Structure,texture, electrochemical properties of carbon materials-II

Diamond

Just like graphite, diamond has been known to exist since ancient times. However, its usage was only limited to decorations at that time, which is now perceived by the contemporary scientists as a misuse of its appropriate potential. As one of its popular excellent properties, diamond is known to have the highest thermal conductivity when compared to any other material. This is decisively attributed to low phonon scattering and strong covalent bonding that held its atoms. The thermal conductivity of natural diamond was reported to be approximately 2200 W/(mK), which is five times more than copper. Based on the high thermal conductivity of diamond, it is widely used in the semiconductor industry to prevent silicon and other semiconducting materials from overheating. The industrial or commercial production of synthetic diamonds traced its history in the 1950s by General Electric. It is well established that the diamond has an excellent carrier mobility, saturated carrier velocities and electric field breakdown strength. However, It has a poor dielectric constant and may likely show 'negative electron affinity' when tested. Many reports considered it to be a wide band gap semiconductor with an eV value of 5.5 that can be doped to *p*-type or *n*-type. Based on its physicochemical properties, diamond is chemically and physically robust, and radiation 'hard'. It is therefore believed that any electronics device made from diamond should not only perform at the highest levels, but should also be capable of operating in extreme environments. Its optical properties are usually considered uncommon and been genetically linked with the carbon family, it is considered to be biocompatible inside a living body. Thus, it is not prone to unwanted cell adhesion or particulate generation. In relation to its thermal stability, diamond (as a form of carbon) can easily be oxidized in air when heated beyond 700 $^{\circ}$C. However, in a flow of high purity argon gas or rather in the absence of oxygen, it can be heated up to 1700 $^{\circ}$C. In general, those combined properties paved the way for industrial applications of diamond in windows, cutting and polishing tools, heat spreaders, and the scientific applications as an optical detector material, diamond anvil cells, diamond knives, etc.

Graphene and Graphene-Derived Materials ('Graphenoids')

Since its discovery at the University of Manchester by Andre Geim and Novoselov in 2004, graphene has become a material of interest and absolutely alerted the scientific curiosity of many research communities around the world. Therefore, it is not an exaggeration to say graphene is one of the most researched, speculated and promising nanomaterials in the past decade. This is based on its exclusive combination of wonderful properties which are inconceivable to normal materials, and this paved the way for its exploitation in a large variety of applications Many important carbon materials contain graphene as the primary building block of their structure. For example, a stacked graphene gives graphite and a rolled-up graphene sheets give carbon nanotubes (Fig. 1). It has been practically proven that the quality of produced graphene has a direct effect on its electronic and optical properties. Therefore, presence of defects, impurities, structural disorders and wrinkles in the graphene sheet can adversely affect those properties. Consequently, in electronic applications, it is imperative to have high quality and single crystalline graphene thin films with high electrical and thermal conductivities alongside with dazzling optical transparency.

