Fundamental parameters for direct-spinning of carbon nanotube aerogels

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The most attractive and scalable route to macroscopic assemblies of CNTs is the one-step continuous synthesis and collection of elastic aerogels of CNTs ("direct spinning"). The technique uses floating-catalyst chemical vapour deposition and starts from simple precursors (hydrocarbon, ferrocene, thiophene, carrier gas). Recent deconvolution of the reaction using aerosol sampling techniques has led to new insights regarding the chemistries driving the process such as:

- The majority of the spinnable CNTs are synthesised from pyrolytic carbon species rather than the initial hydrocarbon precursor.
- The spinnable CNT aerogel process is driven by the re-nucleation of catalyst nanoparticles, where sulphur is necessary to create a sufficiently high catalyst nanoparticle concentration at a temperature-appropriate reactor location.

Despite the relative maturity of the field, the dependencies of the interlinked variables affecting the reaction (e.g. input flow rates influencing residence times, reactant concentrations and process chemistry) mean there are a scarcity of results providing quantitative correlations between precursor input rates and product quality or yield. We therefore conducted a meta-analysis, drawing data from across the scientific community, quantifying atomic input rates and correlating these with product outputs, to map the operable parameter space for spinnable CNT aerogels. The input metrics span several orders of magnitude, and the trends revealed by the mapping have allowed elucidation of the key process parameters and relationships between them. The knowledge gained from deconvolution and mapping provides a quantified baseline for future research and will inform further scale up and industrial development.