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Trends in Life Sciences

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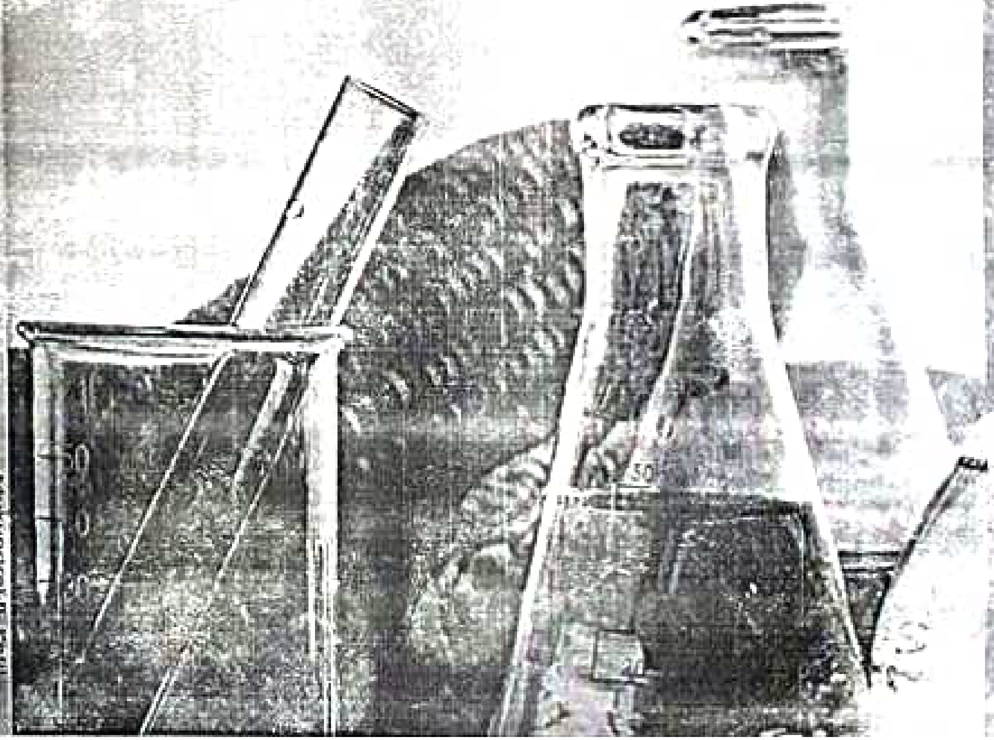

CHAPTER IV

Use of Carbon nanomaterials in medicines: A small solution to big problems

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Carbon is one of the most abundant, important and interesting element found on earth which is major constituents of the living as well as non-living world. Carbon-based nanomaterials are amazing technological tools with unique properties *viz.* high mechanical strength, high conductivity, attractive optical properties, chemical versatility, etc. Among these carbon nanomaterials include 0-D (small ,clusters and fullerenes as well as nano diamonds), 1-D (Carbon nanotubes), 2-D (graphene) and 3-D (Diamonds) materials. Many of scientists are now working on the carbon related such compounds specially carbon nanotubes, fullerenes, grapheme etc. which indicates importance of these materials. In this article we will discuss these carbon nanomaterials and it's applications in medicine.

Carbon nanomaterialsare a novel class of materials that are widely used in biomedical fields including the delivery of therapeutics, biomedical imaging, biosensors, tissue engineering and cancer therapy. In the field of science and technology, carbon-based nanomaterials (CBNs) are becoming attractive nanomaterials. (2)

Due to the existence of diverse allotropes of carbon, from renowned allotropic phases such as amorphous carbon, graphite and diamonds to newly discovered auspicious carbon nanotubes (CNTs), graphene oxide (GO), graphene quantum dots (GQDs) and fullerene, carbon-based materials have recently become prized (Mostofizadeh et al. 2011).

What are Carbon Nanotubes?

