The Telegraph
calcutta, india

Today's Edition | Monday, December 25, 2006 |

IN TODAY'S PAPER
Front Page
Nation
Calcutta
Bengal
Opinion
International
Business Stocks Live
Sports Cricket Live
At Leisure
Sudoku
Crossword New!
Jumble New!
Gallery
Horse Racing

WEEKLY FEATURES
Knowhow
Jobs
Telekids
Careergraph
Etc
ProperTT
Weekend
Look
Insight

CITY NEWSLINES
Choose Region

FEEDS
RSS
My Yahoo!

SEARCH
Archives Web
Google Search

ARCHIVES
Since 1st March, 1999

THE TELEGRAPH
- About Us
- Advertise
- Feedback
- Contact Us

Front Page > KnowHOW > Story

email this page Print this page

Tapping into carbon's wonders

Pulickel Madhavapanicker Ajayan is one of the pioneers in carbon nanotubes, but it's poetry that gives him a high. **T.V. Jayan** talks to the romantic scientist

Pulickel Madhavapanicker Ajayan wanted to be a film director like his idols Satyajit Ray, Yasujiro Ozu and Werner Herzog, when he was young, and was hooked to history in school. He confesses the works of Pablo Neruda, Khalil Gibran and Yasunari Kawabata still give him a "high".

Destiny, however, landed him in a world far away from romanticism — a world governed by hard facts and reason. But, Ajayan, born to a telephone technician father and a schoolteacher mother in Kerala, has no complains. He has done exceedingly well in science, which he has discovered was also "a romantic and a mature thing to do".

Ajayan graduated in metallurgy from the Institute of Technology at Banaras Hindu University in 1985, and is currently the Henry Burlage professor of materials science and engineering at Rensselaer Polytechnic Institute (RPI) in Troy, New York. His 200-odd papers, the majority of them in high-impact research journals, have been cited more than 10,000 times by scientists working elsewhere. The laurels that came his way were numerous, the latest from science magazine *Scientific American*. The magazine early this month recognised him as one of the 50 scientists who have shown outstanding acts of leadership in science and technology.

An assembly of carbon nanotubes seen under a microscope (top), a carbon forest, and (below) Pulickel Madhavapanicker Ajayan

Today, Ajayan's life revolves around carbon. He manipulates carbon atoms to make the tiniest of carbon structures that exhibit several unique properties, which are hidden in the element's natural forms. Called carbon nanotubes, they are cylindrical-shaped materials whose diameter is nearly 50,000 times smaller than a human hair.

Discovered by researchers led by Sumio Iijima at the Japanese company NEC in 1991, carbon nanotubes resemble rolled up sheets of chicken wire and offer an impressive combination of high strength and low weight. Besides, they exhibit unique electrical properties and efficient heat conductivity. "I don't think we have ever come across a material with such a wide range of possibilities," he says of carbon nanotubes. He was initiated into research on these carbon nanostructures by none other than its discoverer himself. Ajayan happened to be present at Iijima's lab at the time of this exciting discovery and spent two years filling these tiny hollow tubes with materials and studying their properties.

Incidentally, some scientists believe that the discovery of carbon nanotubes was first made by a team of Russian scientists about 40 years ago, but this feat did

not catch the attention of 'western' scientists as it was published in a Russian journal. Regardless of the controversy, the NEC scientists' work published in the journal *Nature* in 1991 opened the floodgates to worldwide research on carbon nanotubes.

Research endeavours in carbon nanotubes are already showing signs of huge pay-offs. A long line of nanotube-based materials and devices are already in the pipeline.

Several of them will come from Ajayan's lab. These materials have a multiplicity of applications ranging from aircraft manufacture to medicine, from electronics to water purification. Ajayan, however, adds, "Applications that have resulted from nanotechnology are still far and few. I believe it has all the potential to become one of the most successful technologies of the future, but right now many of the ideas are in the developmental stages."

Ajayan's lab has been a beehive that attracts young minds interested in nanotechnology, particularly involving carbon nanotubes. Under Ajayan's stewardship, these young researchers, many of them from India, play a significant role in pushing the frontiers of this cutting edge technology further. Ajayan also works with a wide range of scholars from other parts of the world: from China to Mexico. These strong partnerships have resulted in several innovative devices and materials. They include multifunctional nanobrushes made of carbon nanotubes that can not just sweep away tiny particles and dust from the smallest of electronic chips but also clean up unwanted deposits in arteries, and artificial gecko feet which uses with 200 times the sticking power of an agile gecko.

His team's work has also showed that films of multi-walled carbon nanotubes can act like a layer of mattress springs, flexing and rebounding in response to a force. Unlike a mattress, which can sag and lose its springiness, these nanotube foams maintain their resilience even after thousands of compression cycles. Such assemblies can be used for myriad applications: from coffee cups to space shuttles. Similarly, in collaboration with researchers from his alma mater Banaras Hindu University, Ajayan devised a method to produce carbon nanotube filters that can efficiently remove micro- to nano-scale contaminants from water and heavy hydrocarbons from petroleum.

Analysing the state of science in India today, Ajayan observes, "Science in India has suffered from a long period of neglect. And unfortunately, Indian science today cannot boast of great scientists of the likes of Raman and Bose. India has incredible talent, but it hasn't been utilised properly." He, however, quickly adds that this trend is slowly changing. "I suppose the romantic period in science that appeals to the general populace has to be brought back."

Twenty years of expatriate life haven't changed Ajayan at all. "I was born in Kodungallur in central Kerala and grew up in a middle class environment. I foster beautiful memories of the landscape composed of backwaters and a culture that was so wrapped around the temples and festivities," he says. Despite long years of research, Ajayan did not allow his artistic bent of mind to die. He writes poetry occasionally, but admits that he has little free time for literary pursuits these days.

Along Pavilions laden with sun
glittering stones, unassumingly talk
of flattened tyres and lifestyles;
On the scorched earth that emits
absorbed sunrays
men and women walk with bare feet, exposing
burnt skins and moral dilemmas;
Arguments torn with egos and blood
stain the ambience, scandalising
pure intentions;
Gods perish in untimely thoughts
and take refuge in far away temples;
Dust carrying particles of imagination
rise and circle and deposit stains on
innocent faces;
Shops filled with spices and incense
attract insects which fly around and chant

primordial sounds;
Milling crowds absorb sounds and sweat
and parade in conformal rhythms;
Smell of ripened fruits and decayed vegetables
mingle with cherished hopes and dreams;
The drone of bicycle bells and autos
and the groans from holy cows, penetrate
the little brains;
From them, faint signals arise
carrying the burden of life, and travel far
into the galaxy and the milky way

— From the poem Bazar, composed by Ajayan


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