

Carbon Fiber **Recycling**

Upcycle CFRP Wastes for a Greener Tomorrow



Thermolysis Co., Ltd.

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

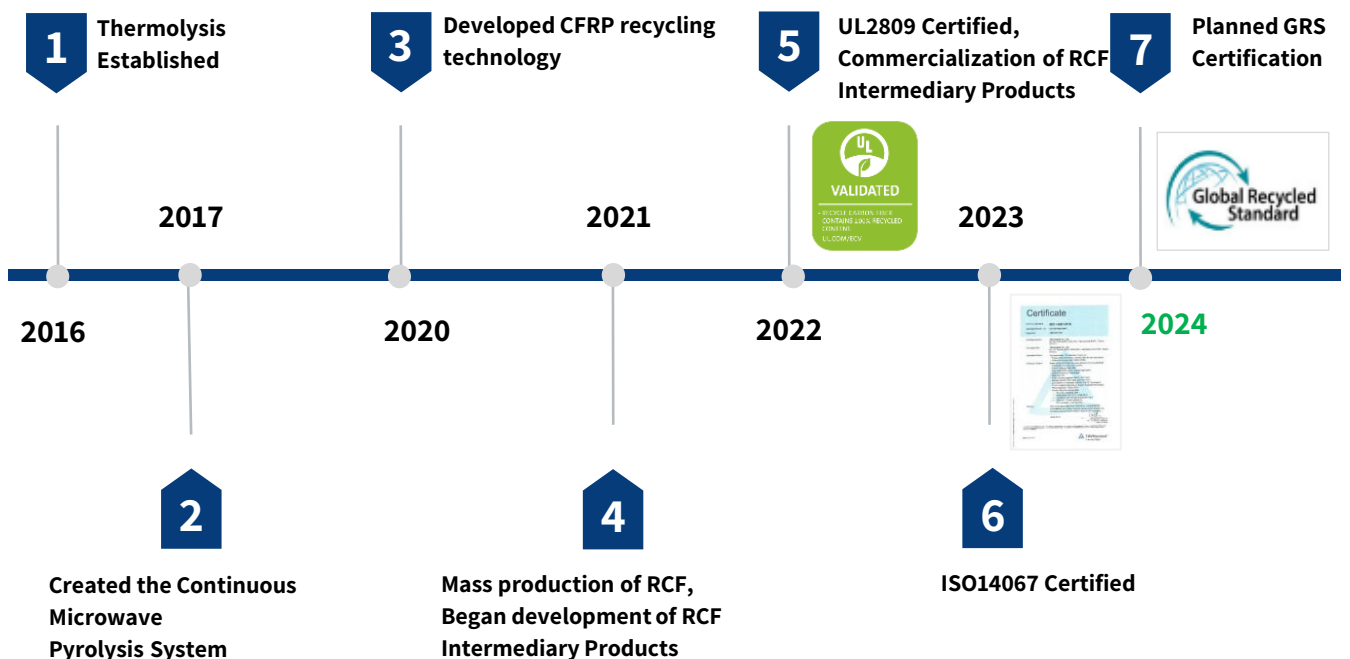


About Us

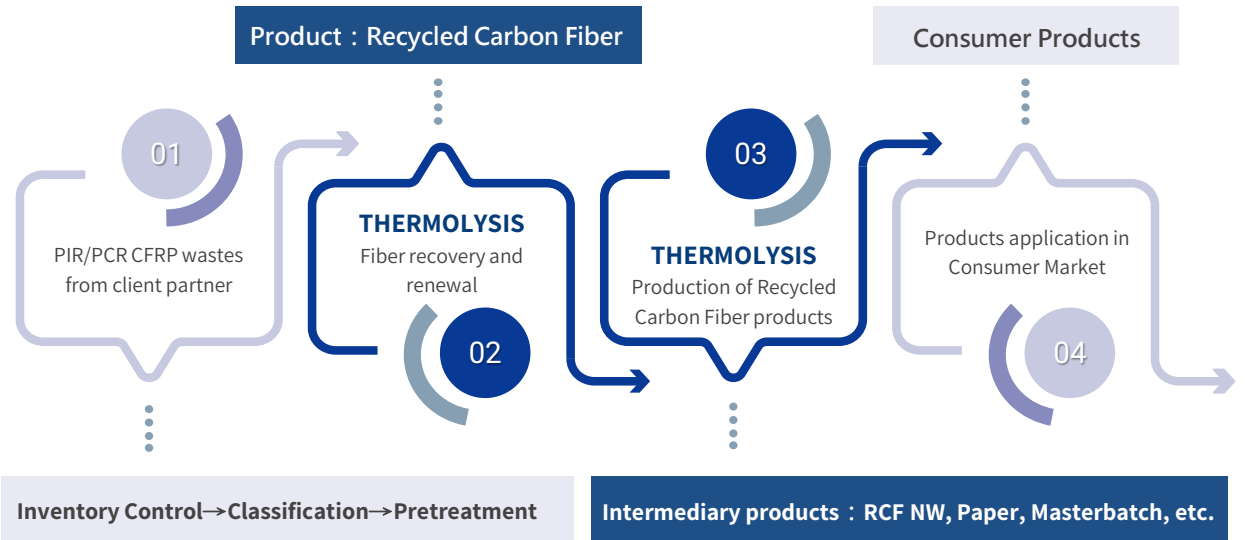
Since its establishment in 2016, Research & Development has always been at **Thermolysis'** core. Our multination-patented, industry-leading microwave pyrolysis technology empowers us to positively impact sustainability through **carbon fiber recycling**.

By embracing the culture of continuous improvement, we have achieved mass production of fiber recovery from CFRP and the manufacturing of intermediary products for downstream applications.

Our goal is to enable industry-wide adoption of recycled carbon fiber, putting an end to CFRP wastes that would otherwise end up in landfills.

