CFRP (Isotropic)

The material. Carbon fiber reinforced polymer (CFRP) composites offer greater stiffness and strength than any other type, but they are considerably more expensive than glass fiber reinforced polymer (GFRP). Continuous fibers in a polyester or epoxy matrix give the highest performance. The fibers carry the mechanical loads, while the matrix material transmits loads to the fibers and provides ductility and toughness as well as protecting the fibers from damage caused by handling or the environment. It is the matrix material that limits the service temperature and processing conditions.

Composition

Epoxy+ continuous HS carbon fiber reinforcement (0, + −45, 90), quasi-isotropic lay-up

General properties

Density	1,500	–	1,600	kg/m^3
Price	40.0	–	44.0	USD/kg

Mechanical properties

Young's modulus	69	–	150	GPa
Yield strength (elastic limit)	550	–	1,050	MPa
Tensile strength	550	–	1,050	MPa
Elongation	0.32	–	0.35	%
Hardness—Vickers	10.8	–	21.5	HV
Fatigue strength at 10^7 cycles	150	–	300	MPa
Fracture toughness	6.12	–	20	$MPa \cdot m^{1/2}$

Thermal properties

Maximum service temperature	140	–	220	°C
Thermal conductor or insulator?	Poor insulator			
Thermal conductivity	1.28	–	2.6	$W/m \cdot K$
Specific heat capacity	902	–	1,037	$J/kg \cdot K$
Thermal expansion coefficient	1	–	4	μstrain/°C

Electrical properties

Electrical conductor or insulator?	Poor conductor			
Electrical resistivity	1.65×10^5	–	9.46×10^5	$\mu ohm \cdot cm$

A CFRP bike frame, courtesy TREK

Eco properties: material

Global production, main component	2.8×10^4			metric ton/yr
Embodied energy, primary production	450	–	500	MJ/kg
CO_2 footprint, primary production	33	–	36	kg/kg
Water usage	360	–	1,367	L/kg

Eco properties: processing

Simple composite molding energy	9	–	12.9	MJ/kg
Simple composite molding CO_2	0.77	–	0.89	kg/kg
Advanced composite molding energy	21	–	23	MJ/kg
Advanced composite molding CO_2	1.7	–	1.8	kg/kg

End of life

Recycle fraction in current supply	0	–		%
Heat of combustion	31	–	33	MJ/kg
Combustion CO_2	3.1	–	3.3	kg/kg

Typical uses. Lightweight structural members in aerospace, ground transportation, and sports equipment such as bikes, golf clubs, oars, boats, and racquets; springs; pressure vessels.