Carbon Nanotubes can be considered as cylinders made of graphite sheets, mostly closed at the ends, with carbon atoms on the apexes of the hexagons. Carbon nanotubes are of two types single wall carbon nanotubes (SWCNT) SWNTs are cylindrical and sp^2-hybridized carbon nanomaterials with nanometer-scale diameters 100–1000 times less than their length, resulting in very large aspect ratios(2) and Multi Wall Carbon Nanotubes (MWSNT). MWCNT can be turned out into SWCNT by using some itching methods. SWWCNTs have diameters 1-2 nm while MWCNTs have 2-25 nm. In 1991, Sumio Iijlma first observed the formation of multiwall CNTs from carbon arc discharge. After some years, Prof. Sumio Iijima and Donald Bethune individually perceived single wall CNTs. Carbon nanotubes are synthesized by either Electric arc discharge or Chemical vapour deposition.

What are Fullerenes?

Fullerenes are allotropes of carbon, also called buckyballs because of their spherical structure. Fullerene was discovered around 1985. In the mid-1980s that H. Kroto, R. Smalley and R. Curl were able to detect the first fullerene molecule obtained by laser vaporization of carbon from a graphite target using mass spectroscopy. The name fullerene (C_{60}) was dedicated to the architect Buckminster Fuller who was famous for designing and building geodesic domes. The C_{60}molecule is composed of hexagonal and pentagonal faces to form a spherical structure similar to a soccer ball with a diameter of ≈10 Å.(3) Fullerenes can have 60,70, 78 or more number of carbon atoms on the surface out of which 60 atom molecule is most stable.

What is Graphene?

Graphene is just a single layer of graphite crystal . A graphite crystal has stacks of carbon layers weakly bonded to each other. Graphene family nanomaterials (GFNs), without question, are the most extensively studied materials by virtue of their great number

of extraordinary physicochemical properties(4). Graphene, which is an isolated sheet of carbon atoms, was considered to be difficult to achieve. However, in 2004 it was shown by the scientists from the university of Manchester, U.K. and institute of Microelectronics Technology, Chernogolovaka, Russsia that it is possible to separate single carbon sheets(monolayer thick) by simply peeling them off using scotch tape. The properties of grapheme sheets could be measured which led to lot of interesting work on graphene. (1)

Applications of Carbon nanotubes, Graphene and fullerenes in medicine

By using these inherent properties of Carbon nanotubes, fullerenes and graphene, different newly invented Carbon Based Nanomaterials, these have been modified and extensively used in biomedicine, including applications for bio-sensing, drug delivery and cancer therapy.

CNTs display strong optical absorption in the near infrared, Raman scattering as well as photo-acoustic properties that widen the scope of *in vivo* applications as they can potentially have bio-imaging and tracing functions coupled with drug delivery.

Some research studies have shown that CNT can be bonded with a single strand of DNA can be bonded, and can then be successfully inserted into a cell. By functionalizing and chemically modifying of the sidewall, CNT can also be used as vascular stents and neuron growth and regeneration.(5) It gives the potential use of CNTs for gene delivery or delivery of small interfering RNA (siRNA). Al-Jamal et al. provided evidence for efficient delivery of siRNA directly to the CNS through stereotactic administration of MWCNTs, resulting in neuroprotein in mice and rats

The application as drug delivery is very common in carbon-based nanoparticles, especially the graphene-based nanoparticles. Both *in vitro* and*in vivo* studies have provided the evidence of the graphene for delivering anti-cancer drugs to the desired location of tumor cells, rather than the normal and healthy cells.(5)

