Utilizing carbon nanotubes as nanoreactors

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Carbon nanotubes (CNTs) - atomically thin cylinders of sp2 hybridized carbon - have high mechanical and chemical stability and are available in different diameters from sub-nanometre to hundreds of nanometres. Due to the hollow nature of CNTs, it is possible to insert a wide variety of atoms and molecules into the internal cavity resulting in the formation of 1D molecular arrays, some of which do not exist outside of carbon nanotubes and thus can be regarded as products of confinement at the nanoscale.[1] The relative chemical inertness of the concave side of the CNTs makes them ideal candidates for use as both reaction vessels, in which the reactants can be combined, and a 1D template for the controlled formation of products which are unfavoured in the bulk phase.[2] Low-voltage, aberration-corrected high-resolution transmission electron microscopy (AC-HRTEM) can be used to visualize these transformations and reactions within the nanotube in real time.[3,4] Encapsulation of the appropriate elemental building blocks, carbon and sulphur, within CNTs results in the formation of sulphur terminated graphene nanoribbons (S-GNRs) in the CNT channel. Such structures represent a new, unexpected hybrid form of carbon, with potentially exciting functional properties.[5] Details of the atomic structure of the novel GNR and the effects of the 1D confinement imposed on the nanoribbon by the CNT have been probed by AC-HRTEM which reveals unusual dynamic behaviour in which the nanoribbon adopts a spiral shape within the CNT. Though the interior surface of carbon nanotubes is known to be chemically inert and typically remains unaffected by reactive species, we have demonstrated that catalytically active atoms of transition metals, when inserted into the internal cavity, can engage the nanotube sidewall in chemical reactions from the inside leading to the formation of nanoprotrusions in the CNT.[6]

[1] D.A. Britz, A.N. Khlobystov, Chem. Soc. Rev. 35 (2006) 637.
[2] D.A. Britz, A.N. Khlobystov, K. Porfyrakis, A. Ardavan, G.A.D. Briggs, Chem. Commun. 1 (2005) 37.
[3] T.W. Chamberlain, N.R. Champness, M. Schroder, A.N. Khlobystov, Chem. Eur. J., 17 (2011) 668.
[4] A. Chuvilin, A.N. Khlobystov, D. Obergfell, M. Haluska, S, Yang, S. Roth, U. Kaiser Ang. Chem. Int. Ed. 49 (2010) 193.
[5] A. Chuvilin, E. Bichoutskaia, M.C. Gimenez-Lopez, T.W. Chamberlain, G.A. Rance, N. Kuganathan, J. Biskupek, U. Kaiser, A.N. Khlobystov, Nature Materials 10 (2011) 687.
[6] T.W. Chamberlain, J.C. Meyer, J. Biskupek, J. Leschner, A. Santana,N. A. Besley, E. Bichoutskaia, U. Kaiser, A.N. Khlobystov, Nature Chemistry 3

(2011) 732.