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HiPerDuCT Programme Grant

Final report: High Performance Ductile Fibres

Single-walled carbon nanotubes (SWCNTs) are envisaged to have superlative mechanical properties. However realising these nanoscale properties on the macroscale level is challenging. One such route is to spin fibres containing SWCNTs from solutions. These SWCNT-based fibres have shown promise in providing a route to strong, tough, low density and ductile materials. Functionalised, orientated nanotubes aligned in the fibre's direction should produce a strain hardening effect under tension. Manipulation of reductive chemistry on SWCNTs to produce individual species further improves stress transfer between neighbouring SWCNTs, improving the macroscopic properties.

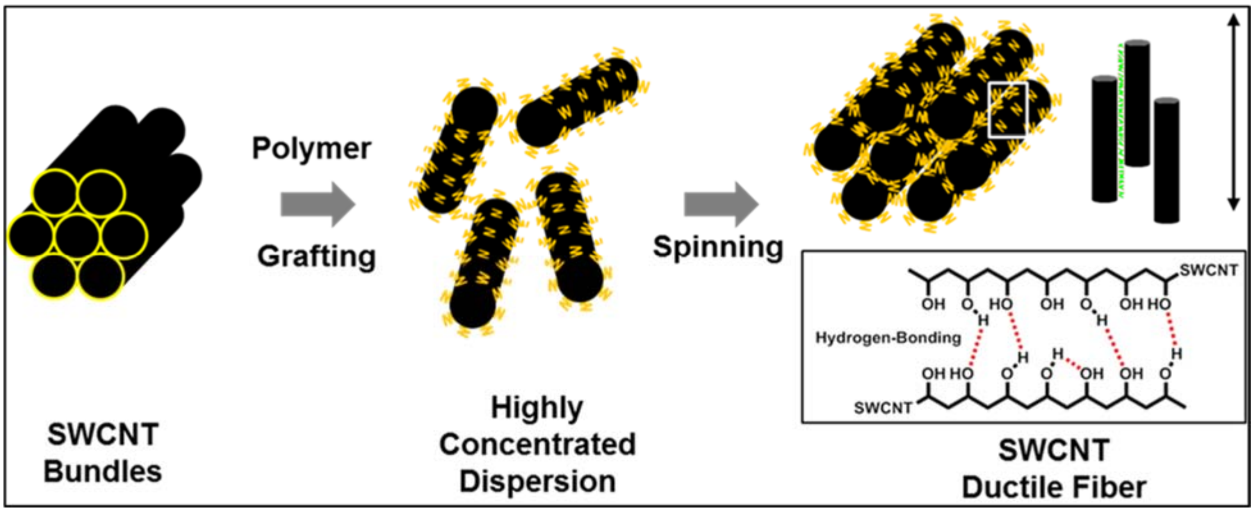

Figure 1. Schematic of the fabrication of Single-walled carbon nanotube (SWCNT) ductile fibres from starting nanotube bundles. SWCNTs are individualised in solution and functionalized before being spun into fibres.

Controlling the nanotube loading tailors the properties of the resulting composite fibre. Fibres with a high loading of SWCNTs (40 wt%) showed a tensile strength of ~1.4 GPa with a strain to failure of 12.7%. Compared to a low SWCNT loading (3 wt%) fibre, a reduced tensile strength of ~0.7 GPa was measured but with a higher strain to failure of 62%. The cyclic tests of both the high strength and high strain fibres demonstrated excellent ductility across the complete range of strains. This bottom-up approach provides a route for producing ductile responses at a fibre level. This development of ductile constituents is required for the realisation of a truly ductile composite.

