AL-KUFA JOURNAL FOR BIOLOGY
ISSN (Print): 2073-8854 **ISSN (online):** 2311-6544

A review

Carbon types derivatives of nanoscience via nanotechnology with applications

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Article history
Received: 14/5/2025
Revised: 23/5/2025
Accepted: 29/5/2025

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Abstract: The article explains types of Carbon nanomaterials which are derivatives from carbon atoms, carbon nanotubes (CNTs) or graphene sheets (GSs). The researchers could create different types of carbon of nanoscience via nanotechnology so we will mention that types of carbon and starting materials of them. The classification of carbon types in this research is bottom –up such as fullerene, carbon nano-onion (CNO)which start from carbon atom, but nanotube of fullerene and fabrication of C_{60} with C_{70} by using fullerene types. However, top-down classification likes carbon dots (CDs) and graphene quantum dots(GQDs) which are unzipping and fragmentation from types of carbon nanotubes (CNTs) and graphene sheets, respectively. Moreover, the fabrication and slicing of carbon nanotubes could make carbon nano ring and short length of carbon nanotubes to be slicing nanotubes. On the other hand, the fabricated shape of graphene sheet looks scrolling graphene sheets or could use many methods to oxidation the surface to create graphene oxide (GO). The global type of carbon has inserted in various applications but the article highlights established biological and industrial application areas such as drug delivery, tissue engineering, photothermal therapy and solar cell. These applications could be very important to make different thing in our life.

Keywords: CNTs, Fullerene, graphene, carbon dots (CDs), graphene quantum dots (GQDs), nanoscience

1. Introduction

Nanoscience and Nanotechnology

Nanoscience is the science which deals with the phenomena shown by materials at levels within nano (one of billion) scale dimensions range of size and structural shape [1].

Nanotechnology represents one of the key inventions in 21st century's science, which deals with the nanoscale design and engineering of diverse materials forms such as; metals, metals oxides, polymers, chalcogenides [2]. It is enable the materials at distinguishing size and structure to be formative [3] and also it can be depicted as the generation and processing of materials at nano (10^{-9}) scale. It is one of modern technologies which has a high attention in food industry due to the developing

Alduhaidahawi *et al* , *Al-kufa journal for biology*, 2025, vol. 17 issue: 2, page 74-88
DOI: 10.36320/ajb/v17.i2.19669

inventive products and applications for food remediation, canning and packaging [4-6]. It is a successful technology in food production and food products packaging fields [7].

Nanotechnology can be described as multi-specialty science which is result from the combination of various specialties such as medicine, biology, chemistry, physics, and engineering [8]. It is includes multi-applications from energy generation, fabrics, cosmetics , and housewares to dental and medical devices and lotions which are necessary for daily human life and to academic researchers in physics , chemistry , biology , materials science , and electric and mechanical engineering. For all these, the widely interests in recent researches were located [8-11].

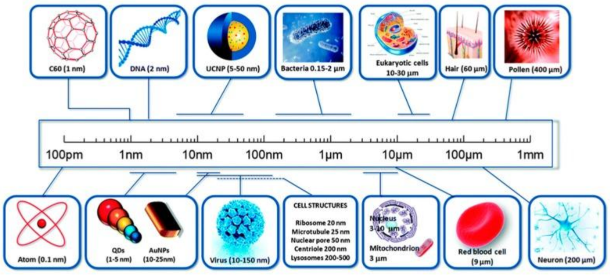

Fig 1: Illustrated rapprochement of nano size [12].

Nanomaterials and Nanoparticles

Nanomaterials have been the temptation center of researchers for the last five decades as a result to their huge implications in multi-specialties like electronics, photonics, and medicine. The various nanomaterials were developed and currently used in countless applications [13].

