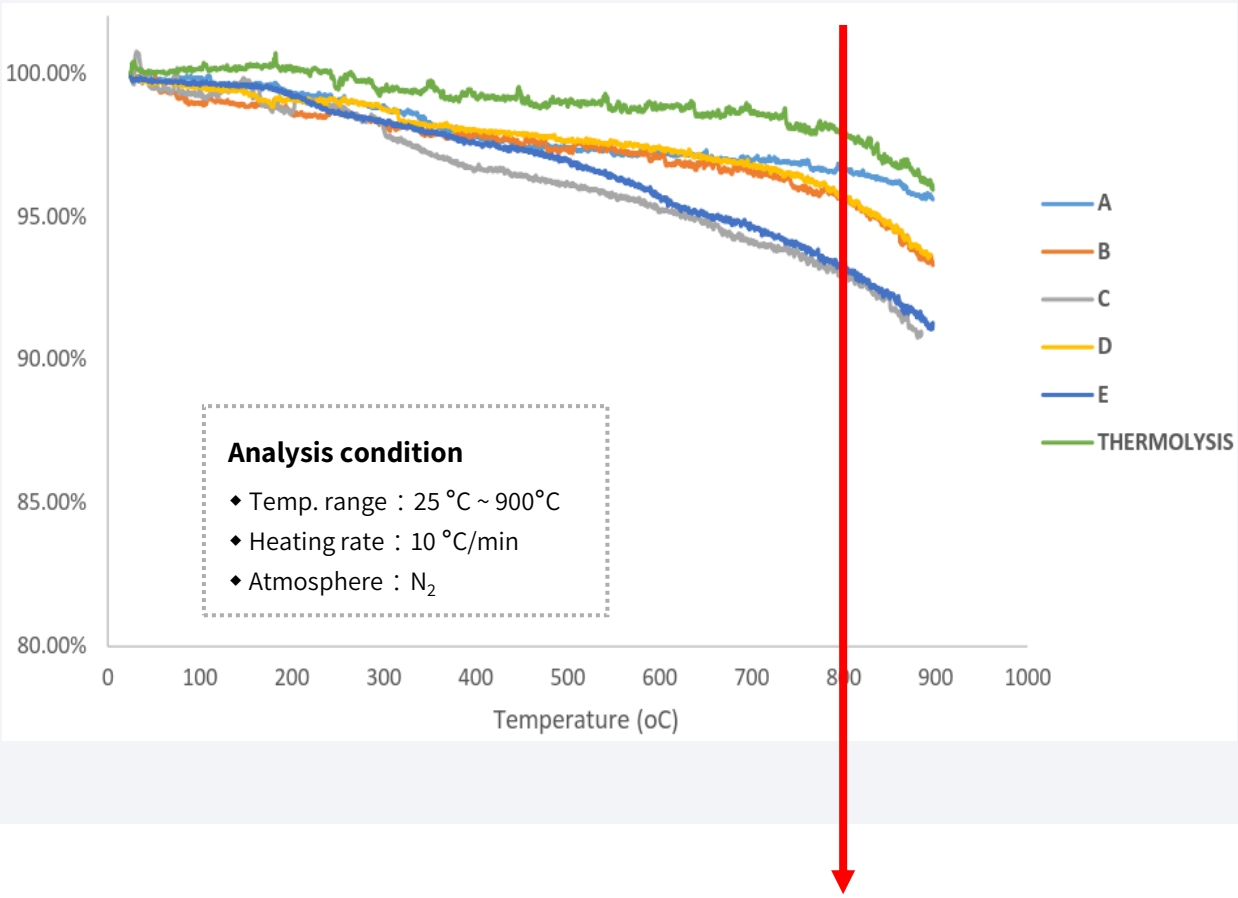
D company's RCF



E company's RCF

"Compared to competitors, THERMOLYSIS's recycled carbon fiber has a cleaner and impurity-free surface."

Recycled Carbon Fiber TGA Analysis (Comparison with Competitors)



“

- When Td3% is **higher**, it is indicated that sample has **lower impurity content**.
- **THERMOLYSIS RCF** has stable and the lowest weight loss percent when temperature ramp up to 800 °C.