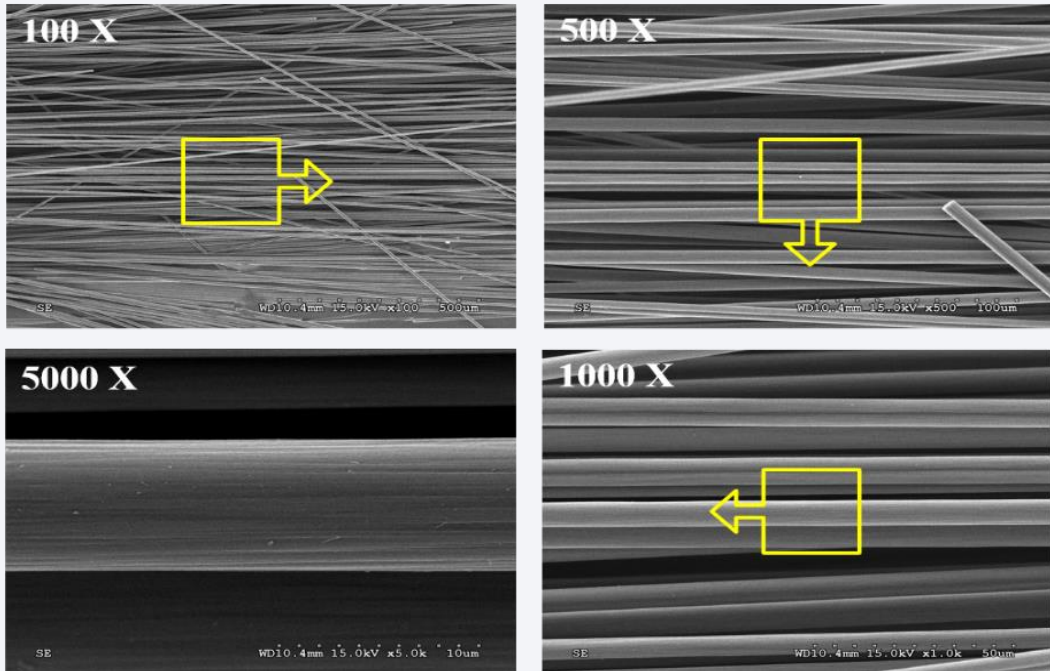


OUR RECYCLING PROCESS



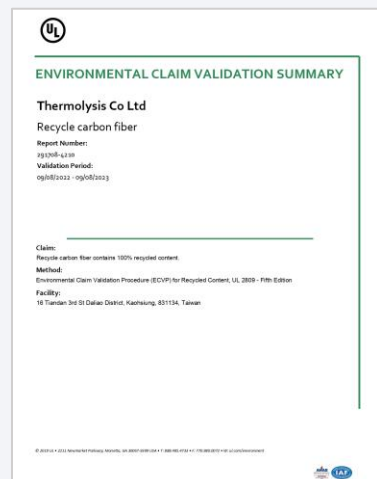
Our Recycled Carbon Fiber

Our industry-leading continuous pyrolysis technology reclaims highly-purified, free-of-resin carbon fiber from CFRP. These clean and undamaged fibers enable Thermolysis to build a wide portfolio of intermediate products for the industry adoption of recycled carbon fiber.



Recycled Carbon Fiber with clean and undamaged surfaces observed under SEM

UL2809 Recycled Material Content Certification



ISO 14067 Carbon Footprint

The Carbon Footprint of our process has been certified by the internationally accredited standard of ISO 14067. With 5.047 kg of CO₂e per kg of fiber recovered, **we emit only ¼ of CO₂ than those of virgin carbon fiber.**

By adopting Thermolysis' recycled carbon fiber, customers can realize the financial and environmental benefits from the immediate reduction of carbon footprint, as well as having product differentiation by using sustainable material.



