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# Mesoporous carbon encapsulated zinc oxide nanorods derived from plant species '*Argyreia sharadchandrajii*' for live cell imaging of drug delivery and multimodal bioactivities†

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In this report, we develop a drug delivery system by binding *Argyreia sharadchandrajii* (A. S.) biomass-derived carbon encapsulated on the surface of zinc oxide (ZnO) nanorods by a two-step method. Firstly, we prepared mesoporous carbon (MC) by pyrolysis under an inert atmosphere at 800 °C for 3 h. Simultaneously, hydrothermal synthesis of ZnO nanorods was performed, followed by composite formation with surface modification of ZnO nanorods with carbon particles. The physicochemical properties of the mesoporous carbon encapsulated ZnO nanorods were studied by using X-ray diffraction, Fourier transform infrared spectroscopy, X-ray photoelectron spectroscopy, scanning electron microscopy, energy dispersive X-ray analysis, Brunauer–Emmett–Teller (BET) analysis, *etc.* The mesoporous carbon encapsulated ZnO nanorods revealed a wurtzite hexagonal crystal structure. The SEM image showed the mesoporous carbon covered on the surface of the ZnO nanorod-like morphology with an average diameter of 300–400 nm and an average length of 1.2 μm. Based on these characterizations, we have reported several bioactivities like antioxidant, antimicrobial, anticancer, and drug delivery. The carbon/ZnO composite (C@Z) loaded with doxorubicin (DOX) (C@Z-DOX) manifested sustained drug release to live cancer cells. Taking into consideration the ubiquitous availability of carbon sources and the facile synthetic strategy of composites for promising drug delivery studies and bioactivities, this approach could acquire remarkable results in biomedical research.

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## Introduction

In conjunction with the rapid growth of the population, human health issues have increased prominently worldwide due to hybridization. Cancer is indeed one of the world's most dangerous diseases, killing thousands of people every year across the globe. The development of innovative materials and processes to promote sustainability is a universal challenge with regard to human health and the environment. As such, research on green and sustainable technology and its clinical implementation is a need in the present era.[1,2] The family of carbon nanomaterials is a rapidly growing branch of novel materials with enormous promise for expansion of the scientific community.[3] Nonetheless, the synthesis of carbon nanomaterials entails the use of harmful chemical reagents, the use of fossil fuels, and high energy consumption, all of which are in opposition to green principles. To achieve the peak performance of these materials, green synthetic procedures and the use of natural resources are prerequisites.[4] The advancement of nanocarriers for drug delivery based on bioderived carbon and its nanocomposites is now a potential platform for the biomedical field.[5,6] Various forms of carbon materials like graphene, fullerene, carbon nanotubes, and carbon dots have been developed to be exploited in sensing, bioimaging, drug delivery, tumor theranostics, *etc.*[7–10] Recently,

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