OPINION

A review of carbon nanotube structure

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ABSTRACT

Carbon nanotubes (CNTs) are carbon allotropes with a nanostructure with a length-to-diameter ratio greater than one million. Arc discharge, laser ablation and chemical vapour deposition are some of the techniques that have been developed to create nanotubes in large quantities. Recent advancements have demonstrated nanoparticles' revolutionary potential, particularly in biomedical imaging, drug delivery, bio sensing and the construction of functional nanocomposites. For these applications, methods to effectively interface proteins with nanomaterials are still evolving. Because of the high surface-to-volume ratio of nanoparticles, the concentration of the immobilised entity was significantly higher than that of other materials. There's also a growing interest in learning more about how nanomaterials affect the structure and function of proteins. Various techniques of immobilisation have been devised, with a specialised attachment of enzymes to carbon nanotubes receiving particular interest. With the increased focus on cascade enzymatic reactions, multienzyme immobilisation could become one of the next targets in the future. In this study, we look at new techniques for immobilising enzymes on carbon nanotubes.

Key Words: *Allotropes; Immobilisation*

INTRODUCTION

Diamond and graphite are two crystalline forms of pure carbon found in nature. Carbon atoms in diamonds show hybridization, which occurs when four bonds are pointed towards the corners of a normal tetrahedron. One reason for its hardness is that the resulting three-dimensional network (diamond) is exceedingly stiff. Hybridization happens in graphite, where each atom is bonded uniformly to three carbons in the plane 120°C and the axis has a weak bond. The set creates the hexagonal (honeycomb) lattice found in graphite sheets. In 1985, a team led by Korto and associates discovered Buckminsterfullerene, a novel type of carbon. Aside from diamond, graphite and fullerene, the quasi-one-dimensional nanotube was originally identified by Ijima in 1991 in carbon soot produced by an arc-discharge process. Carbon nanotubes (CNTs) are carbon allotropes. CNTs are constructed of graphite and are tubular. The tubes had at least two layers, and typically many more, and their outer diameters ranged from 3nm to 5 nm. Two years later, single-walled carbon nanotubes were discovered (SWCNTs were). Dresselhaus et al. developed single-walled carbon nanotubes using the same method as MWCNTs, but with the addition of transition metal particles to the carbon electrodes. Single-walled nanotubes are typically smaller than multi-walled tubes, with widths ranging from 1-2 nm with a bent rather than straight shape. The structural, electrical, mechanical, electromechanical, and chemical properties of carbon nanotubes have been studied extensively over the last decade. Improved catalytically generated nanotube quality has been the subject of a recent study.

PROPERTIES

Carbon nanotubes have incredible mechanical qualities due to the strength of their carbon-carbon bonds. No other material has ever demonstrated the combination of superior mechanical, thermal, and electrical qualities that they have. Their densities can be as low as 1.3 grams per cubic centimeter. CNTs have stronger Young's moduli than all carbon fibers, with values greater than 1TPa, which is around 5 times higher than steel. Their strength, on the other hand, is what distinguishes them. Carbon nanotubes are the most powerful materials humans have ever discovered. A carbon nanotube's maximum measured tensile strength or breaking strain reached up to 63 GPa, which is around 50 times stronger than steel. Carbon nanotubes exhibit strengths of many GPa, even the weakest varieties. CNTs also offer exceptional chemical and environmental stability, as well as great strength. Carbon nanotubes have amazing electrical characteristics as well. Electrical conductivity is high. Nanotubes can be metallic or semiconducting, which is particularly noteworthy. The planar system's symmetry is broken by the rolling action, which imposes a different direction for the hexagonal lattice and the axial direction. The nanotubes may behave electrically as a metal or a semiconductor depending on the relationship between this axial direction and the unit vectors describing the hexagonal lattice. The bandgaps of semiconducting nanotubes scale inversely with diameter, ranging from about 1.8 eV for very tiny diameter tubes to 0.18 eV for the broadest feasible stable SWCNT. As a result, although some nanotubes have conductivities higher than copper, others act more like silicon.

SYNTHESIS TECHNIQUES OF CARBON NANOTUBES

Nanotube materials of high quality are sought after for both basic and practical purposes. The lack of structural and chemical flaws at a substantial length scale along the tube axes is referred to as high quality. The number of patents and articles on carbon nanotube synthesis is rapidly increasing. However, there are still several issues to be handled in terms of CNT synthesis. In the field of nanotube

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synthesis, there are now four major hurdles. (a) Mass production, or the development of low-cost, large-scale procedures for producing high-quality nanotubes, such as SWCNTs. b) Selective production, or the ability to regulate the structure and electrical properties of the nanotubes created. (c) Control over the placement and orientation of the generated nanotubes on a flat surface. (d) The mechanism, or the development of a full understanding of nanotube growth processes. The growth mechanism is still debated, and multiple mechanisms may be at work during CNT production. CNTs and MWNTs with various topologies and morphologies have been produced in laboratory quantities using several processes. Arc discharge, laser ablation, and chemical vapour deposition are the three most prevalent ways to make CNT (CVD). A catalyst, a carbon supply, and sufficient energy are required for the creation of nanotubes. The addition of energy to a carbon source to make fragments that can recombine to generate CNT is a common aspect of these approaches. Electricity from an arc discharge, heat from a furnace 900°C for CVD, or high-intensity light from a laser is all possible energy sources.

PURIFICATION OF CARBON NANOTUBES

Carbonaceous contaminants and metal catalyst particles in as-synthesized CNTs generated by the preceding processes are unavoidable, and the amount of impurities often rises as CNT diameter decreases. The essential issues that remain are how to (1) eliminate contaminants such as amorphous carbons and metallic catalysts, and (2) create homogeneous carbon nanotube dispersions in dispersing media or polymer solutions. The mechanical and electrical properties of unpurified carbon nanotubes are severely harmed by impurities. Impurities abound in CNTs soot as it is manufactured. All currently available production methods produce CNTs with contaminants. Purification has been a significant synthetic effort since the discovery of carbon nanotubes. Graphite (wrapped up) sheets, am--orphous carbon, metal catalyst, and smaller fullerenes are the main impurities in soot. In addition, structural flaws such as dangling bonds are common in most CNTs. Most of the intended features of CNTs will be hampered by these contaminants. Because CNTs are insoluble, liquid chromatography is limited, posing significant purification challenges. As a result, much effort has gone into purifying carbon nanotubes to remove extraneous nanoparticles that alter their physicochemical qualities. We only want to give a quick overview of the principles

CONCLUSION

To synthesise CNTs on a large scale for commercial use, various modified synthesis processes have been devised. The CVD approach is currently the most promising way of producing a large number of CNTs due to its low cost compared to other methods. Commercial applications of carbon nanotubes have been sluggish to emerge, owing to the high costs of producing the highest quality nanotubes. The chemistry of carbon nanotubes has advanced dramatically, and this field will drive carbon nanotube applications. The molecular control of CNT-based materials and devices will improve with the functionalization of CNTs, particularly CNTs with defined length, diameter, and chirality. The current article demonstrates that their enormous potential for biotechnology and biomedicine is only now being realised. Different biomolecules can interact and immobilise on CNTs, resulting in a broad range of applications. However, there is no uniform enzyme support, and the ideal method of immobilisation may vary by enzyme, application, and carrier. In the future, data from protein sequences, 3D architectures, and reaction mechanisms should be integrated with the intriguing properties of CNTs and physical/chemical approaches to create an immobilised enzyme with even more stability and catalytic activity. Enzymes are less denatured when immobilised using non-covalent methods, and the intrinsic electronic structure and characteristics of CNTs are retained.