”

Competitor	$T_{d3\%}$
Thermolysis	**809.57**
A	717.24
B	584.23
C	353.10
D	656.65
E	461.34

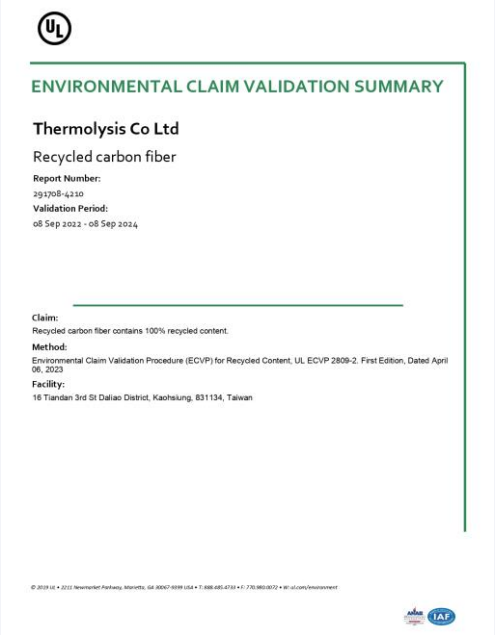
※ $T_{d3\%}$: Temperature at 3% weight loss.

Recycled Carbon Fiber (RCF)

UL 2809 Recycled Content Verification

In the past, the lack of mature and scalable recycling technologies led to opaque and untraceable sources of recycled materials. Additionally, the varying quality of these materials reduced industry confidence in their use.

To gain customer trust, Thermolysis enlisted UL to certify the source of our materials. In 2022, we received UL 2809 Recycled Content Verification, offering full transparency and traceability to confirm that Thermolysis processes recycled materials.



ENVIRONMENTAL CLAIM VALIDATION SUMMARY

Thermolysis Co Ltd

Recycled carbon fiber

Report Number:
291708-4210

Validation Period:
08 Sep 2022 - 08 Sep 2024

Claim:
Recycled carbon fiber contains 100% recycled content.

Method:
Environmental Claim Validation Procedure (ECVP) for Recycled Content, UL ECVP 2809-2. First Edition, Dated April 06, 2023

Facility:
16 Tiandan 3rd St Daliao District, Kaohsiung, 831134, Taiwan

ISO 14067 Carbon Footprint Certification

To showcase the substantial carbon emission reduction achieved by using recycled materials, we had our recycled carbon fiber production process certified by TÜV Rheinland, Germany, according to ISO 14067 standards.

In 2023, we received certification confirming that Thermolysis' "recycled carbon fiber" emits only 5.047 kilograms of carbon dioxide equivalent per kilogram. This is one-fifth the emissions of manufacturing virgin carbon fiber, highlighting the significant environmental benefits of Thermolysis' recycled carbon fiber.

Certificate

Inventory Standard	ISO 14067:2018
Certificate Registr. No.	CO 50575535 0001
Report No.	48214531 001
Certificate Holder:	**Thermolysis Co., Ltd.** No. 68, Wanxing Rd., Dadu Dist., Taichung City 43241 , Taiwan (R.O.C.)
Verification Site:	**Thermolysis Co., Ltd.** No. 16, Tiandan 3rd St., Daliao Dist., Kaohsiung City 83162 , Taiwan (R.O.C.)
Verification Method:	Verification Body: TÜV Rheinland Taiwan Ltd. - Process: Document review, interview, site visit and recalculation - Verification Standard: ISO 14064-3:2006
Verification Scope:	Based on the information we have received and evaluated that: - Programme: Voluntary PCF scheme - Product Category Rule: N/A - Organizational Boundary: Operational Control - Level of Assurance: Reasonable - Materiality: 5% - Global warming potential (GWP): IPCC 2021 - Analysis method: IPCC 2021 GWP100 V1.01 - LCA software or database: SimaPro 9.4.0.2 / Ecoinvent 3, Carbon footprint database of Carbon Footprint Information Platform(Owner: Taiwan EPA) - Product: Recycled carbon fiber - Boundary: Cradle to Gate - Data period: 2022.01.01~2022.08.31 - Functional unit: one kg(including package) - Model no. / Carbon emissions: N/A (average) / 5.047 kg CO_2e
Validity:	This certificate is valid from 2023/03/21 until 2025/03/20 This certificate only verified the target product carbon footprint, this verification does not include review of external communication.