The nanomaterials can be known as materials which have an outer or inner structures in nanoscale, the nanoparticles are kinds of nanomaterials and the objects of which have at least 2-dimensions in nanoscales [14]. The nano-dimensional materials (< 100 nm in size range) can be described as an intermediate state or bridge between the materials at atomic (or molecular) levels and the bulk materials, which showed chemically, physically and electronically distinguishing properties [15].

The main components of nanomaterials are; nanoparticles , nanowires , and nanotubes as result to their uses in the most important applications [16].The physical and nanoparticles chem-properties are not justly depended on their size , but so on their compositions which probably be organic (like polymers) , bio-organic (like lipid) , as well as inorganic (like metals, metals oxides,…) or mixture of them [17-19]. As such, the shape of nanoparticles effects on the physical properties of nanoparticles [20]. The nanoparticles possess surface areas too more than the bulk particles, and at the same time the surface area of nanoparticles were defined by their size and shape [21].

Properties of Nanoparticles and nanomaterials

The nanoparticles properties are different from their counterparts of nanomaterials. The key of this difference lies in the fact that nanoparticles possess a high surface area/ volume – ratio compared with nanomaterials. The physical and chemical properties of nanoparticles and nanomaterials are essential factors to define their uses and applications in the different fields such as; medicine, imaging, catalysis, voltaic cells fabrications, and environmental application fields.

The properties of nanoparticles and nanomaterials are essentially based on a various factor such as; surface area, surface energy, nano-size, shape, structure, and morphology [22-24].

Chemical Properties

Among the almost important chemical properties of nanoparticles and nanomaterials are the reduction-oxidation reactions catalytic activity, where the nanoparticles and nanomaterials behave as solid phase catalysts ,especially in heterogenetic catalysis reactions.

The catalytic activity strongly depends on the size of nanoparticles and nanomaterials, where the catalytic activity is increased with reducing the nanoparticles and nanomaterials that leads to increasing in surface area camper with volume ratio, as a result to lowering the activation energy and crossing the high energy barrier. This reason makes nanoparticles of a superior catalytic activity compared with nanomaterials [25-30].

Beside the size effect, the nanostructured shape and morphology of nanoparticles and nanomaterials have an important influence on the catalytic activity of nanostructure [27,31,32], the electronic state, ability to reduction-oxidation [29], type of liquid support (such as glycerol) and additives as stabilizers (such as PVP) which are utilized in the synthesis solution during nanoparticles synthesis process [33]. The nanomaterials include in environmental applications [34], and they are application in industrial manufacturing [35].

The controlling on the size of nanoparticles and nanomaterials do not affect the catalytic activity only, but it affects the selectivity in catalytic reduction-oxidation reactions and the type of nano-components [36,38]. Alongside that, nanoparticles and nanomaterials possess another property, the quenching or trapping of free radicals property [39]. The catalytic properties of nanoparticles and nanomaterials were exploited in the degradation of some organic materials such as methylene blue [40,41].

Physical properties.

The significant alteration is seen by size changing to material and particles reduces the size to be nanoscience which is the properties of the surface. The surface compering with volume proportion increases rapidly with the reducing size to be nanosize. The surface area change of the material and particles works on catalytic sites on the outer layer of them subsequently working on its reactant action [42]. The melting point is one example of physical properties; the melting point of nanomaterials is lower than natural size. The energy property of surface high with a reduction in the size of the material and particles. The outer layer of a molecule goes through a response with atmospheric air which results in a change in the installation of the melting point of particles to low because they reduce the surface area. [43,44]. Another example is the Mechanical properties of nanomaterials, optical properties and electrical properties; a large amount of literature has concentrated on the mechano-properties of nanomaterials and nanoparticles. Those studies fundamentally work on the mechano-properties of nanomaterials by composite with nanoparticles which is mostly not a nanomaterial. It very well may composite nanomaterials with particles nanosize have harder breach than sloid [45]. The nanoparticles have attracted in more interest of novel optical effect, which differ remarkably from mass structures. Significant contributory auxiliary factor contains quantum sequestration of electrical transporters inside nanoparticles, productive energy and charge moving over nanoscale distances, and, in many systems, a highly enhanced role of interfaces [46]. Since the wave is on the limit of the metal and the external air-medium or water medium, these vibrations are very sensitive to any exchange of this boundary, like the adsorption of particles the surface on the metal. [47]. The electro-properties of NMs are a way in the creation of helpful electro-devices. The electro-conductive of NMs is hard to understand because of the least size and based on various. NMs can hold extensively high energy than standard ones as a result of their large GB area [48].

