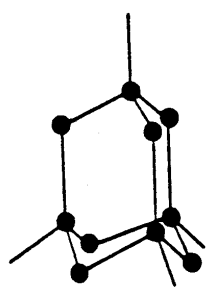
CARBON FIBER ATTRIBUTES

- Moderate Density
- High Modulus ⟩ Different Fibers
- High Strength ⟩ Different Fibers
- Low to Moderate Strain
- Negative CTE
- Anisotropic
- High Cost
- Moderate to High Service Temperature
- Conducting
- Good Chemical Resistance
- Poor Abrasion Resistance
- Inert Surface



Diamond

Figure 1. The symmetrical three-dimensional diamond lattice.

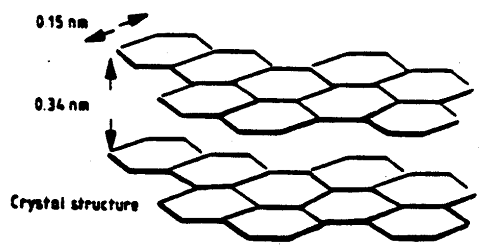


Figure 2. Close-packed sheets of graphite. Tensile strength and stiffness depend on the covalent bonds in the aromatic rings:

Theory (GPa)	Practice (Range of fibres)			
E1 ~1000	680	230	700	250–350
E2 ~35	—	—	—	—
UTS1 ~ 100	20	3.5	2	5–6
%Strain Ult.	~3	~1.5	0.3	~2.0

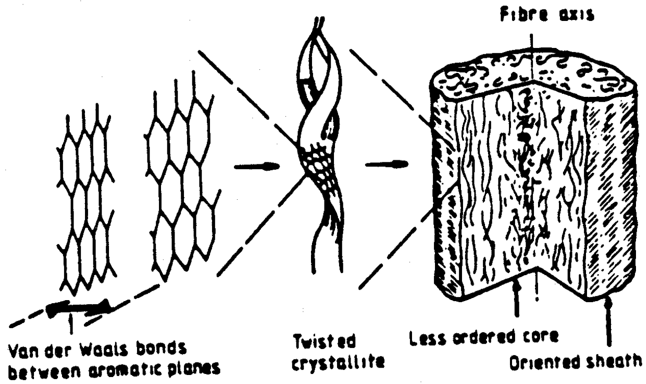


Figure 3. The structure of carbon fibre.

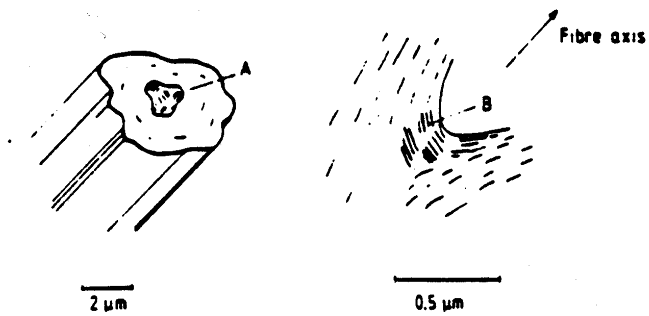


Figure 5. Graphitic plates lining flaws in carbon fibre (from EM micrographs). (Plates at a large angle to the fibre axis at A, B.)

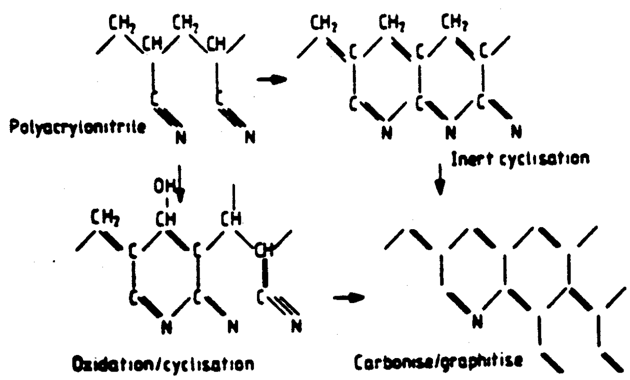


Figure 6. PAN-based carbon fibre.