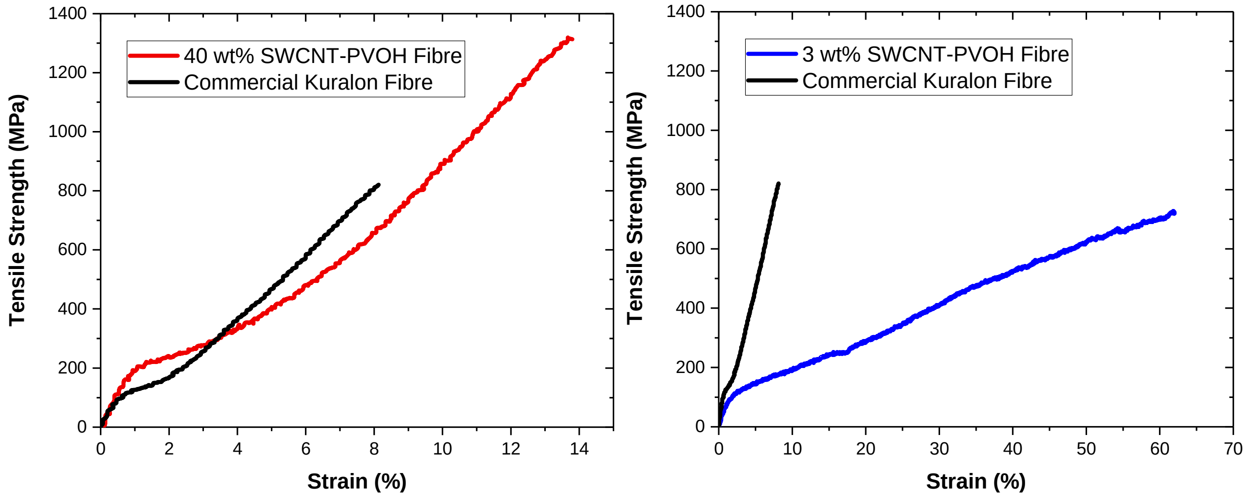

Figure 2. Left: Tensile stress-strain curve for the high strength SWCNT-PVOH based fibre compared to commercially available Kuralon fibre. Right: Tensile stress-strain curve for the high strain SWCNT-PVOH based fibre compared to commercially available Kuralon fibres.

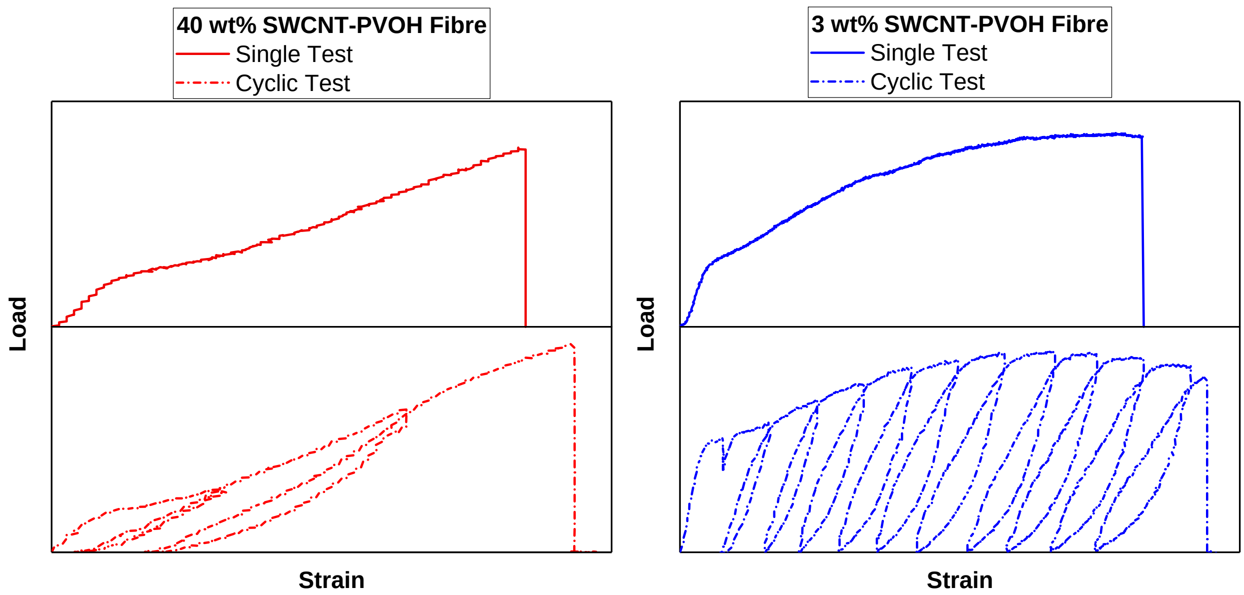

Figure 3. Left: Tensile stress-strain curve for the high strength SWCNT-PVOH based fibre compared to a fibre produced with the same method tested cyclically. Right: Tensile stress-strain curve for the high strain SWCNT-PVOH based fibre compared to another SWCNT-PVOH fibre tested cyclically.

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