Our RCF Traceability Platform

Thermolysis' RCF Traceability Platform provides its customer partners full transparency across the supply chain. Our partners can substantiate their ESG commitments with fully traceable and accountable products, resulting in possible higher ESG scores.

The platform records lot-level information on RCF and the intermediary products. This includes and not limited to the original source of waste, quantity, product type, CO₂e, and transaction details, as well as the certified recycled contents under UL2809.

#NO	Waste Information
#15346	Carbon Fiber Leftover
#15345	Carbon Fiber Leftover
#15344	Carbon Fiber Leftover
#15343	Carbon Fiber Leftover
#15342	Carbon Fiber Leftover
#15341	Carbon Fiber Leftover
#15340	Carbon Fiber Leftover
#15343	Carbon Fiber Leftover

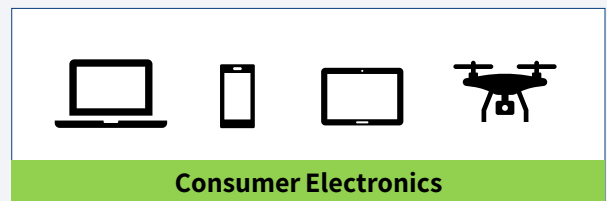
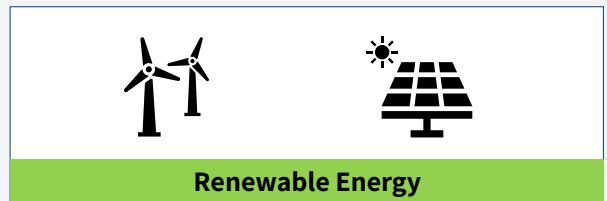
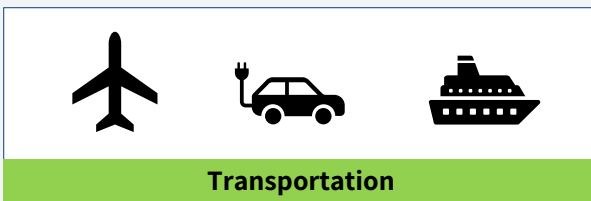


Recycled Carbon Fiber Boosts Both Environmental Sustainability and Remarkable Strength.