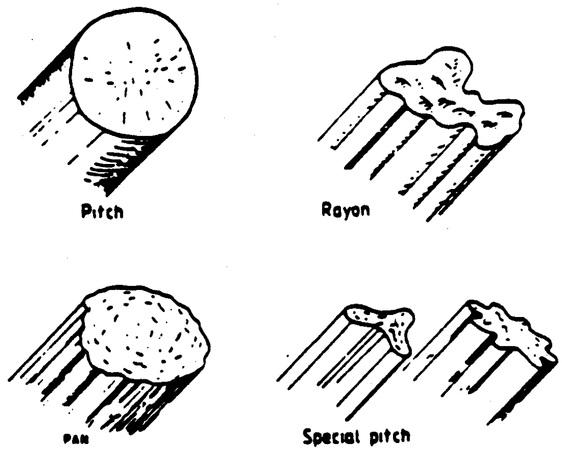


Figure 8. Typical morphology of carbon fibres.

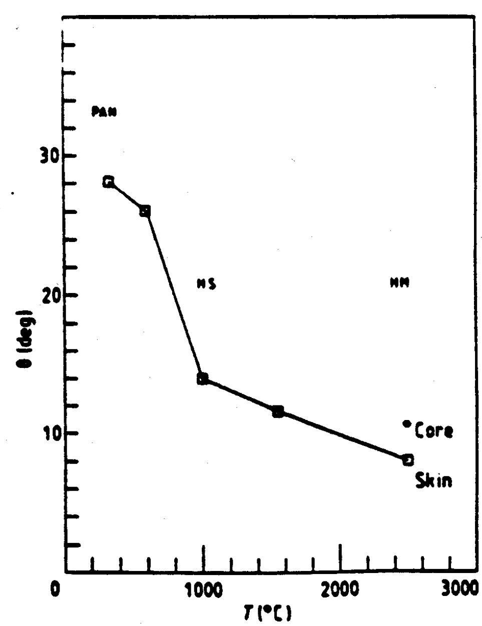


Figure 4. The crystal orientation angle, θ, plotted against the temperature, T.

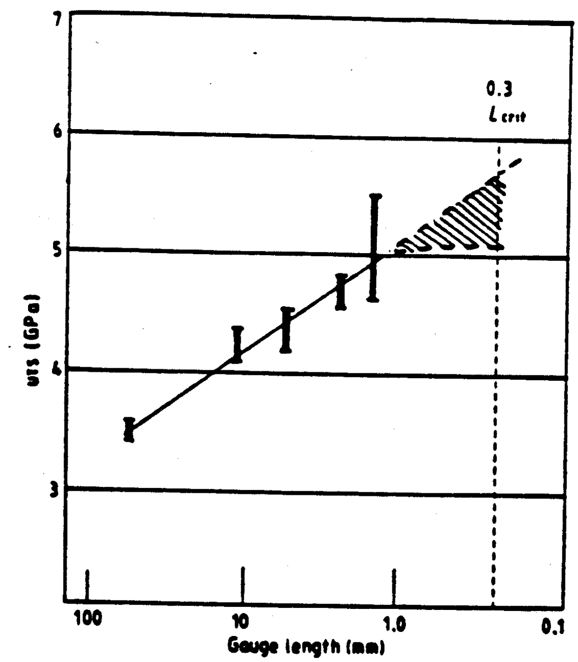


Figure 9. The UTS plotted against the gauge length of single fibres, showing an increase in strength with a decrease in gauge length.

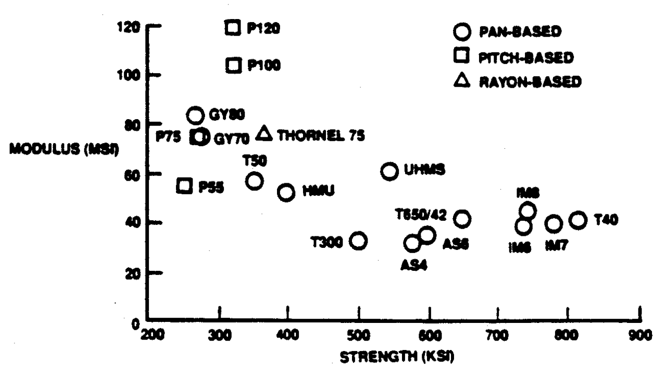


Figure 80: Properties of Available Carbon Fibers

3.4 KEVLAR 49 FIBER ATTRIBUTES

- Moderate Density (S.G. =1.45)
- Moderate Modulus (E = 19 msi)
- High Strength (σ = 525 ksi)
- Moderate Strain (e = 2.8%)
- Negative CTE (-2 µm/m-°C)
- Anisotropic
- Moderate Cost ($20/lb)
- Low Service Temperature
- Insulating
- Good Chemical Resistance (except water)
- Moderate Abrasion Resistance
- Inert Surface (requires activation)

