Graphene, and Graphene Nanoribbons in Biomedicine

Subjects: Health Care Sciences & Services
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Graphene and graphene nanoribbons hold the promise for improving existing contrast agents as well as drug delivery and biosensing. The entry “Graphene, and Graphene Nanoribbons in Biomedicine” to Encyclopedia is dedicated to applications of graphene and graphene nanoribbons in biomedicine.

Keywords: carbon nanotubes ; graphene ; graphene nanoribbons ; biosensing ; bioimaging ; drug delivery

1. Introduction

The entry “Graphene, and Graphene Nanoribbons in Biomedicine” to Encyclopedia is dedicated to applications of graphene and graphene nanoribbons in biomedicine.

2. Applications

Graphene and its derivatives hold the promise for improving existing contrast agents as well as developing completely new probes and agents in biomedical imaging. A wide array of techniques is available to monitor processes in living cells or in tissues or even entire bodies [1]. Radionuclide-based imaging methods are widely employed [2][3][4][5]. Magnetic resonance imaging (MRI) offers a high spatial resolution and is noninvasive. Graphene oxide (GO) on its own is a diamagnetic material and can not be used as a contrast agent for MRI [6]. Graphene does, however, enable photoacoustic imaging. Graphene-based nanomaterials are actively investigated to harness their high near-infrared absorption and conversion to acoustic waves [7][8]. Cancer treatment is clearly in the focus of the development of drug delivery applications of graphene [9][10]. The principal feasibility of pH-controlled drug pickup and delivery by GO for cancer treatment was demonstrated, too [11][12]. More biosensing and imaging applications of graphene were explored in Refs. [13][14][15][16][17].

The finite width of graphene nanoribbons (GNRs) gives, in stark contrast to infinitely extended graphene, rise to lateral quantum confinement, which in turn opens up a semiconducting gap in the band structure. The width-controlled band gap renders GNRs and their derivatives well-suited for optical and near-infrared bioimaging [18][19][20][21]. GNRs also offer a large surface area for crafting functional chemical groups or physisorbed moieties. Oxidized (oGNRs) and reduced graphene nanoribbons (rGNRs) can be prepared in the same way as GO and are envisaged as a unique drug delivery agents in cancer and tumor therapy [22][23]. In Reference [23], mice were injected with ^{99m}Tc-labeled and polyethylene glycol-coated (PEGylated) graphene oxide nanoribbons (PL-PEG-GONRs). Single photon emission computed tomography (SPECT)/ computed tomography (CT) images revealed the biodistribution in the mice 30 min after injection. There was also a strong signal in the bladder (Fig. 1a) [23]. The volume-rendering images of ^{99m}Tc-labeled PL-PEG-GONRs in mice were obtained at different times after injection (0.25, 0.75, 1.25 and 1.75 h) and showed that a strong signal appeared in the kidney after 1.75 h (Fig. 1b) [23]. The series show the renal clearance of PL-PEG-GONRs *in vivo*.

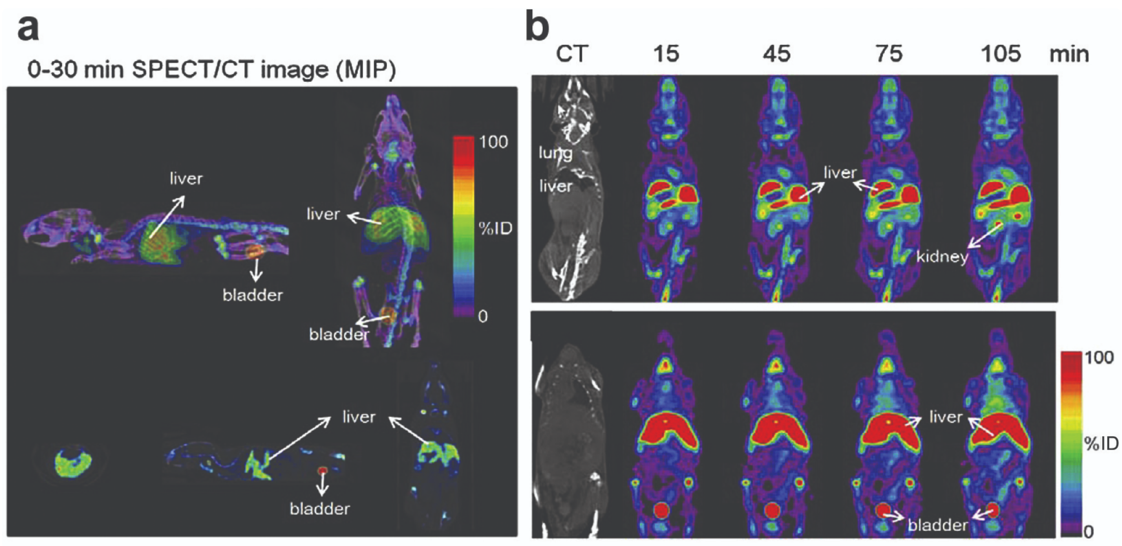

Figure 1. (a) Whole-body SPECT/CT images of ^{99m}Tc-labeled PL-PEG-GONRs in mice (from 2 angles) 0.5 h after injection. (b) Whole-body SPECT/CT and volume-rendering images of ^{99m}Tc labeled PL-PEG-GONRs in mice (0.25, 0.75, 1.25 and 1.75 h) after injection. Reprinted from [23], Copyright 2014, with permission from Elsevier.

GNRs were also employed for applications in biosensors [24][25][26]. Ultrasensitive targeting of deoxyribonucleic acid by nanoparticle-functionalized GNRs and detection by GNR-based field-effect transistor were shown [27][28].

Next to graphene and graphene nanoribbons, carbon nanotubes are also considered as promising materials for biomedical applications. In particular, endohedrally functionalized single-walled carbon nanotubes [29][30][31][32][33][34][35][36][37][38][39][40][41][42][43][44][45][46][47][48][49][50][51][52][53][54][55][56][57][58][59][60][61][62][63][64][65][66][67][68][69][70][71][72][73][74][75] can be similarly applied in bioimaging, drug delivery and biosensing. The field of medical bioapplications of carbon nanomaterials is actively developed and will in the near future revolutionize our therapeutic and diagnostic capabilities.

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