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Introduction to Carbon Nanotubes: Properties and Applications

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Commentary

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DESCRIPTION

Carbon tubes with diameters commonly measured in nanometers are known as carbon nanotubes. One type of carbon allotrope, single-wall carbon nanotubes have diameters around one nanometer and fall somewhere between fullerene cages and flat graphene. Single-wall carbon nanotubes can be envisioned as cuttings from a two-dimensional hexagonal lattice of carbon atoms that have been rolled up along one of the Bravais lattice vectors to form a hollow cylinder, even though they are not really manufactured in this way. A helical lattice of flawlessly connected carbon atoms is produced on the cylinder surface in this construction by imposition of periodic boundary constraints throughout the length of this roll-up vector. Vander Waals interactions weakly bind single-wall carbon nanotubes together into multi-wall carbon nanotubes, which have the appearance of tree rings.

These tubes are very similar, if not identical, to the long straight and parallel carbon layers cylindrically stacked around a hollow tube proposed by Oberlin, Endo, and Koyama. Double- and triple-wall carbon nanotubes are also sometimes referred to as multi-wall carbon nanotubes. Tubes with an unknown carbon wall structure and sizes under 100 nanometers are also referred to as carbon nanotubes. Although it is frequently unreported, the length of a carbon nanotube created by standard production techniques is typically substantially more than its diameter.

As a result, end effects are frequently disregarded and the length of carbon nanotubes is thought to be unlimited. It is demonstrated that all of the indefinitely long single-wall carbon nanotubes produced by rolling up a hexagonal lattice in various orientations have nontrivial rotational symmetry about the tube's axis in addition to helical symmetry. Furthermore, the majority are chiral, making it impossible to superimpose the tube and its mirror copy. Additionally, single-wall carbon nanotubes can be identified with this technique by a pair of numbers. In the study of nanotubes, a zigzag path is described as a path that steps through each bond and then turns 60 degrees, alternating left and right. A common definition of an armchair path is one that takes four steps and then makes two left turns that are 60 degrees apart, followed by two right turns. On some carbon nanotubes, the tube is encircled by a closed zigzag route. One claims that the tube is a zigzag nanotube or that it is of a zigzag sort or configuration. The term "armchair type" or "armchair nanotube" is used to describe a tube that is surrounded by a closed armchair route. A single-walled nanotube can have more types of structures than just the zigzag and armchair shapes. The structure of a general infinitely long tube can be

described by picturing it being split open along its axis by a cut that passes through some atom A, and then being unrolled flat on the plane so that its atoms and bonds match those of an imagined sheet of graphene—more specifically, with an infinitely long strip of that sheet. Over two graphene atoms A1 and A2 on the strip's opposite sides will be the two halves of the atom A. Concentric tubes of graphene are the numerous wrapped layers that make up multi-walled nanotubes (MWNTs). The architectures of multi-walled nanotubes can be modelled using one of two different approaches. In the Parchment model, a single graphite sheet is rolled inward and over itself to resemble a scroll of parchment or a rolled piece of newspaper. The interlayer distance in multi-walled nanotubes. Recently, a number of studies have emphasised the potential for creating three-dimensional macroscopic all-carbon devices employing carbon nanotubes as building blocks. In order to create macroscopic, free-standing, porous, all-carbon scaffolds. These scaffolds have pores that are macro, micro, and nanostructured, and the porosity can be adjusted for different uses. The next generation of energy storage, supercapacitors, field emission transistors, high-performance catalysis, photovoltaics, and biomedical devices, implants, and sensors may be made using these 3D all-carbon scaffolds and architectures. Doping in carbon nanotubes is different from that of bulk crystalline semiconductors from the same group of the periodic table because the -electron system plays a crucial role in shaping the electronic characteristics of graphene. When boron or nitrogen are used as graphitic dopants to replace carbon atoms in the nanotube wall, the resulting behaviour is p-type or n-type, as would be predicted in silicon. Alkali metals and electron-rich metallocenes are examples of non-substitutional (intercalated or adsorbed) dopants that can generate n-type conduction because they donate electrons to the nanotube's -electron system. In contrast, -electron acceptors that pull -electrons down from the top of the valence band, such $FeCl_3$ or electron-deficient metallocenes, act as p-type dopants.