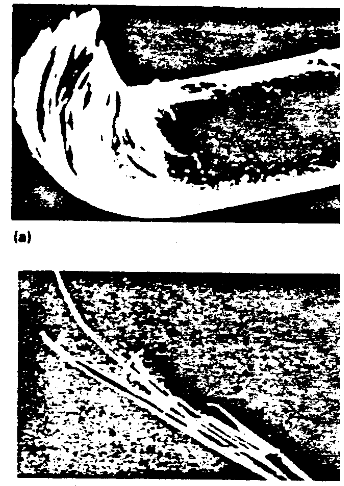


Fig. 4 Fibrillar structure of Kevlar aramid fib (a) Loop break. (b) Tensile failure

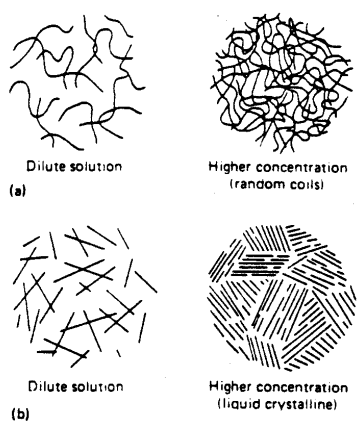


Fig. 2 Polymer states in solution. (a) Flexible molecules. (b) Rigid molecules

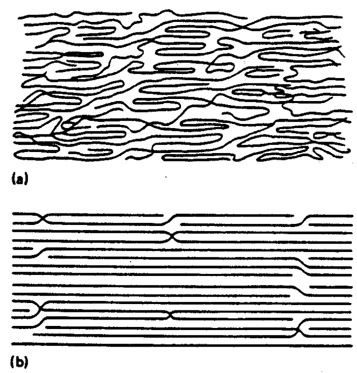


Fig. 3 Polymer chain orientation. (a) Conventional organic, characterized by chain folds, misalignment, and crystalline and amorphous regions. (b) Para-aramid, characterized by long, straigh t chains without folds, parallel to the fiber axis, crystalline

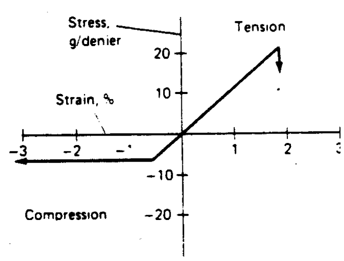


Fig. 9 Para-aramid stress-strain behavior in tensi and compression

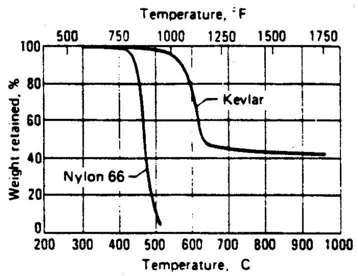


Fig. 11 Thermal stability; thermogravimetric analysis done at 20 °C (70 °F)/min in nitrogen

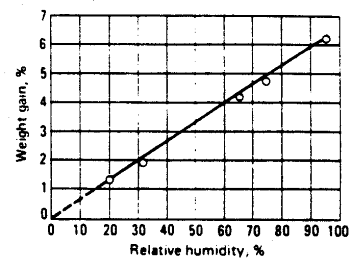


Fig. 13 Equilibrium moisture content versus relative humidity for Kevlar 49 at room temperature

Table 4 Properties of Spectra polyethylene fibers

	Spectra 900	Spectra 1000
Density		
g/cm^3	0.97	0.97
Filament diameter		
μm (μin.)	38 (1500)	27 (1060)
Tensile modulus		
GPa (10^6 psi)	117 (17)	172 (25)
Tensile strength		
GPa (10^6 psi)	2.6 (0.380)	2.9-3.3 (0.430-0.480)
Tensile elongation		
%	3.5	0.7
Available yarn counts		
No. filaments	60-120	60-120

CERAMIC FIBER PROPERTIES

PROPERTY	BORON	SIC	AL2O3
Diameter, microns	140	133	20
Specific Gravity	2.7	3.1	4.0
Tensile Modulus, GPa (msi)	393 (57)	400 (58)	379 (55)
Tensile Strength, GPa (ksi)	3.1 (450)	3.4 (485)	1.9 (275)
Strain to Failure,%	0.8	0.8	0.4
CTE, microns/m/°C	5	1.5	8.3
Poisson's Ratio	0.2		