Types of carbon derivatives

Out of the survey of literature and reviews [49-51] in the synthesis methods of nanomaterials field, it can be stated that synthesis methods of nanomaterials are divided into two aggregations; chemical and physical techniques. The chemical techniques include a set of methods such as; hydrothermal, sol-gel, sonochemical, co-precipitation, electrospinning, micro emulsion, chemical reduction, and wet chemical methods. On the other hand, the physical techniques also include a set of methods such as; arc discharge, photochemical impregnation, laser ablation, ball milling, chemical vapor deposition, inert gas condensation sputtering, and electrochemical methods. All the methods above could have classified under two titles bottom-up and top-down.

Bottom-up approach

The useful technique is a term choosing to describe the bottom-up way, figure 2 [52]. This technique is the inverse of the top-down with obvious shape, nanosize, and chemical structure are formed over to develop the self-assembly methods of atoms and particles as their structure blocks [53].

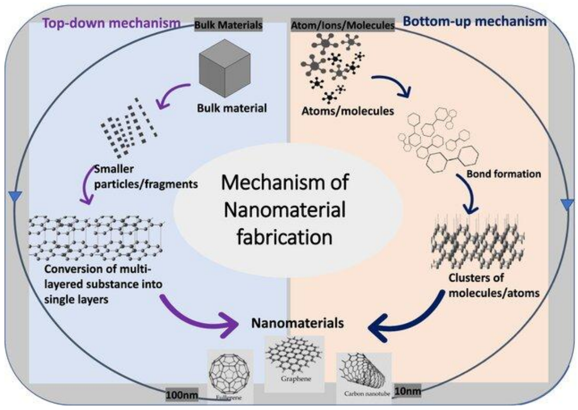

Fig 2: Illustrated the bottom-up and top-down of the nanomaterials[52].

Fullerenes

Fullerenes are globular carbon particles, the carbon atoms together by covalent bond to be sp2 hybridization. thus, the globular structure is included carbon atoms from 20 until 1500 atoms, with diameters going from 1 nm of one molecular until 36 nm for complex fullerenes

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DOI: 10.36320/ajb/v17.i2.19669

so nanomaterials made out of spherical empty enclosures, like ball types of carbon which are fullerenes and famous structures are C60 and C70, figure 3 [54]. Because of their electro- conductive, high intensity, electro-fondness, and flexibility have drawn in business interest [55].

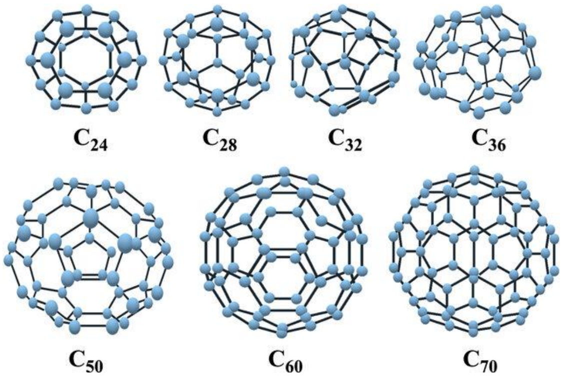

Fig 3: Fullerene shapes [54].

Moreover, the kasturi's group could fabrication of fullerene C_{60} in toluene by vortex fluidic devise (VFD) to created nanotube design figure 4 [56].

