Manipulating carbon nanotube to carbon nanobulb and carbon tube-in-tube assembly

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We report the manipulating of carbon nanotubes into carbon nanobulbs and carbon tube-in-tube assembly. Carbon nanobulb is realized in a unique tube growth environment generated by explosive decomposition of picric acid. The blown spherical bulbs are characterized by large dimensions (up to 900 nm), thin walls (around 10 nm), and fully hollow cores. A joint action of the filled high-pressure gases and the structural defects in the tubes is responsible to the blowing. The blowing behavior of carbon nanotubes indicates that CNTs exhibit, at least during their generation, excellent thermoplasticity and expansibility, in opposition to the usual opinion that the thermal expansion coefficient of grown CNTs is near zero. This finding also suggests that it is possible to engineer tubular structures on nano-scale into various shaped devices by adjusting and controlling reaction environments.

For the synthesis of carbon tube-in-tube assembly, the initial CNTs were oxidized in nitric acid and subsequently refluxed in tedrahydrofuran with sulfuric acid and different organic additives such as oxalic acid and adipic acid[1]. As a result of this treatment, a new carbon nanotube grew along the initial CNT. This result can be easily explained if we consider that the small overtop layer of amorphous carbon in the initial CNTs was exfoliated into graphene nano-sheets and subsequently aggregated around the initial CNTs. The organic additives reacted with the different nano-sheets acting as bridge between them. The morphology and microstructure of the new carbon material can be modulated by using different organic additives. For instance, the use of short C-chain molecules, such as oxalic acid, leaded to the formation of a new tube which is parallel to the initial tube. On the other hand, using long C-chain molecules, such as adipic acid, the flexibility of the new wall increase and different shapes were observed. It should be pointed out that the new nano materials are synthesised without metal catalyst in mild and controllable conditions. The observed tube-in-tube structure could increase the BET surface area, making these materials attractive as catalysts support or for H_2 storage[2]. Moreover, the microstructure and surface properties of these novel nanocarbons can be easily controlled by the addition of different organic compounds, opening new and amazing possibilities for catalyst design and funcionalization.