Our Recycled Carbon Fiber Intermediary Products



Application of Our RCF Intermediary Products



Recycled Carbon Fiber Paper



- Made of 85% recycled carbon fiber and 15% chemical fiber. (Customizable)
- The flat surface is easy to combine with various thermosetting and thermoplastic resins and can be remanufactured into various composite materials.
- The thickness and basis weight of the paper are consistent.
- Retains excellent performance properties, such as corrosion resistance, electrical conductivity, air permeability, and high mechanical strength.

Application

 <p>Prepreg</p>	 <p>Reinforcement</p>	 <p>Lightweight</p>	 <p>Thermomoulding</p>
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Test item	Unit	Result	
Base Weight	g/m ²	30	70
Thickness	mm	0.18	0.37
Tensile Strength (MD)	N/15mm	3.3	20
Tensile Strength (TD)	N/15mm	1.0	4.0
Density	g/cm ³	0.179	0.189

* The above results are test values, for references only.

Recycled Carbon Fiber Non-Woven



- Using Thermolysis’s 100% recycled carbon fiber filaments and combining with the exquisite needle punching technology to produce non-woven mat.
- Customizable composition to make into different thermoplastic sheets and hot-pressed products.
- The thickness and basis weight of the non-woven mat are consistent.
- Can be impregnated with a thermosetting resin to make prepreg.

Application

 <p>Prepreg</p>	 <p>Reinforcement</p>	 <p>Lightweight</p>	 <p>Thermomoulding</p>
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Test item	Unit	Result
Types of Thermoplastic Polymers		PA6、PET、TPU
Ratio of Recycled Carbon Fiber		10~100 %
Base Weight	g/m ²	100~500
Length (Recycled Carbon Fiber)	mm	20~60
Width (Mat Roll)	mm	1000~2000

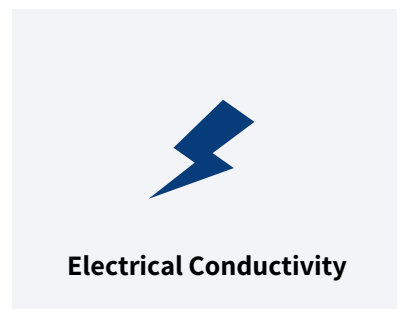
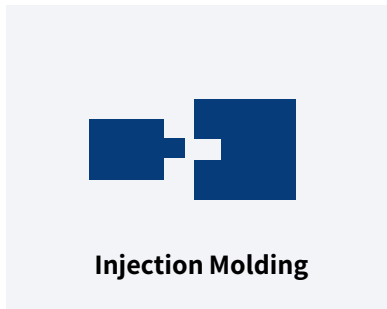
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▶ Recycled Carbon Fiber Masterbatch



- Using 100% recycled carbon fiber, adding 10%-50% engineering plastics such as PA series, ABS, PC, PS, etc.
- Thermoplastic polymer materials can be added according to the needs of downstream applications.
- High mechanical strength, wear resistance, and electrical conductivity.
- Mainly used for injection molding, suitable for injection of parts with complex shapes, or for mass production of complex handicrafts.