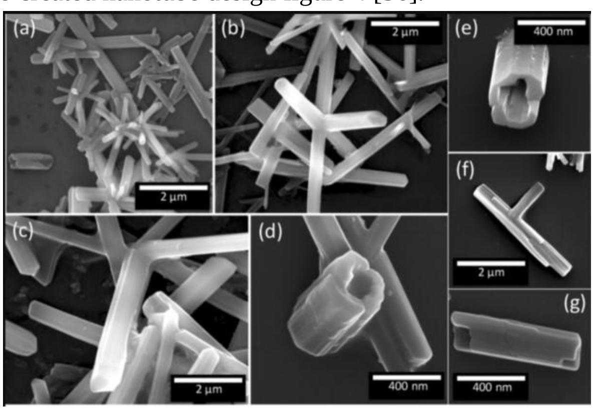

Fig 4: Nanotubes of fullerene C60 by vortex fluidic devise (VFD) [56].

On the other hand, the researchers fabricated fullerene C_{60} with C_{70} in ethanol/ mesitylene to collect Nano flowers, figure 5 [57]. Moreover, the new structure of assembly of carbon atoms to make carbon nano onions (CNOs), figure 6 [58].

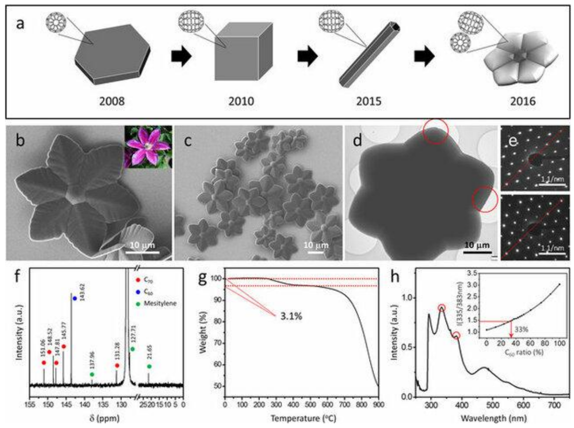

Fig 5: Fabrication of C60 with C70 in ethanol/ mesitylene [57].

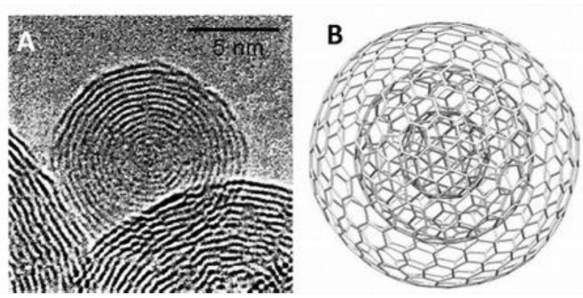

Fig 6: High resolution TEM image of carbon nano onions (CNOs) [58].

Top-down approach.

Fermentation of particles to reduce mass material changes to nanoparticles methodology. the methodologies of top-down are easy using of researchers but they are not useful for manufacturing. the shaped is very small particles from large size by many different methods [59]. An example of this methodology is gas phase condensation aerosol spray etc.

Carbon nanotubes (CNTs).

Carbon nanotubes (CNTs) are delivered from a carbon atom with a haxagnal aromatic structure of carbon atoms into frame nanotubes of carbon with sizes around 0.7 nm for single wall carbon nanotubes (SWCNTs), double wall carbon nanotubes (DWCNTs) and 100 nm for multi wall carbon nanotube (MWCNTs), and lengths will generally range size from micrometers to millimeters. The ends of the tube could be can be without particles, or hemisphere shape to close the tubes. The structure likes scrolling graphene sheets [60]. The carbon atoms would deposit. after vaporized from graphite on particles of metal by a laser method or an electric field. As of late, they have result utilizing the chemical fume deposition (CVD) method [61]. These materials have just one dimension >100 nm carbon-based 1D nanomaterials with a high aspect ratio, figure 7 [62].

