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Feasibility of graphene in biomedical applications

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ABSTRACT

Nanotechnology is the developing field, bringing the materials in the nanoscale level, has been applied in the interdisciplinary sciences. Different nanomaterials, such as gold, silver, zinc, copper and graphene are shown to have a wide range of applications. Among these, graphene is one of the faster upcoming two-dimensional nanomaterials utilized in various fields due to its positive features including the properties of thermal, electrical, strength and elasticity. Biomedical applications of graphene have been widely attested to be popular among academician and industrial partners for creating next generation medical systems and therapies. In this review, we selectively revealed the current applications of graphene in the interdisciplinary medical sciences.

Contents

1. Introduction

Nanobiotechnology is the developing field, utilizing the nanomaterials for the applications in a wide range of disciplines. With the nanotechnological approaches, devices or materials have been generated in the nanoscale dimension (< 100 nm) for the downstream applications. Applications of nanotechnology spread almost in all the fields including water purification, sports, cosmetics, textiles, food and beverage and computing. Each nanomaterial has its unique properties such as, thermal conductivity, electrical and mechanical properties. Depends on the properties of nanomaterials have also been used as catalyst, medicine, cosmetic, sensor, food, agriculture, energy and in display. Among different fronts, biomedicine is one of the leading disciplines has the predominant requirement of nanomaterials for the applications such as biosensing, imaging, drug screening and delivery. Several researches have proved the applications and impact of nanomaterials in the fields of biomedicine and biotechnology [1–4].

Graphene is one atom thick nanomaterial has been popularized widely due to its excellent properties and feasibility especially in the biomedical applications [5,6]. Graphene has been

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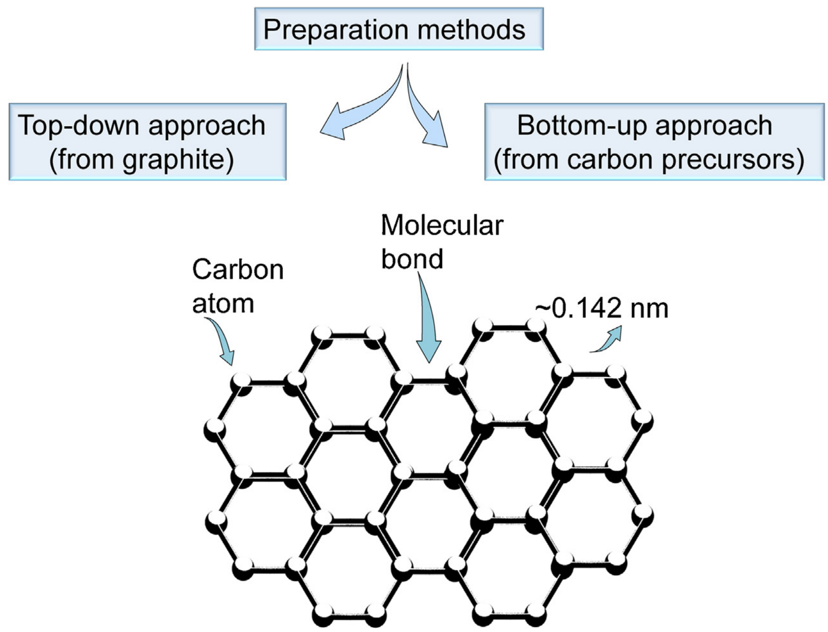

Fig. 1. Fundamental on graphene material. Approaches for graphene synthesis are shown. Top-down and bottom-up approaches are common for the synthesis of graphene. Infrastructure of graphene is displayed. It has 6 carbon atoms with the molecular bond of ~0.142 nm.

predominantly synthesized by both top-down and bottom-up approaches (Fig. 1). With the graphene, there are quite successful biomedical applications such as, biomolecular analysis, discovery of biomarkers, bioimaging, target delivery and photothermal therapy have been demonstrated [5]. The electrochemistry and fluorescent can be used to associate graphene-based materials and bring the better performance in the biomedical field. Besides that, the low toxicity nature of the graphene had shown the better improvement in bio-applications. In addition, the shape, size, morphology, the thickness and degree of oxidation of the graphene favors the biomolecular studies. Since graphene can be applicable for several applications, the associated problems with the technologies can be solved. The low cost of graphene made with anti-bacterial agents can be used in clinic or hospital. Additionally, the presence of anti-bacterial effect is discovered in the graphene nanosheet during the formation of nanowalls in the process of deposition on stainless steel [7]. In this overview, we discussed in detail on the graphene properties and its biomedical applications.

2. Characteristics and feasibilities of graphene

Graphene is in sheet form and packed in a regular hexagonal pattern [8], while single-walled carbon nanotube from graphene is as a hollow cylinder shape with one atom thick. The graphene has a specific surface area of 2630 m^2/g and double the size of single-walled carbon nanotubes which is around 1000 m^2/g [9]. The mechanical strength of graphene has the bond length of carbon–carbon is about 0.14 nm and interplanar spacing of 0.34 nm [10]. It is the strongest material with the tensile strength of 130 GPa and stiffness of 1TPa [11]. It can be simplified that 1 square meter of graphene layer could support 4 kg of material [12]. There are two configurations of graphite, which include alpha and beta. Alpha hexagonal is about ABAB arrangement on graphene sheet while beta hexagonal is rhombohedral ABCABC arrangement. The distance of c—c σ bond is ca.1.42 Å apart [8]. The crystal structure can recognize both structures although they are having similar physical properties. In structure of alpha graphite, the interplanar spacing is 0.34 nm and the parallel distance is 0.67 nm [13]. There is a weak Van Der Waals force of attraction inside the layers of graphite, it is the weakest attraction and makes graphite to be soft, such as the lead of pencil and it can be broken easily.

For the chemical reaction, graphene consists of carbon, has two sides for the chemical reaction with its two-dimensional structure. The edge or side of graphene is chemically very reactive and it get burned at temperature of 350 °C [14]. Graphene has the properties of high opacity, high chemical reactive and unparalleled thermal conductivity [15], functionalize easily and remarkable for biocompatibility. Because of these feasibilities, it makes interesting to the academicians and scientists and revealed the applications of graphene. One of the suitable areas for graphene is the biomedical

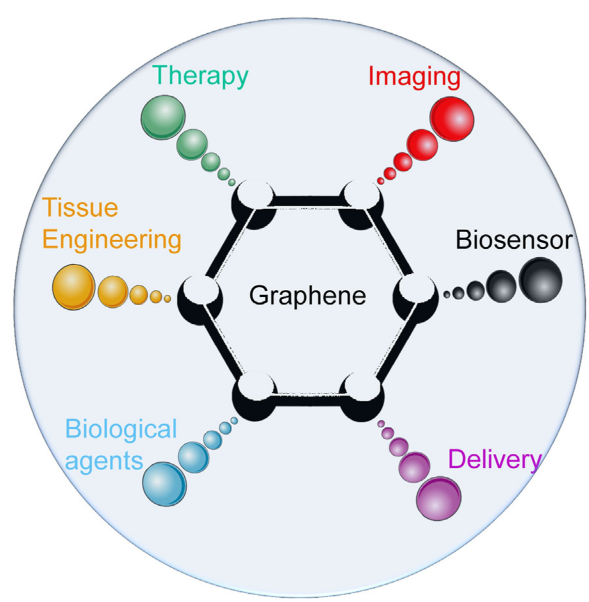

Fig. 2. Biomedical applications of graphene. Different biomedical applications are displayed. Applications include therapy, imaging, biosensor, delivery, biological carrier and tissue engineering.