▶ Application



Test item	Unit	Result	
Types of Thermoplastic Polymers		PA6	
Ratio of Recycled Carbon Fiber	%	20	30
Tensile Strength (ASTM D638)	MPa	125	176
Flexural Strength (ASTM D790)	MPa	192	274
Flexural Modulus (ASTM D790)	GPa	6.6	12.7

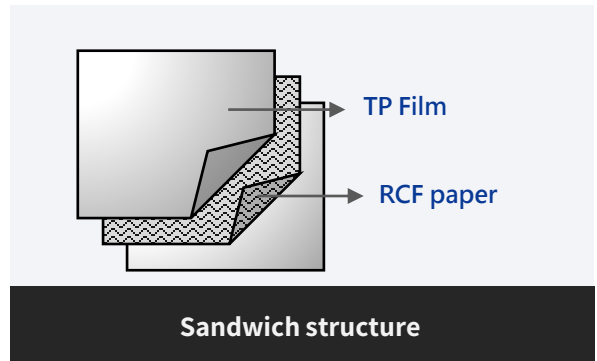
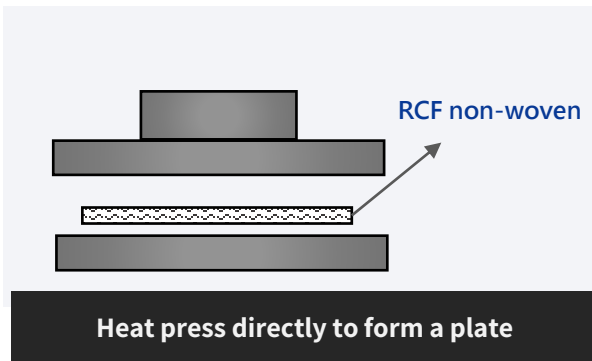
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Recycled Carbon Fiber Thermoplastic Laminate



- It is made of recycled carbon fiber paper or recycled carbon fiber non-woven. Can be combined with TPU, PA series, PC and other compound materials to make hot-pressing boards with different thicknesses and fiber alignment directions.
- Thermoplastic polymer materials can be added according to the needs of downstream applications. (TPU, PC, PA6)
- High mechanical strength, wear resistance, and electrical conductivity.

Forming Type

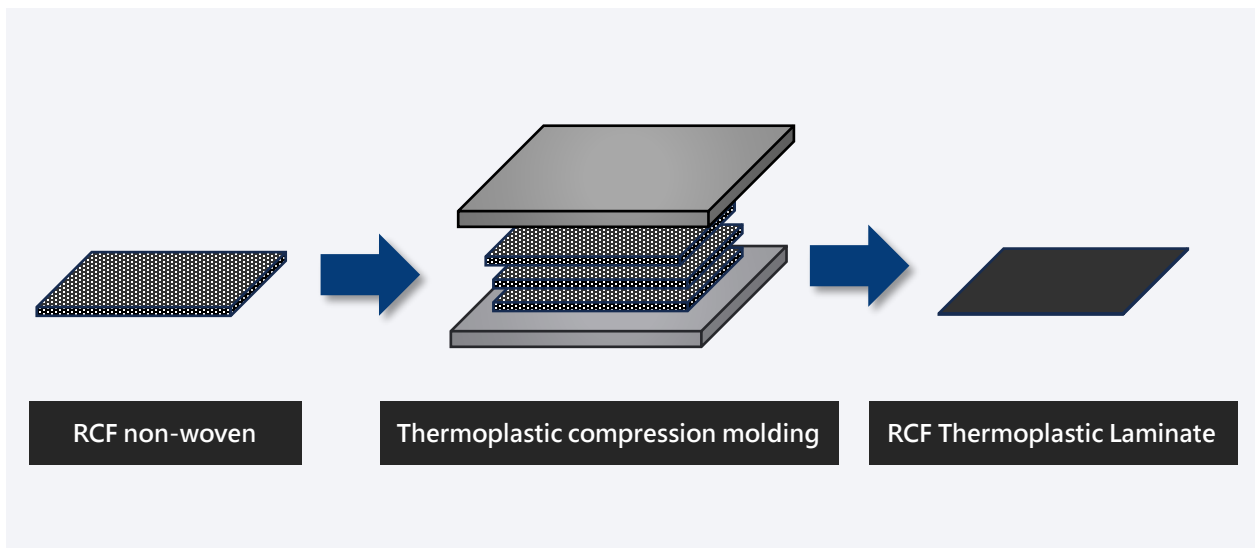


Test item	Unit	Result	
Thermoplastic material		PC	TPU
Stack-up		PC: 8 layers RCF paper: 7 layers	TPU: 9 layers RCF paper: 8 layers
Thickness	mm	1.0	1.0
Flexural modulus	GPa	19.7	10.7
Flexural strength	MPa	283	102
Resistance	Ω	10^3	10^3

* The above results are test values, for references only.