2023-03-21

TÜV Rheinland Taiwan Ltd.
11F., No. 758, Sec. 4, Bade Rd., Taipei 105, Taiwan

This verification and validation is based on the information made available to TÜV Rheinland and the engagement conditions detailed above. Therefore, TÜV Rheinland cannot guarantee the accuracy or correctness of this information. TÜV Rheinland cannot be held liable by any party relying or acting upon this verification and validation.

www.tuv.com

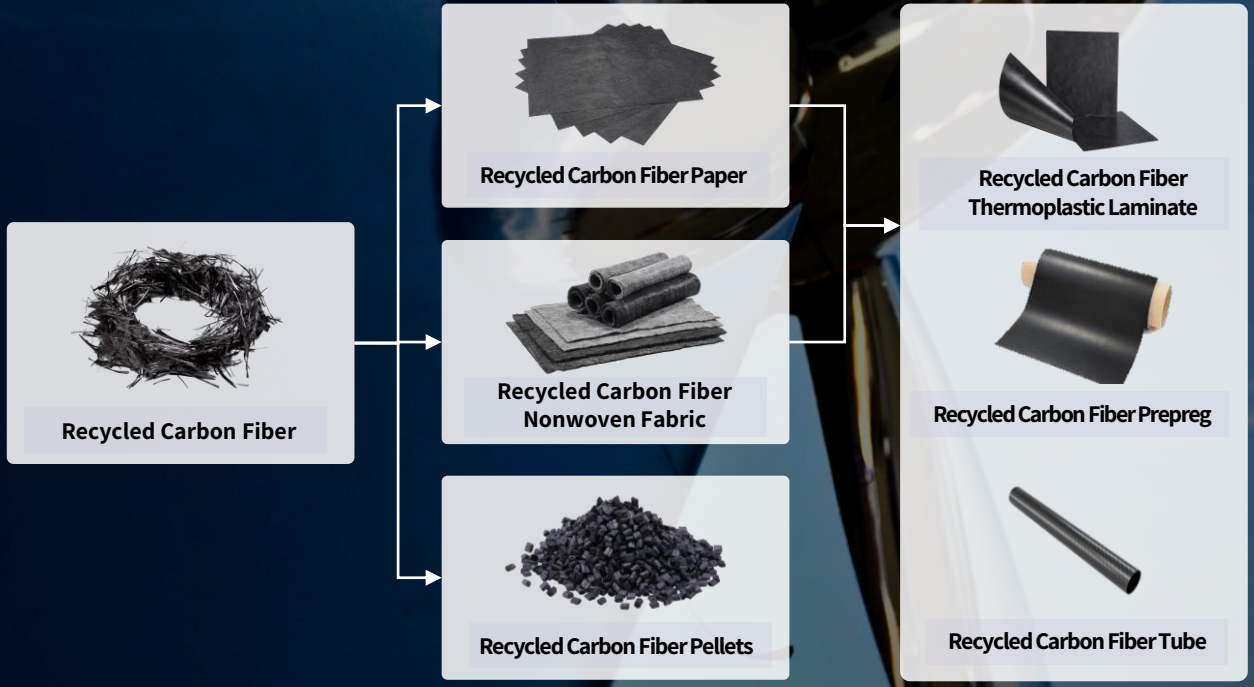
TÜVRheinland®
Precisely Right.

Recycled Carbon Fiber Material Series

“

Recycled carbon fiber, a new raw material, is not directly compatible with existing processing equipment. Thermolysis modifies recycled carbon fiber into usable forms like ***carbon fiber paper, nonwoven fabric, and plastic pellets***, enabling easier integration into production lines. This extends to intermediate products like recycled ***carbon fiber prepreg, thermoplastic laminates, and carbon fiber tubes***.

”



Recycled Carbon Fiber Paper

- 100% from carbon fiber waste, environmentally friendly.
- Through wet processing, the fibers are evenly dispersed in a binder, then dried to form recycled carbon fiber paper.
- The paper has a smooth surface, ideal for bonding with various resins to create composite materials.
- It boasts excellent properties like corrosion resistance, conductivity, breathability, and high mechanical strength typical of carbon fibers.
- Available in a basis weight range of 30 to 70 g/m^2, with typical options of 30 g/m^2 and 70 g/m^2.
- Customization is offered.

