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INTERVIEWS


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Angel Rubio Secades

XVI DuPont Prize for Science

"Nanotubes could be one of the components of all this technological revolution"

Angel Rubio Secades, Professor of Materials Physics at the Chemistry Faculty of the University of the Basque Country (UPV-EHU) and researcher at the CSIC-UPV mixed centre, was awarded the XVI DuPont Prize for Science for his notable contributions in the field of nanotubes.

You have been awarded the XVI DuPont Prize for Science for your notable contributions in the field of nanotubes. But, what is it, in fact, that you are investigating?

It has two aspects. On the one hand, it is to explain and analyse the properties of carbon nanotubes in different environments and for various technological applications. Our work has been undertaken in collaboration both with experimental groups and with groups that use these materials, putting forward different schemes for combining nanotubes with other materials in such a way that new, nano-structured materials are created for applications in mechanical and in optical devices and in communications. Our contribution has involved the modelling and the prediction of properties of materials and the defining of a number of ways for experimental work. Of course, none of this would have ben possible if it had not been for contributions from foreign groups, both European and American – and with which we closely collaborate.

The second aspect is, twelve years ago we had already predicted the existence of other, inorganic or non carbon-based nanotubes, based on boron nitride. We realised that there was a general law for the formation of nanotubes and so what we did was to extend the family of tubular structures that exist at a nanometric scale to almost all inorganic compounds that form laminar structures. In principle, any laminar system can form nanotubes. For example we are currently exploring the existence of nanotubes formed by high-temperature superconductor materials.

In particular the award was for the prediction, and for the generality thereof, given that these boron nitride nanotubes can be applied to other systems and, moreover, may be combined with each other.

Before going further, what exactly are nanotubes?

Nanotubes are tubular structures the diameter of which is in the order of nanometres. There are nanotubes of many materials, such as carbon or boron nitride.

Carbon nanotubes are made of the element carbon in the form of diamond, graphite or fullerenes. They may be perceived as laminas of graphite wrapped around each other. If you take a lamina of graphite and roll it up, it forms a cylinder – this is s carbon nanotube; rolled up graphite. Depending how the lamina of graphite is rolled up, the resulting can be either metallic or a semiconductor.

Another way of understanding it is to see a human hair as a cylinder that has a diameter of a micra. A nanotube is exactly this, but about a thousand times smaller.

Generally, the term refers to carbon nanotubes. Why is this?

Carbon nanotubes were synthesised at the beginning of the 90s, many research teams having been involved in this field. First because its synthesis is simpler and second because is a very abundant material. Thirdly, it is very light. This last property is also one that boron nitride possesses.

Carbon ones may be either metallic or semiconductor, while boron nitride ones are insulators, given that this compound is an excellent insulator, very light and hard.

Boron nitride nanotubes have a main advantage: they can emit light in the ultraviolet spectrum. Ultraviolet emission is important because, instead of obtaining optical storage devices with red light, it can be obtained with blue, a light with a higher frequency and shorter wavelength; thus having greater capacity for storage of information.

There are many other inorganic nanotubes; to mention one, molybdenum sulphide nanotubes are generally used as lubricants.

So, they have special properties.

As regards properties for technological applications, nanotubes are hard, flexible and light materials which can be used as insulators, semiconductors or with highly useful electron conduction. Moreover, they possess high thermal conductivity derived from their graphite thermal conduction properties. This last property means that if nanotubes are in a device and this undergoes heating, the tubes are capable of extracting this heat energy. Thus, they are useful for maintaining computers at a normal temperature, one of the problems of this device being overheating.

There are properties of a fundamental character that enable the undertaking of studies – previously not possible – on phenomena involving the interaction of many bodies and the effects of electronic confinement.

But without doubt, it is the electronic properties that currently give rise to much more intense interest; we can say that this is what the future is. So, having the components (transistors, diodes, connectors, and so on.) at this scale is required. The tube could be the ideal conductor. Moreover, the semiconductor tube doped with itself functions as an electronic transistor. How to make it compatible with current, silicon-structured conductors is the task ahead. Molecular electronics is the future, because it opens doors to devices that are faster, more efficient, lighter and that consume less.

Research work in the field of nanotechnology is quite recent, but undoubtedly it has many applications. Is that right?

At the street level today, nanotubes and even nanotechnology in general are found, e.g. in reinforced materials in the construction sector, in applications in electron emitters for flat screens, etc. All this, clearly, at a very low scale.

At a research level there are many more applications. In the medical field, tests are being carried out for the treatment of certain skin cancers with functionalised nanotubes. The nanotube itself is toxic. Thus, if it is placed beside a cell, this will die. What is involved is to functionalise it in such a way that it adheres to the cells targeted and it selectively kills these. With these biomedical developments one has to be very cautious in how nanotechnology will affect medicine.

It would seem that there are a thousand and one applications and nanotubes have a great future. Is this right?

For the future, basically, the target is to obtain an improvement in data storage systems and transmission speeds and in capacity for calculation and processing.

Nanotubes could be one of the components of all this technological revolution. Whether it will be the fundamental component or not, I have my doubts.

The fundamental point is that it is perfect and ideal for carrying out basic investigations; it enables us to access properties that we otherwise would not have known. Once we have these properties under control, we can design structures on a larger scale; currently laboratory-scale work is being carried out at a scale of only one, two or three nanotubes. What is looked to is to have millions of them working together. This is the challenge, a challenge which has two aspects: their synthesis or how to generate them (not manually as at present) and then there is the aspect of information management.

The concept of toxicity has been mentioned. What is your view on the ethical debate that has arisen in society regarding the dangers of nanotechnology in general?

I believe it is good that there is a debate but it should not be carried out with preconceived ideas. I think that a little freedom and benefit of the doubt should be given to the scientific community. I do not believe that scientists have a tendency to make advances with their eyes closed, without checking if there is a risk of toxicity or not.

I will give you an example. With the discovery of X-rays from Marie Curie's radioactive materials, being exposed to a lot of toxic radioactivity killed her. She was able to make advances without being aware of the toxicity involved – if they had known about it, perhaps the advances would not have occurred.

So we can say that there is always a process of adaptation from the moment you discover something or you believe you can make progress. Once discovered, you have to weigh up the pros and cons. All this takes time. I do not believe it is a good thing to think that everything that is nano is dangerous. Or the other extreme. Scientists have to be left to make progress and put forward ideas and applications, discover new systems, properties and function; in short, to make advances in our knowledge of the world at a nanoscopic level. Subsequently, it can be evaluated which advances have medical applications, which can be used in alternative energies and which for extraordinary-performance materials we can use directly in everyday life or not. We should not take things out of their context.

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