➤ Recycled Carbon Fiber Thermoplastic Laminate

- Applicable for thermoplastic compression molding.
- Made with our certified RCF and thermoplastics **Non-woven** mat.
- Customizable resin-to-RCF ratio and matrices of choice
- Currently offering PA6, PC, TPU, PET, and more matrices.
- High tensile, flexural strength yet light weighted, ideal for consumer electronics, sporting goods, shoes, and other consumer sector applications.



Test item	Unit	Typical value		
Thermoplastic material	-	FRPC	TPU	PA6
Carbon fiber content	%	40%	60%	40%
Areal weight	g/M ²	350	350	350
Stack-up	-	3 layers nonwovens	3 layers nonwovens	3 layers nonwovens
Thickness	mm	1.0	1.0	1.0
Flexural modulus	GPa	18.9	23.3	14.5
Flexural strength	MPa	242	335	281
Resistance	Ω	10 ^{^3}	10 ^{^3}	10 ^{^3}

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➤ Recycled Carbon Fiber Prepreg



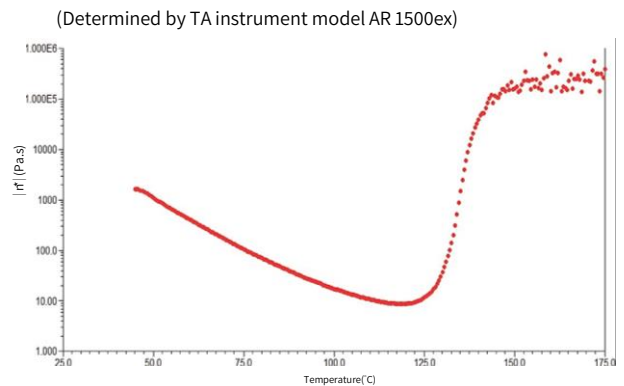
- RCF prepreg is a 130°C~150°C curing epoxy-based prepreg designed for high-performance structural applications.
- This material is a green carbon fiber prepreg material composed of RCF paper/non-woven and thermosetting epoxy resin.
- It is well suited for structural components and applications in sports equipment, electronic products, medical facilities and industrial manufacturing.
- It recommended cure cycle is 3~10°C/min ramp to 150°C and a hold of 30 minutes.

➤ Feature

- Controlled flow
- Good tack
- Toughened
- High surface quality

Curing Temperature (°C)	Curing Time (min)
130	60
140	45
150	30

➤ Melt Viscosity Profile



Test Method	Units	Values	Other Describe
0° Tensile strength (ASTM D3039)	MPa	228	1. Fiber type: Recycled carbon fiber paper 2. FAW = 70 g/m ² 3. RC = 75% 4. All data are normalized to 30% fiber volume.
0° Tensile modulus (ASTM D3039)	GPa	22.8	
0° Flexural strength (ASTM D790)	MPa	382	
0° Flexural modulus (ASTM D790)	GPa	21.4	
ILSS (ISO 14130)	MPa	15	

* This product is developed in cooperation with Advanced International Multitech CO.,LTD.

* The above results are test values, for references only.

