infertility research, which is a multi-crore business/industry, may be a good way of attaining self-sufficiency in this industry.

In vitro fertilization techniques are mainly offered by the private sector, which is very heavily dependent on imported drugs, equipment and devices including disposable plasticware used in *in vitro* culture. Consequently, the cost of IVF is extremely high in India and unaffordable to many. Research into aspects of human reproduction is almost non-existent in the private sector and there is hardly any scientific paper that emerges from Indian laboratories or clinics practising IVF. In the symposium, collaboration between the private and pubic sector funding agencies was stressed. Examples were given of the programmes available under the Department of Scientific and Industrial Research such as the Program Aimed at Technological Self-Reliance (PATSER) and Co-operative Research Associations that enable the establishment of research centres as a collaborative effort between the private sector and Government funding agencies. This aspect was appreciated by the participants who endorsed the view that similar collaborations must be established between private IVF clinics and even the ICMR to address issues that are of common interest and are aimed at improving patient care and more importantly, providing indigenous substitutes for imported equipment, supplies and drugs.

T. C. Anand Kumar, Hope Infertility Clinic, Bangalore 560 042, India
e-mail: anand_kumar@vsnl.com

RESEARCH NEWS

An elegant synthesis of multi-walled carbon nanotubes

C. Srinivasan

Since the exciting discovery of multi-walled carbon nanotubes (MWNTs) by Iijima[1] in 1991 and subsequent production of single-walled carbon nanotubes[2,3] (SWNTs), research studies in carbon nanotubes (CNTs) have acquired the important status of one of the most active fields of nanoscience and nanotechnology. Several CNT characteristics like the mechanical properties, viz. Young's modulus and tensile strength, field emission, possible storage of hydrogen in CNTs and others will have potential applications[4,5]. There are several reports on the use of these nanotubes in catalysis[6]. The electron emission characteristics of CNTs have motivated a Korean company to develop a flat-panel display for television and computer monitors. The switching times in devices fabricated from field-effect transistors with CNTs have been estimated to be very fast, allowing clock speeds of a terahertz, which is four times faster than the present processors[4]. The recent observation of Ghosh *et al.*[7] that the flow of a liquid in SWNT bundles induces voltage in the sample along the direction of flow, points out the device potential for CNTs as sensitive flow-sensors.

Several methods are now available for the production of CNTs[4,5,8–10] and each method has its strength and weakness. The preparation techniques include arc-discharge, laser ablation, catalytic decomposition of hydrocarbons and electrolysis methods. The isolation protocol of CNTs requires a complex purification process to remove nanoparticles of catalyst and carbon and graphite pieces with considerable loss of CNTs, and these result in an escalation of production cost. In spite of the availability of a variety of methods for the production of CNTs, the cost of

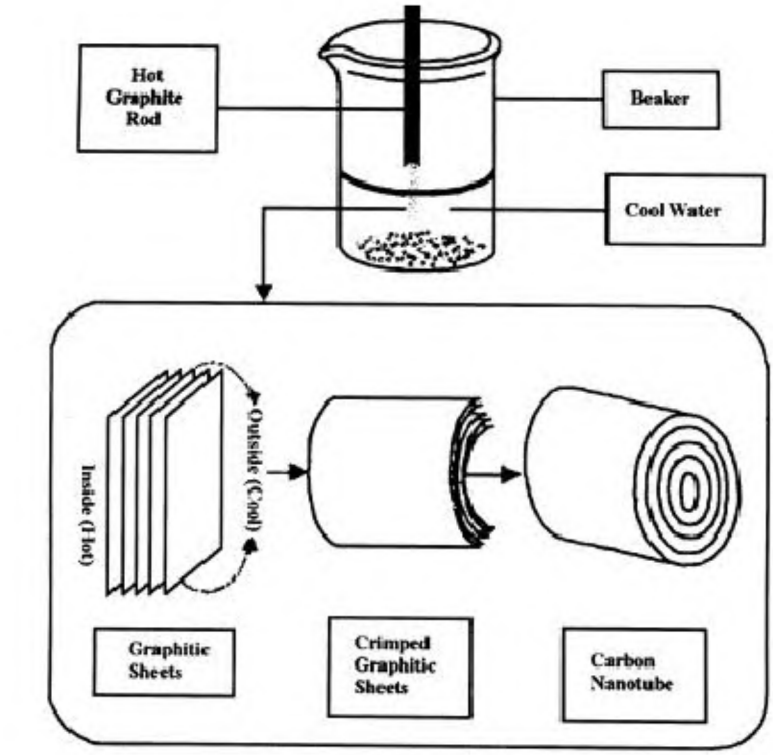

Figure 1. Scheme for the formation of MWNTs from graphite rods (reproduced from ref. 11 with permission from Zhenhui Kang and Enbo Wang).