Product Specifications

Item	Unit	Value	
Areal Weight	g/m^2	30	70
Thickness	mm	0.180	0.370
Density	g/cm^3	0.179	0.189
Roll Width	mm	1030±10	
Tensile Strength (0°)	N/15mm	3.3	20.0
Tensile Strength (90°)	N/15mm	1.0	4.0

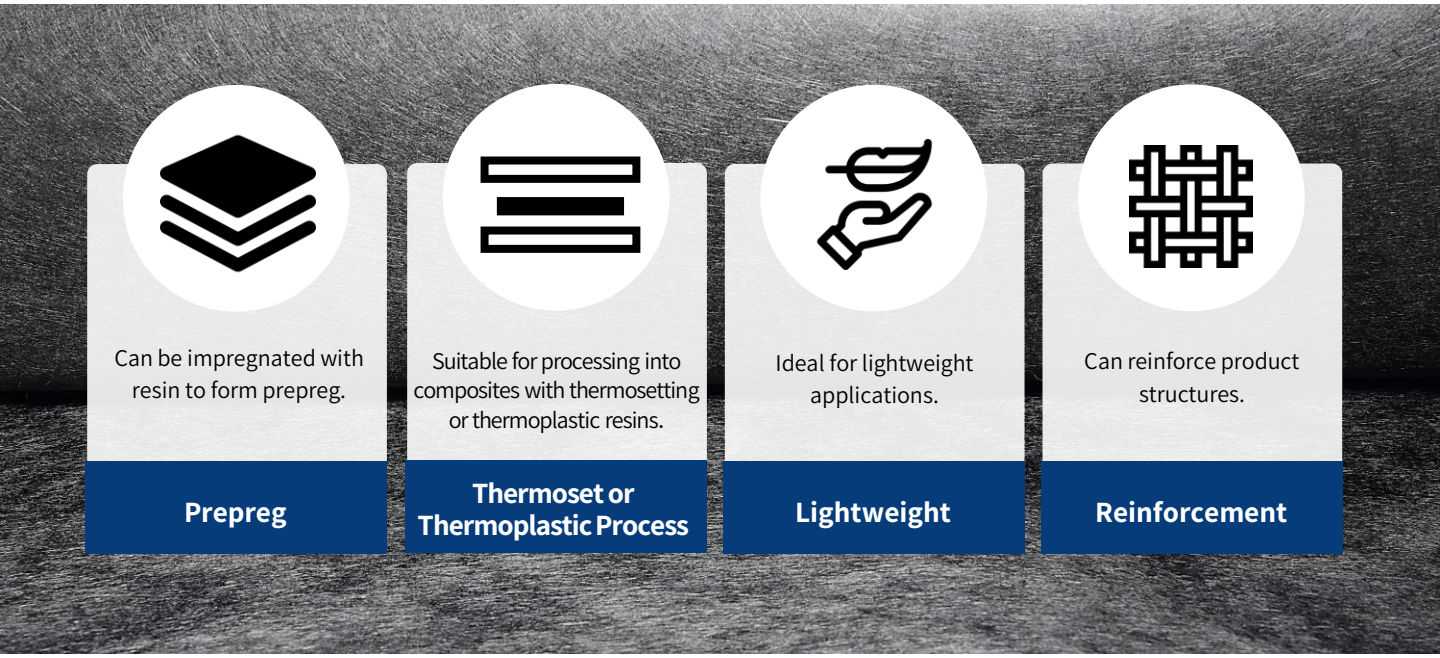
※ The product data is based on our analysis for reference. Accurate values depend on the production equipment and processes.

Applicable Processing Techniques

- **Hand Lay-up**
- **Resin Transfer Molding, RTM**
- **Thermo Molding**

Recycled Carbon Fiber Paper

Product Applications



Product Sampling (all made from recycled carbon fiber by Thermolysis)

Laptop Inner Support Frame

Tube

Swim Fins

Camping Table

Suitcase

Paddle Tennis Racket

Recycled Carbon Fiber Nonwoven Fabric

- Using a dry nonwoven process, recycled carbon fibers are needle-punched to create nonwoven fabric.
- The length of the recycled carbon fibers used ranges between 6 to 10 cm.
- Mass-production of 100% pure RCF nonwoven fabric or customize blends with thermoplastic materials (like TPU, FRPC, PA6, PP, PPS, PET, etc.).
- The basis weight range for mass-produced pure RCF nonwoven fabric is 100-300 g/m^2, while the basis weight range for blended products is 100-500 g/m^2.
- Thermosetting and thermoplastic resins can be used to impregnate carbon fiber nonwoven fabric to produce prepreg.
- It can also be further processed into thermoplastic laminates and thermoformed products.

