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# Confinement of Carbon Dots Localizing to the Ultrathin Layered Double Hydroxides Toward Simultaneous Triple-mode Bioimaging and Photothermal Therapy

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## ABSTRACT

It is a great challenge to develop multifunctional nanocarriers for cancer diagnosis and therapy. Herein, versatile CDs/ICG-uLDHs nanovehicles for triple-modal fluorescence/photoacoustic/two-photon bioimaging and effective photothermal therapy were prepared *via* a facile self-assembly of red emission carbon dots (CDs), indocyanine green (ICG) with the ultrathin layered double hydroxides (uLDHs). Due to the J-aggregates of ICG constructed in the self-assembly process, CDs/ICG-uLDHs was able to stabilize the photothermal agent ICG and enhanced its photothermal efficiency. Furthermore, the unique confinement effect of uLDHs has extended the fluorescence lifetime of CDs in favor of bioimaging. Considering the excellent *in vitro* and *in vivo* phototherapeutics and multimodal imaging effects, this work provides a promising platform for the construction of multifunctional theranostic nanocarrier system for the cancer treatment.

*Keywords:*
Carbon dots; Ultrathin layered double hydroxides; Triple-mode imaging Photothermal therapy

## 1. Introduction

Theranostics, combining therapeutic modalities and diagnostic imaging is a promising cancer therapy for concurrent monitoring and individualized treatment [1-2]. Generally, an appropriate imaging technique is a crucial part of theranostics system to precisely observe the growth and location of tumors for efficient cancer therapy and specific diagnosis. The common diagnosis approaches contain fluorescence (FL) imaging, magnetic resonance imaging (MRI), computed tomography (CT), photoacoustic (PA) imaging and so on [3-5]. Among those techniques, FL imaging is one of the most effective techniques due to its non-invasiveness, high sensitivity and simplicity for realization [6]. However, the spatial resolution of the PL imaging is not satisfaction due to its limited penetration depth [7]. On the contrary, two-photon fluorescence imaging has attracted attention owing to its higher spatial resolution induced by longer excitation wavelength [8]. In addition, PA imaging utilizes short laser pulses to generate the ultrasonic waves and provides deeper biological tissue imaging as a state-of-the-art technique [9-10]. Therefore, integrating FL and PA with two-photon fluorescence imaging into one technique can be beneficial for the cancer diagnosis, especially for detection of deeper tissues with excellent sensitivity and resolution.

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