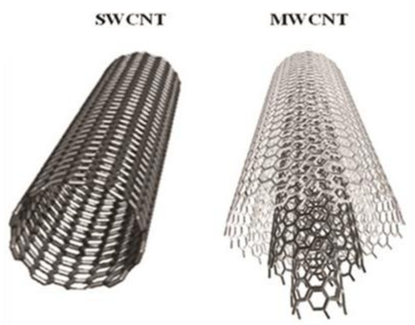

Fig 7: single wall carbon nanotubes (SWCNTs) and multi wall carbon nanotubes (MWCNTs) [62].

Also, other carbon structure has one dimension is carbon nanowires, figure 8 [63], and carbon nano fibers, figure 9 [64] which are good electron sources transmit electrons in a less electric range [65].

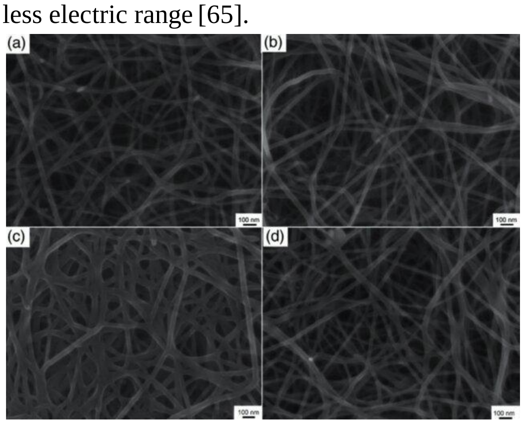

Fig 8: SEM images of carbon nanowire [63].

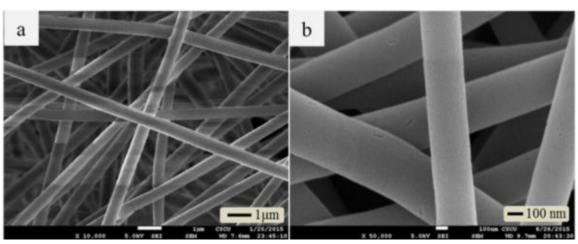

Fig 9: FESEM images of carbon Nano fibers [64].

The researchers use carbon nanotubes to derivative other type of carbon which is carbon dots (CDs). The expanded popularity in the researches of carbon dots field at the past three decenniums comes as a result to their distinguishing dynamics, electric, and optical properties [66-69]. The carbon dots are low dimensional structured semiconductors nanoparticles [70]. The CDs are a modern class of functional groups which have a mounting important opto-electric, and structural properties as a result to quantum effect by the relation between area of the surface to size [71]. The reason of using (carbon dots) term comes as a result to their possessing quantum size, large transition matrix elements and energy spectra similar to those of atomic or molecular systems [72]. The CDs structures have an energy band gap lower than of the same chemical structure bulk materials [73]. The optical and electric properties to CDs relate to size of CDs and shape [74]. The CDs are used in imaging and high – (speed & resolution) screening, drug vectors, and solar cells. Xuan's group could prepare CDs by using multi-wall carbon nanotubes with vortex fluidic devise (VFD) and laser figure 10 [75].

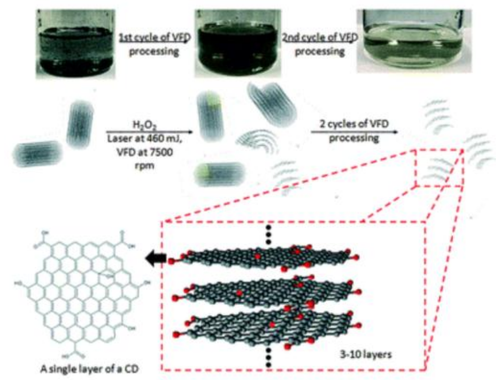

Figure 10: steps carbon dots (CDs) from multi- wall carbon nanotubes [75].