However, to date, many drugs have been loaded onto the CNT including doxorubicin (4) CNTs have been studied intensively as drug carriers: with doxorubicin being the most common model drug. To this end, drugs may be loaded onto CNTs through noncovalent interactions, *eg.*, π-π stacking as shown for doxorubicin.(5) although covalent binding has also been explored for hydrophillic drugs. In the latter study, the authors covalently attached not only the drug, cis-platin but also the targeting ligand, epidermal growth factor (EGF), and demonstrated that these targeted vectors were selectively taken up by head and neck squamous carcinoma cells over expressing EGF receptors. Moreover, regression of tumor growth was rapid in mice treated with targeted SWCNT-cisplatin conjugates relative to the non-targeted ones. CNTs may also serve as multi-functional devices for selective cancer cell destruction, by virtue of their intrinsic physicochemical properties. For instance, Kam et al reported that SWCNTs can be deployed for targeted delivery of oligo nucleotides to cancer cells with near-infrared light-mediated killing of cancer cells due to the excessive local heating of the CNTs.

Graphene is another promising material for drug delivery. Indeed, as pointed out by Novoselov et al, graphene derivatives can solubilize and bind drug molecules as a result of their large surface area and delocalized π electrons, and thus have the potential to act as durg delivery vehicles if sufficiently high drug loading and suitable *in vivo* drug distribution and release profiles can be achieved.(5)

Graphene oxide is capable of dynamically interacting with the probe and/or for the transduction of a specific response toward the target molecules. This transduction process is achieved by fluorescence, Raman scattering and electrochemical reaction. On the basis of this, GO are broadly used as biosensors (5)

Fullerenes, especially C_{60}, have received widespread attention as drug and gene delivery vehicles. In one pertinent example, gene delivery *in vivo* using water-soluble fullerenes was demonstrated. The *in vivo* biodistribution of the fullerene-DNA complexes and a lipid-based system (Lipofectin) showed similar patterns. Furthermore, as proof-of-principle, the authors demonstrated that

the delivery of an insulin gene using fullerenes increased plasma insulin levels and reduced blood glucose concentrations in mice.

Gadolinium(Gd) based metallofullerenes are developed as innovative contrast agents, and may also act as anti-cancer agents. For example, the multi-hydroxylated metallofullerenol Gd $C_{82}(OH)_{22}$ was recently shown to inhibit tumor metastasis through MMP inhibition rather than through direct killing of the cancer cells, thus suggesting a new, nanomedicine-based approach in the management of tumor metastasis.(5)

Conclusion:-

Above vast applications shows Carbon nanomaterials are a novel class of materials that are widely used in biomedical fields including the delivery of drugs, biomedical imaging, biosensors and cancer therapy.

As a primary conclusion based on the considerable research over the past two decades, it can be said that Carbon Based Nanomaterials have tremendous potential in early comprehensive diagnosis and precise treatment of cancer due to their intrinsic physicochemical properties.

References:

1. Nanotechnology: Principles and Practices . Sulabha K. Kulkarni

2. Multifunctional Carbon-Based Nanomaterials: Applications in Biomolecular Imaging and TherapyYanyan Zhang,Minghao Wu,Mingjie Wu,Jingyi Zhu and Xuening Zhang*,*ACS Omega* 2018, 3, 8, 9126–9145 Publication Date:August 15, (2018)

3. Synthesis and applications of carbon nanomaterials for energy generation and storage Marco Notarianni[1,2], Jinzhang Liu[3], Kristy Vernon[1]and Nunzio Motta[1]Beilstein J. Nanotechnol. 2016. 7. 149–196.

4. Goenka, S.; Sant, V.; Sant, S. Graphene-based nanomaterials for drug delivery and tissue engineering. *J. Controlled Release* 2014, 173, 75– 88, DOI: 10.1016/j.jconrel.2013.10.017

5. Biological interactions of carbon-based nanomaterials: Fromcoronation to degradation Kunal Bhattacharya, PhDa, Sourav

P. Mukherjee, PhDa, Audrey Gallud, PhDa,Seth C. Burkert, MScb, Silvia Bistarelli, MScc, Stefano Bellucci, PhDc,Massimo Bottini, PhDd,e, Alexander Star, PhDb, Bengt Fadeel, MD, PhDa, Nanomedicine: Nanotechnology, Biology, and Medicine 12 (2016) 333–351

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