Product Specifications

Item	Unit	Pure RCF	Blended Product
Types of Thermoplastic Polymers	-	non	TPU, FRPC, PA6, PP, PPS, PET, etc.
Ratio of Recycled Carbon Fiber	%	100 %	10~90 %
Length of Recycled Carbon Fiber	mm	20~60	20~60
Areal Weight	g/m^2	100~300	100~500
Roll Width	m	Standard Product：1M；Custom Product：1~2M	

※ The product data is based on our analysis for reference. Accurate values depend on the production equipment and processes.

Applicable Processing Techniques

- **Hand Lay-up**
- **Resin Transfer Molding, RTM**
- **Thermo Molding**

Recycled Carbon Fiber Nonwoven Fabric

Product Applications

Can be impregnated with resin to form prepreg.	Suitable for processing into composites with thermosetting or thermoplastic resins.	Ideal for lightweight applications.	Can reinforce product structures.
Prepreg	**Thermoset or Thermoplastic Process**	**Lightweight**	**Reinforcement**

Product Sampling (all made from recycled carbon fiber by Thermolysis)

Bicycle Fender

EV Bike Battery Cover

Electric Scooter Wheel Cover

Athletic Shoes Midsole

Safety Shoe Toe Cap

Laptop Cover

Recycled Carbon Fiber Pellets

- Made from 100% recycled carbon fiber.
- The product combines recycled carbon fiber and thermoplastic resin to make plastic pellets, which can enhance material strength and stiffness.
- Engineering plastics, such as PA6, TPU, PP, and PC, can be added in a range of 10% to 30% according to customer requirements.
- Recycled carbon fiber from thermolysis is of high quality and retains high-strength physical properties. The resulting plastic pellets also maintain excellent properties, including high strength, high rigidity, wear resistance, conductivity, and light weight.
- The granular form is convenient for injection molding, extrusion, and compression molding.

Product Specifications

Item	Unit	Value						
Types of Thermoplastic Polymers	-	PA6		TPU	PP		PC	
Ratio of Recycled Carbon Fiber	%	10	20	20	20	30	20	30
Tensile Strength (ASTM D638)	MPa	132	177	68	78	109	132	145
Flexural Strength (ASTM D790)	MPa	189	262	49	107	155	184	196
Flexural Modulus (ASTM D790)	GPa	6.0	10.1	1.6	7.3	10.6	12.2	14

※ The product data is based on our analysis for reference. Accurate values depend on the production equipment and processes.

Recycled Carbon Fiber Pellets

Product Applications

Product Sampling (all made from recycled carbon fiber by Thermolysis)


Bicycle Bottle Cage


Bicycle Saddle


Bicycle Pedal


Road Bike Shoe Sole


Bicycle Mudguard


Shoe Midsole


Shoe Insole


Comb


Sunglasses

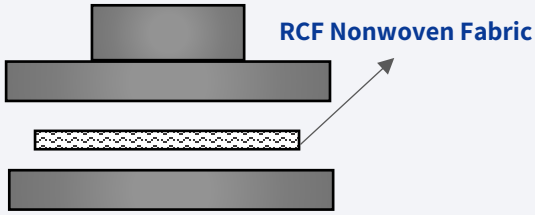
Recycled Carbon Fiber Thermoplastic Laminate

- Made from 100% recycled carbon fiber.
- Recycled carbon fiber paper or nonwoven fabric can be processed into laminate. By mixing in thermoplastic polymers like TPU, PA, PC, and PP, laminates of various thicknesses, resin-to-fiber ratios, and strength orientations can be tailored to suit customer requirements.
- Boast high strength, durability, and conductivity.
- Produced through hot pressing, they are ideal for mass-producing large parts and intricate crafts.
- Currently widely used in various industries including automotive, electrical equipment, and sports equipment in both consumer and industrial sectors.

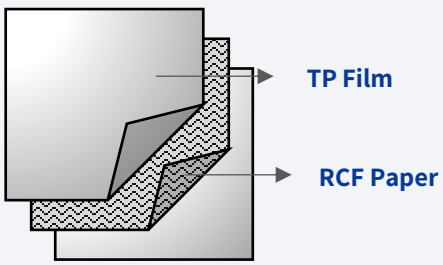
Applicable Processing Techniques

- **Sheet Molding Compound, SMC**

Forming Type



Heat press directly to form a plate



Sandwich structure

Recycled Carbon Fiber Thermoplastic Laminate

Product Specifications

Recycled Carbon Fiber Paper Laminate	Unit	Value	
Types of Thermoplastic Polymers	-	PC	TPU
Ratio of Recycled Carbon Fiber	%	34	34
Stack-up	-	PC：8 layers RCF Paper：7 layers	TPU：9 layers RCF Paper：8 layers
Thickness	mm	1.0	1.0
Flexural Strength	MPa	283	102
Flexural Modulus	GPa	19.7	10.7
Resistance	Ω	10^3	
Maximum Size	m	1m*1m	