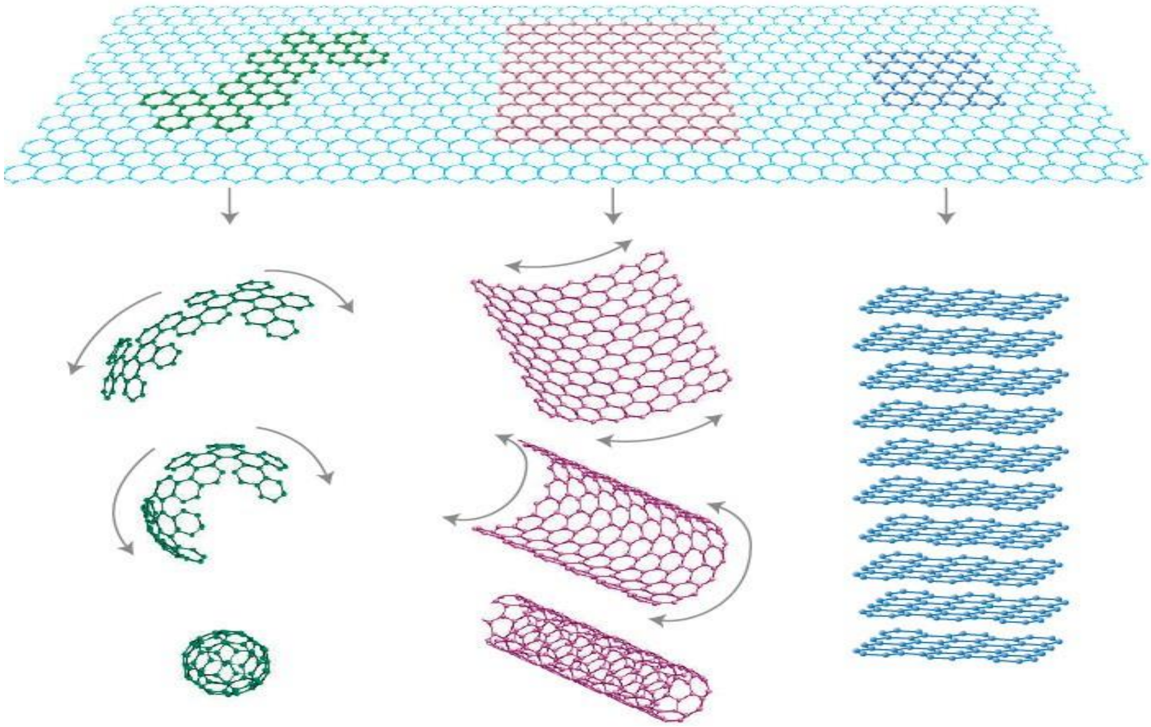

Fig. 1. Structure of graphene configured to buckyballs (0-dimensional) by wrapping up, to nanotubes (1-dimensional) via rolling and to graphite (3-dimensional) by stacking.

A widespread and commercial application of graphene and graphene-related materials has been hindered to some extent by the high cost towards the production of these materials. Hence, a number of researchers have used materials that are generally cheap such as agricultural waste (bio-waste), insects, food, etc. as the precursors for the synthesis of carbon nanomaterials particularly graphene.

Activated Carbon

By considering its nature, properties and forms, activated carbon (AC) is placed or rather fit into the amorphous carbon category. It is believed to be the most popular and established of all carbons fabricated from sustainable resources. Chemically speaking, AC is a carbon that has been chemically enhanced to micro porous structure. The surface functionality in AC results in materials that are excellent at adsorption of various chemical species.

It is popularly known to possess a high surface area to volume ratio, which in turn make it very useful as an adsorbent material Therefore, it is commonly used as an adsorbent in poisoning, reducing cholesterol level, plummeting internal gas, flatulence and many other useful applications. Historically, in the previous century, activated carbon was mainly used for purifying air and water supply and demand for it grew rapidly. In the 1950s, the invention of carbon fibers paved the way for a new lightweight and incredibly strong material.
Conventionally, activated carbon are mostly produced from biomass precursors such as lignocellulosic materials (palm kernel shell, oil palm trunk, olive cake, olive bagasse, oil palm empty fruit bunch, wood, coconut shells, date palm seeds, rice husk etc.) different kinds of coal or other sorts of carbon.

Fullerene, Buckyball and Carbon Nanotubes Family

The discovery of C_{60} was published in nature in November 1985 by Harry Kroto and Richard Smalley of University of Sussex and Rice University, respectively. It was this report, which paves the way for fullerene-related carbon nanotube synthesis. Fullerenes or bulkyballs composed exclusively of carbon of varying size and molecules which resembles a hollow sphere or tube. Fullerenes have been studied comprehensively in relation to carbon nanotubes, and together with the latter have opened a new science and technology field on nano-scale materials since before the advent of graphene in 2004. As the word 'nanotube' entails in the name of all sorts of carbon nanotubes, the materials consist of only two coaxial cylinders. The multi-walled sort of nanotubes has an outer diameter as small as 55 Å and an inner diameters as small as 23 Å. In a simple term, carbon nanotubes possess a thickness or diameter on the order of only some nanometers and the thickness is comparatively about 50,000 times smaller than the width of a human hair and can be up to many centimeters length-wise. Nanotubes belong to the fullerene structural family, which also comprises buckyball. Structurally, a nanotube is cylindrical in shape with one of its ends usually wrapped into a hemisphere of buckyball spherical structure.

Basically, carbon nanotubes are divided into two main categories; single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs). Experimental studies reveal that nanotubes are the stiffest and strongest fibers ever produced. This has been notably correlated with better mechanical and electronic properties of this material. In order to maximally harness these properties tailored for specific applications, there is a need to incorporate the tubes into nanocomposite materials. In light of the above, for instance, in drug delivery systems, carbon nanotubes have been found to be proficient to improve metabolism of drugs and increase their therapeutic effect and decrease toxicity of bioactive materials by conjugating with therapeutic molecules which as a result facilitate those molecules to unravel some of their intrinsic drawbacks.

References

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