Accepted Manuscript

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PII: S0142-9612(18)30126-1

DOI: 10.1016/j.biomaterials.2018.02.032

Reference: JBMT 18505

To appear in: *Biomaterials*

Received Date: 13 December 2017

Revised Date: 6 February 2018

Accepted Date: 16 February 2018

Journal homepage: www.elsevier.com

Hydrotalcite Monolayer toward High Performance Synergistic Dual-modal Imaging and Cancer Therapy

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ARTICLE INFO

Article history:
Received 00 December 00
Received in revised form 00 January 00
Accepted 00 February 00

Keywords:
Layered double hydroxide
Gold nanoclusters
Theranostic
Magnetic resonance imaging
Fluorescence imaging
Photodynamic therapy

ABSTRACT

Recently, theranostic has drawn tremendous attention by virtue of the nanotechnology development and new material exploration. Herein, we reported a novel theranostic system by loading Au nanoclusters (AuNCs) and Chlorin e6 (photosensitizer, Ce6) onto the monolayer nanosheet surface of Gd-doped layered double hydroxide (Gd-LDH). The as-prepared Ce6&AuNCs/Gd-LDH exhibits a largely enhanced fluorescence quantum yield (QY) of 18.5% relative to pristine AuNCs (QY= 3.1%) as well as superior T_1 magnetic resonance imaging (MRI) performance (r_1= 17.57 $mM^{-1}s^{-1}$) compared with commercial MRI contrast agent (Gd(III)-1,4,7,10-tetraazacyclododecane-1,4,7,10-tetraacetic acid (Gd-DOTA): $r_1\approx$ 3.4 $mM^{-1}s^{-1}$), resulting from a synergistic effect between AuNCs and Gd-LDH. In addition, both *in vitro* and *in vivo* therapeutic evaluations demonstrate an efficient dual-modality imaging guided anticancer performance, especially the synergetic enhanced magnetic resonance/fluorescence (MR/FL) visualization of tumor site. Therefore, this work demonstrates a successful paradigm for the design and preparation of LDHs monolayer-based theranostic material, which holds great promises in practical applications.

1. Introduction

Theranostics, which combines diagnostic and therapeutic moieties into a single platform, can realize simultaneous diagnosis and therapy, real-time monitoring of drug distribution/delivery, and assessment of the treatment efficacy [1−6]. With the development of nanotechnology, a variety of inorganic and organic nanomaterials have been explored as theranostic agents with great potential applications in biomedicine [7−12]. Although much progress has been made [13−17], how to integrate diagnostic and therapeutic agent into one formulation, even with a largely enhanced synergistic effect between each component, is vitally important for theranostics effectiveness but remains a challenge. Recently, ultrathin two-dimensional (2D) nanomaterials (*e.g.*, graphene, transition-metal dichalcogenides, hexagonal boron nitride, black phosphorus, etc.), have attracted considerable interest in theranostics, owing to their intriguing quantum size and surface property [18−21]. However, previous ultrathin nanomaterials synthesized via "top-down" mechanical-exfoliation strategy, show difficulties in a fine control over composition, size, thickness, and uniformity [22−24]. Therefore, developing a new drug formulation which affords imaging and therapeutic modality on the basis

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