nanotubes is high and the current challenge is the search for a low-cost industrial method of preparation of these nanotubes. Recently, Kang *et al.*[11] have reported a one-step water-assisted synthesis of high-quality CNTs directly from graphite. For the transformation of graphite into pristine CNTs, two things are essential: (i) to get necessary power that can make the graphite sheets crimp and (ii) to wrap the honeycomb pattern back on top of itself and let the edges join by the C–C σ-bonds.

Kang *et al.*[11] employed a water-assisted method that realizes the above two processes. Graphite rods were rapidly heated to red-hot (above 800°C) in air and then dipped into cold water (0°C). The water turned a little turbid after a slight explosion. The process was repeated several times and MWNTs formed were separated. From TEM measurements, the yield was found to be > 40%. On immersing the hot graphite rod into cold water the temperature of the graphite surface was lowered, but the internal temperature was still very high that provided enough power for the graphite sheets to crimp (Figure 1). Though it is well known that many complex chemical reactions occur between red-hot carbon and water, the detailed mechanism for the formation of CNTs in such conditions is yet to be understood. However, it seems that water plays an important role in the connection of the edges[11].

Recently, a chemical route to carbon nanoscrolls (with two free edges, one inside and the other outside the tube) has been reported[12]. In this method graphite was intercalated with potassium and exfoliated with ethanol. Upon sonication, the exfoliated graphite sheets curled onto themselves, forming nanoscrolls. That the product obtained by the one-step water-assisted process[11] was MWNTs and not the simple carbon nanoscrolls was established from the following observations: (i) TEM image shows that the wall-to-wall distance is uniform, 0.34 nm, which is akin to the 002 distance of graphitic carbon; (ii) the electron diffraction patterns of the products are single crystalline, which is not possible with a scroll; (iii) the Raman spectral bands resemble those reported for nanotubes with concentric multi-wall layers of hexagonal carbon lattice.

The study by Kang *et al.*[11] reveals that graphite can be transformed into pure and high-quality pristine CNTs using a one-step treatment, with the assistance of water at atmospheric pressure without any catalyst.

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C. Srinivasan is in the Department of Materials Science, Madurai Kamraj University, Madurai 625 021, India.
e-mail: ceesri@yahoo.com

Methane fuse for Cambrian mass evolution, volcanism for mass extinction: Proponents review their hypotheses

A. V. Sankaran

Life began on earth, close to 4 billion years (b.y.) ago, but its progress to higher forms was haltingly slow to begin with, and suddenly at the end of the Proterozoic period, about 550 million years ago, there was a burst in its progress. Complex multicellular forms began to evolve at a rate some 20 times the rate observed in the younger Mesozoic period, triggering a veritable 'evolutionary big bang' or the 'Cambrian explosion of life'. The march of life thereafter was not unimpeded either for it periodically experienced extinction *en masse*. Explanations, so far, for these phenomena were not entirely convincing, but now, in the wake of accumulating new data, two papers published recently have underscored the role of sudden and voluminous bursts of methane for the Cambrian evolution[1] and the periodic flood basalt volcanism in earth's history for repeated global extinction of life[2].

In 1997, Kirschvink, along with Ripperdan and Evans[3], had claimed that a unique event, known as the True Polar Wander (TPW) (see Box 1) involving change in direction of earth's spin axis, relative to the continents, occurred intermittently during Vendian–Cambrian period and this promoted development of congenial scenarios for rapid expansion of life. They explained how the balance of mass within the earth was disturbed due to the TPW and how all continents remaining stable till then were forced to shift to different latitudes. These TPW shifts, unlike those that occurred in later geologic times, were unique in earth's history, as they had resulted from interchange events in earth's moment of inertia tensor termed – Inertia Interchange True Polar Wander or IITPW (see Box 1). The authors suppose that at least half of Earth's continental lithosphere rotated by nearly 90° between 534 and 505 m.y. ago. Their movements were rapid (≥ 30 cm/yr), far exceeding tectonic motions of a few cen-