Also, other researchers at 2006 created new type of carbon nanotube which is carbon nano rings, figure 11 [76] also by vortex fluidic devise (VFD) at 2014 created nano rings, figure 12 [77].

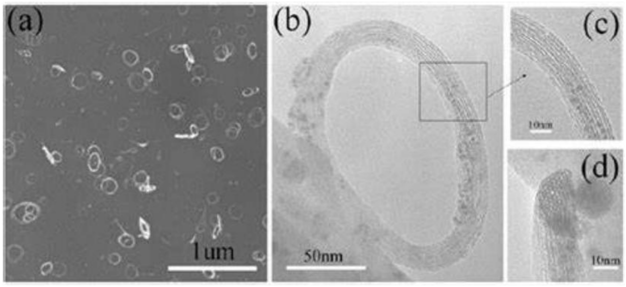

Fig 11: TEM images of nano rings [76].

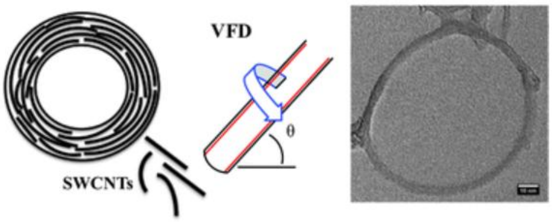

Fig 12: Carbon nano rings by vortex fluidic devise [77].

Also, the scientists sliced the carbon nanotubes and reduce the length from micro size to be nanosize, figure 13 [78].

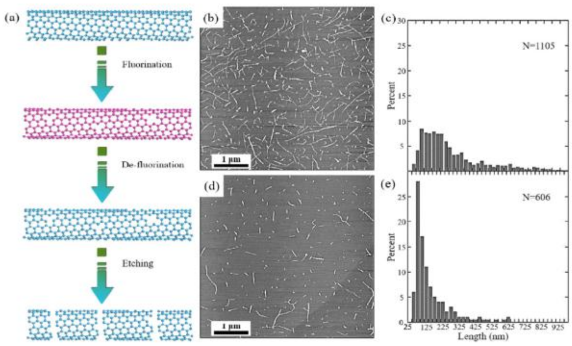

Fig 13: SEM images of slicing carbon nanotubes and length distribution [78].

Graphene

Graphene is 2D nanomaterials which has two dimensions less than >100 nm. They have two layers or few layers which mean the layer would not be less than one carbon atomic, figure 14 [79]. Their regular shapes, good properties of volume surface, and charge on the surface are shown by their specific physical, chemical, optic, and bio characteristics [80].

Fig 14: graphene (a) single layer (b) multi layers [79].

The latest structure of graphene type is procedures of the graphene quantum dots (GQDs) which are publishing paper. The graphene quantum dots (GQDs) could prepare by top-down production methods which are starting from big graphene sheet to prepare graphene quantum dots (GQDs) as nano-science application. Thus, the researchers could use the electronic methods to synthesis GQDs, figure 15 [81].

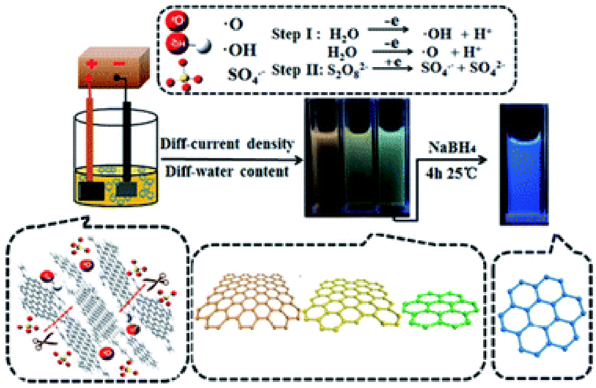

Fig 15: Graphene quantum dots via Electrochemical method [81].

