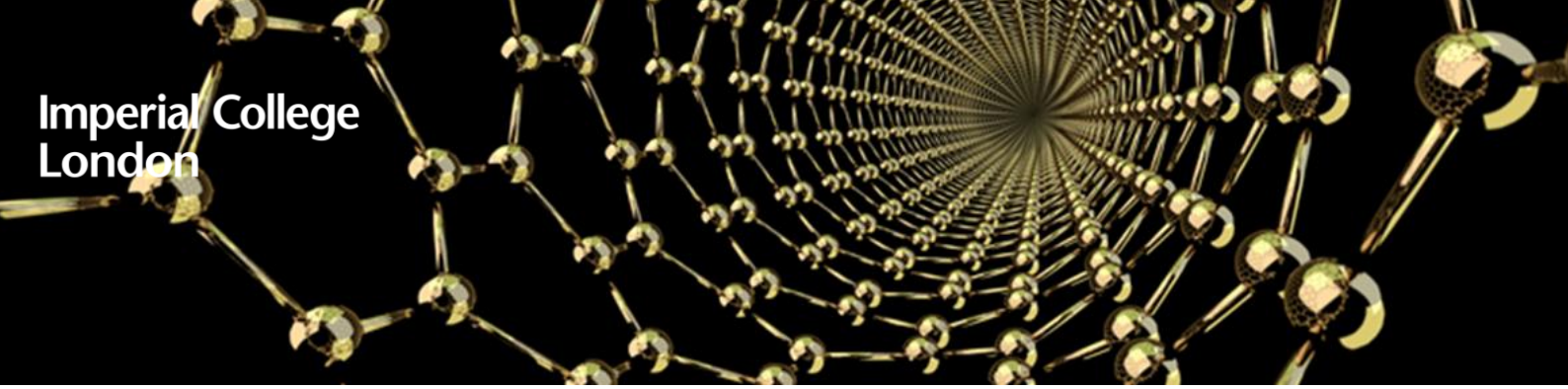

Nanotube-grafted carbon fibres

A novel and patented production method introducing carbon nanotubes (CNTs) to carbon fibre (CF) composites to give enhanced electrical, mechanical and electrical properties.

Proposed use

This novel production method can be applied to an open-ended chemical vapour deposition (CVD) reactor in a continuous fashion and can be easily incorporated into continuous industrial production of carbon nanotube grafted carbon fibres (CNT-g-CF) without causing any damage or requiring a coating. The invention is simple and comparable with existing carbon fibre processing, thus requiring minimal retooling, equipment and capital investment.

Problem addressed

CF composites are state-of-the-art structural materials with excellent tensile properties, but there are critical limiting factors associated with the fibre-matrix interface, such as poor compression performance and poor interlaminar toughness.

CVD use to synthesise CNTs in-situ on primary fibres is simple, economic and has shown promising results. However, on CF the CVD process typically leads to damage of the underlying CF substrate through catalyst pitting, reducing the primary properties of interest. While protective coatings can mitigate this, they create an additional weak interface and limit anticipated benefits.

Technology overview

A modification of the CVD process can produce CNT-g-CF without causing damage or requiring a coating. Applying a potential difference to the catalyst loaded CF tow, such that the growth occurs in an electric field, encourages uniform CNT growth without degrading the primary mechanical properties. The approach can be easily incorporated into continuous industrial production. In addition, the process can be used to graft short (sub 0.3 µm), small diameter CNTs, such that the fibre volume fraction of primary fibres may be retained in the final consolidated composite.

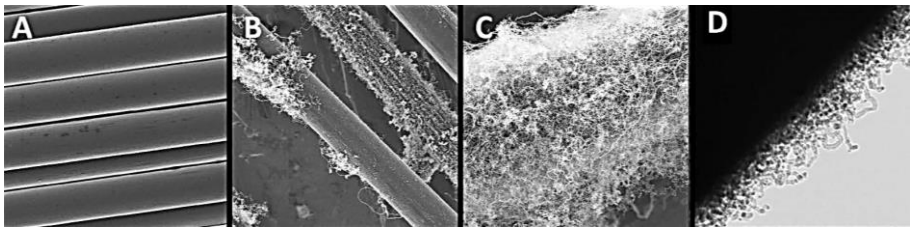

Figure 1 I (A) CF as received from the manufacturer. (B) No potential difference applied to CF - shows damage through catalyst pitting and poor nanotube coverage. (C) Potential difference applied to CF - shows no CF damage, promoted nanotube synthesis and superior coverage. (D) applied potential difference to the carbon fibre in continuous arrangement, showing nanotube coverage.

Benefits

- CNT grafted CFs with superior material properties
- CF tow left undamaged without need for barrier coatings or vacuum processes
- Uniform aligned and densely packed CNT growth within and along the carbon fibre tow
- Uniquely suitable for structural composite applications

Contact:
Dr Fiona Jamieson
Industry Partnerships and Commercialisation Executive,
Faculty of Natural Sciences
Enterprise
Imperial College London
e: f.jamieson@imperial.ac.uk
t: +44 (0)207 594 7596

Technology reference: **6702**

Intellectual property information

Patents: EP3169825A1, US20170198390A1

Inventor information

Professor Milo Shaffer and Dr David Anthony

Links to published papers

Anthony, D. B., Sui, X., Kellersztein, I., De Luca, H. G., White, E. R., Wagner, H. D., ... & Shaffer, M. S. (2018). Continuous carbon nanotube synthesis on charged carbon fibers. *Composites Part A: Applied Science and Manufacturing*, 112, 525-538.

Anthony, D. B., Qian, H., Clancy, A. J., Greenhalgh, E. S., Bismarck, A., & Shaffer, M. S. (2017). Applying a potential difference to minimise damage to carbon fibres during carbon nanotube grafting by chemical vapour deposition. *Nanotechnology*, 28(30), 305602.