Recycled Carbon Fiber Tube



- Composed by RCF paper prepreg
- Can be combined with different customizations of filament winding techniques with virgin carbon fiber to improve its mechanical properties.
- High strength-to-weight and stiffness-to-weight ratio, good fatigue resistance, and low coefficient of thermal expansion (CTE)
- Easing manufacturing process; simplifying the production of complex components; reducing the need for unnecessary design structures

Mass-production capability

- Length: up to 3000mm
- Diameter/thickness: customized
- Surface processing: customized(including polishing, cutting, drilling...)

Test item	Unit	Result
100% RCF tube	Kgf	150
100% RCF tube + Winding (45 degree)	Kgf	210

Test method:
 1.Refer to ASTM D790, and the support span is 200mm.
 2.The outer diameter of the tube is 42mm, the thickness is 2mm.

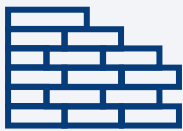
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Recycled Carbon Fiber Board / Aluminum-Foam Composites



- The inner layer of this product is aluminum foam, and the outer layer is carbon fiber laminate, which is combined in a sandwich structure and can bear most of the bending load. Aluminum and carbon fiber materials are all recycled materials.
- Low-density aluminium foam core provides high structural stiffness and other functions, such as high energy absorption capacity, thermal conductivity, and acoustic damping.
- Multiple options for carbon fiber boards, such as thermoset epoxy or thermoplastic composite boards.

Application



Building Materials



Lightweight



Sound Insulation

Test Method	Units	Values	Other Describe
Sound absorption rate	-	0.1-0.8	1. Material type : Recycled Aluminium 2. Density : 0.2 g/ cm ³ 3. Flame resistance grade (CNS14705) : L1 4. Good waterproof effect
Sound insulation	dB	10-30	
EMI (300-1000 MHz)	%	≥ 80	
Compressive strength	MPa	≥ 4	

* This product is developed in cooperation with Metal Industries Research & Development Centre.

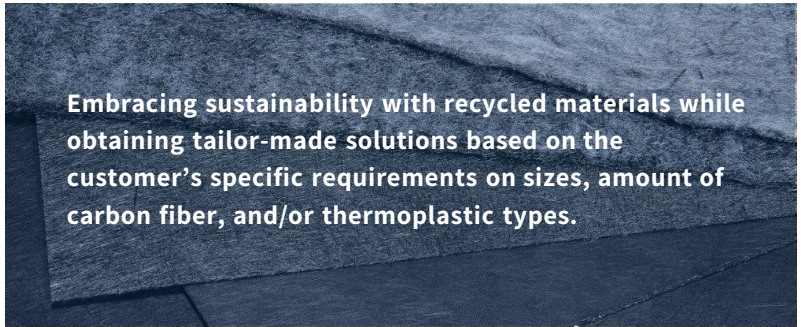
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Our Business Models

Thermolysis provides products and services at every stage of carbon fiber recycling, ranging from renewing CF/CFRP wastes to manufacturing and commercialization of RCF products. Customers can partner with us at any stage of the cycle, including on-site processing together with the client. Currently, we offered the following 3 collaborations models:



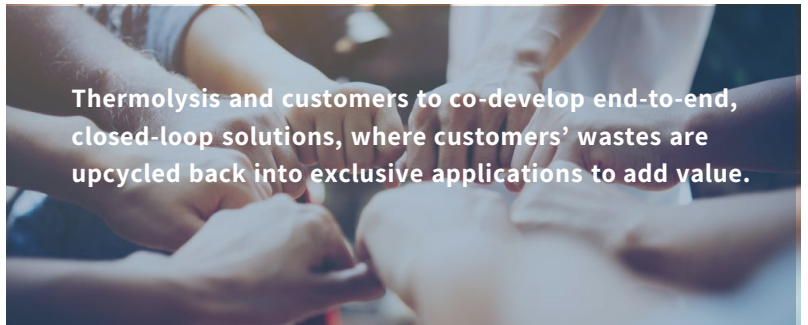
Sourcing Model



Recycling Model



Closed-loop Model





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