Carbon Nanotubes: An Overview

In recent years there has been much research into the development and advancement of carbon nanotubes. From microwires to hydrogen storage units, carbon nanotubes have a wealth of potential applications in our world

Structure and Chemistry

Carbon nanotubes are in the structural family of fullerene. They are molecules composed entirely of carbon atoms. The carbon atoms are usually arranged in a hexagonal pattern, bonded together with extremely strong covalent bonds. A carbon nanotube can be visualized as a finite number of carbon graphite shells arranged around a hollow center axis with a constant spacing of around 0.34 nm, a tubular diameter normally ranging from 2-25 nm, and with lengths up to several microns. This number of graphite shells is the basis for the major division in carbon nanotubes: single walled nanotubes (SWNT) and multi walled nanotubes (MWNT). The concept of either single walled or multi-walled carbon nanotubes is important because the properties change significantly with respect to each other.

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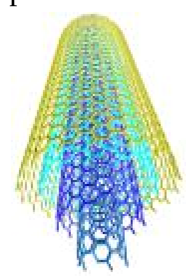

Figure 1

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Physical Properties

Electronic Properties: Much research has been invested into determining how well electrons flow through carbon nanotubes. As it turns out, many of the results were inconsistent. In most cases, multi-shelled nanotubes have individually different properties, even when made from the same laboratory. Uncontrollable inconsistencies between each individual nanotubes make it difficult to develop a consistent theory of electric flow. In general, the flow of electrons is affected greatly by the amount of defects and debris in each carbon nanotube. These defects are not fully understood, but need to be studied and eliminated to ensure maximum effectiveness for nanotube conductance.

Material Properties: The material properties are where carbon nanotubes show their strengths. From a mechanical viewpoint, most defects can be neglected, allowing us to view each nanotube as an ideal carbon fiber. The covalent C-C bonds in carbon nanotubes are one of strongest bonds in nature, making ideal an ideal carbon nanotube one of the strongest structures in nature. The Young's modulus (simply a measure of stiffness) for ideal single shelled carbon nanotubes has been theoretically calculated as high as 5000 x 10^9 Pascals. A more reasonable value average for nanotubes in general is around 1800 x 10^9 Pascals. Compare these values to the Young's modulus of steel: 200 x 10^9 Pascals. Studies on deformation, strain, and tensile stress have yielded similar results for the incredible strength and durability of carbon nanotubes.

Nanotube Filling: Simply put, carbon nanotubes are very small, very strong open-ended cylinders. As with most cylinders on the macroscale, you would want to try to fill these super strong nano-cylinders with something useful. The core property used in nanotube filling is the capillary action. The capillary action is the ability of a narrow tube to draw liquid against the force of gravity. This occurs because the forces between the liquid and solid are stronger than the forces that hold the liquid together; thus causing the liquid to move towards the solid. This unique force can be harnessed to fill nanotubes with a variety of different substances. For example, much money and research is being put into using SWNTs as storage units for hydrogen for use in hydrogen fuel cells.

Nanotubes and the future

Because of their unique intrinsic properties, carbon nanotubes have a plethora of potential world changing applications. Their immense strength properties have been harnessed into creating stronger and more durable concrete. There is also research into using the strength of the nanotube fibers to create ultra strong and ultra light combat armor. Also, SWNTs have great potential in the micro and nano electronics industry. Singularly produced SWNTs are extremely good conductors, however, electrical properties of bulk produced carbon nanotubes are fraught with defects, making them difficult to consistently use. This translates into the necessity of making one nanotube at a time, which is both enormously expensive and time consuming.

References

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