Recycled Carbon Fiber Nonwoven Fabric Laminate	Unit	Values			
Types of Thermoplastic Polymers	-	FRPC	TPU	PA6	PP
Areal weight	g/m^2	350			
Ratio of Recycled Carbon Fiber	%	40			
Stack-up	-	RCF Nonwoven：4 layers			
Thickness	mm	1.0			
Flexural Strength (0°)	MPa	189	280	290	223
Flexural Strength (90°)	MPa	235	361	358	237
Flexural Modulus (0°)	GPa	13.7	14.4	13.8	13.9
Flexural Modulus (90°)	GPa	16.2	22.4	19.1	14.0
Resistance	Ω	10^3			
Maximum Size	m	1m*1m			

※ The product data is based on our analysis for reference. Accurate values depend on the production equipment and processes.

Recycled Carbon Fiber Prepreg

- Made from 100% recycled carbon fiber.
- Using thermosetting epoxy resin as the matrix, along with recycled carbon fiber paper or nonwoven fabric, it is impregnated to create recycled carbon fiber prepreg.
- The product cures at temperatures ranging from 130°C to 150°C, designed specifically for high-performance structural applications.
- There are two types of resin to choose including M type (normal) and K type (fast curing).
- It's suitable for use in automotive, sports equipment, electronics, medical facilities, and industrial manufacturing to produce lightweight, high-strength structural components.

Applicable Processing Techniques

- **Sheet Molding Compound, SMC**
- **Autoclave Molding**
- **Winding**

Processing Condition

Curing Temperature (0℃)	Curing time (min)	
	M Type	K Type
130	60	15
140	45	12
150	30	9

Recycled Carbon Fiber Prepreg

Product Specifications

Product	Item	Unit	Value	Description
Recycled Carbon Fiber Paper Prepreg	Tensile Strength (0°)	MPa	228	1. Matrix : RCF Paper 2. M Type Resin 3. FAW = 70 g/m^2 4. RC = 65% 5. Width = 1000 mm
	Flexural Strength (0°)	MPa	382	
	Flexural Modulus (0°)	GPa	21.4	
	Tensile Strength (90°)	MPa	140	
	Flexural Strength (90°)	MPa	246	
	Flexural Modulus (90°)	GPa	15.1	

Product	Item	Unit	Value	Description
Recycled Carbon Fiber Nonwoven Fabric Prepreg	Tensile Strength (0°)	MPa	185	1. Matrix : RCF Nonwoven 2. M Type Resin 3. FAW = 100 g/m^2 4. RC = 70% 5. Width = 1000 mm
	Flexural Strength (0°)	MPa	293	
	Flexural Modulus (0°)	GPa	16	
	Tensile Strength (90°)	MPa	258	
	Flexural Strength (90°)	MPa	412	
	Flexural Modulus (90°)	GPa	23	

※ The product data is based on our analysis for reference. Accurate values depend on the production equipment and processes.

Series of Consumer Products Made from Recycled Carbon Fiber

> Thermolysis has created a green brand "**RCF**," focusing on recycling responsibility and embodying environmental consciousness. Using recycled carbon fiber processed by Thermolysis, the brand offers high-quality sports, leisure products, and daily necessities. Thermolysis commits to recycling all "**RCF**" products in the future, ensuring no environmental pollution and promoting continuous carbon fiber recycling.

Bicycle Bottle Cage

Bicycle Saddle

Bicycle Pedal

Road Bike Shoe Sole

Comb

Sunglasses

Swim Fins

Paddle Tennis Racket

Thermolysis Co., Ltd.

HEADQUARTERS

No. 68, Wanxing Rd., Dadu Dist., Taichung City 43241 , Taiwan (R.O.C.)
TEL +886 4 2698 0329
FAX +886 4 2698 0330

FACTORY

No.16, Tiandan 3rd St., Daliao Dist., Kaohsiung City 83162, Taiwan (R.O.C.)
TEL +886 7 787 7497
FAX +886 7 787 7508

WEBSITE https://www.thermolysis-asia.com
E-MAIL info@thermolysis-asia.com