On the other hand, other scientists manipulate graphene to be scrolling graphene which be good as nanofluidic channel, figure 16 [82].

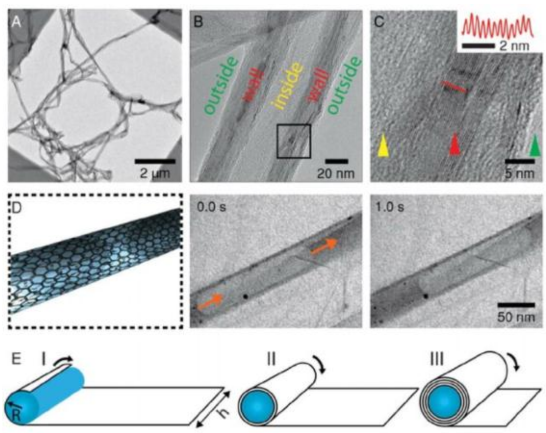

Fig 16: Scrolling graphene as nanofluidic channel[82].

That is not all, the review publish paper at 2022 explains the methods to prepare the graphene oxide (GO) from graphene, figure 17 [83]. The graphene oxide (GO) has faction groups such as carboxylic, hydroxyl and carbonyl group on the surface of graphene.

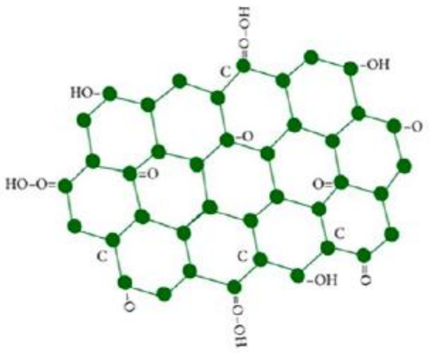

Fig 17: graphene oxide structure (GO)[83].

Applications of carbon types

The global properties of carbon types could be applying for many applications in different areas such as drug or gene delivery, tissue engineering, antibacterial, active-antioxidant, solar cell, apply for Pl sensors and other, photothermal therapy and other applications. This research would mention about four of them because the human's life needs applications relative with our developing life.

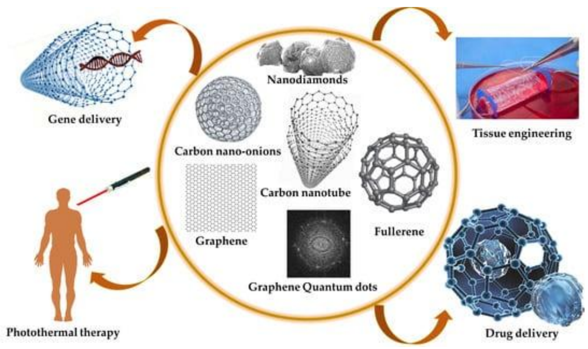

Fig 18: applications of carbon types [58].

Drug or gene delivery.

Carbon quantum dots based and graphene quantum dots are very important for biological-medical applications, biological-compatibility, biological-degradability, better efficiency, functional groups on the surface, and physico-chemical properties [84]. Thus, carbon quantum dots (CQDs) or graphene quantum dots (GQDs) are eligible of bright new line for drug and gene delivery application. Fang's group used GQDs such as carrying of drug to target, figure 19 [85].

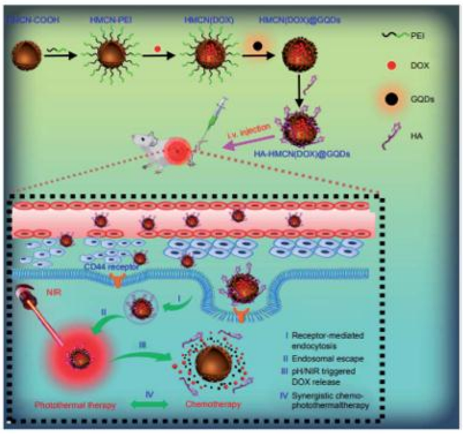

Figure 19: Drug delivery by using GQDs [85].

Tissue engineering

The researcher's group develops the idea to use tissue engineering in biological application such as bones, skin, neural, dantest, cartilge and many engineering field and science application to create good environment for tissue and organ regeneration [83].

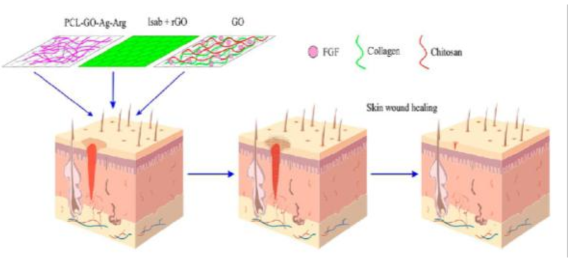

Fig 20: Graphene oxide application as tissue engineering [83].

Solar Cells

The basis of the action of solar cell is concert with photo-electric phenomenon, so it fabricates from materials undergoing this phenomenon. Whenever the light exposed surface area is increased the efficiency will be increased. The nano carbon have surface area conductivity or semiconductivity due to the finer size. Solar cells efficiency is based on the size and shape of nanocarbon. The solar cells efficiency is increased with reducing nanocarbon size as a result to the reducing of reflectivity and light exposed large surface area, figure 21[86].

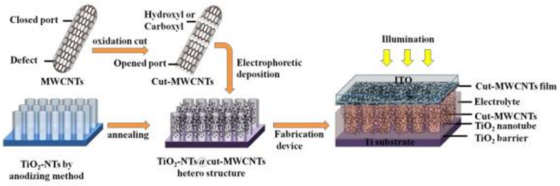

Fig 21: Solar cell devise with slicing multiwall carbon nanotube [86].

Photothermal therapy

The photothermal application of carbon nanomaterials in the therapy of cancer is still at the exploratory stage of clinical research. The researchers have found big challenging application and possibility idea. On the other hand, the side effect studies of carbon toxicity of long-time after inject in the body and understanding affect of synthesis methods to prepare carbon. Scientists group used C_{60} with this application, figure 22 [87].

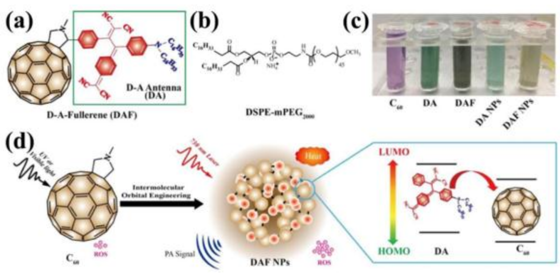

Fig 22: Illustrated of C_{60} as photothermal therapy application [87].

Conclusion

Our review conducts global types of carbon which includes synthesis methods by nanoscience and nanotechnology. the derivatives of carbon types are classification to Bottom -up such as fullerene and carbon nano-onion (CNOs) which start from carbon atom under different conditions to be structure zero dimension. Moreover, the researchers could prepare nanotube of fullerene and fabrication of C60 with C70 by using fullerene types which are one dimension and two dimension. On the other hand, the top- down carbon types are carbon dots (CDs) and graphene quantum dots(GQDs) which are unzipping and fragmentation from carbon nanotubes (CNTs) and graphene sheets, respectively. Furthermore, other fabrication and slicing of carbon nanotubes are carbon nano ring and slicing nanotubes with zero dimension but graphene sheet has fabricated the shape to be scrolling graphene sheets or oxidation the surface to create graphene oxide (GO). The applications of carbon types are drug delivery, tissue engineering, solar cell and photothermal therapy which are very important in our life.

Funding Information

No funding was allocated

Author's Contributions

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