Research Article

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http://www.imedpub.com

Nano Research & Applications
ISSN 2471-9838

2017
Vol. 3 No. 2 : 5

DOI: 10.21767/2471-9838.100022

Dual Mode Atomic Force Microscopy and Interferometric Scattering Imaging of Single Fe_3O_4@Au Nanoshell Synthesized for Biomedical Applications

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Citation: Khosroshahi ME, Ghazanfari L, Hasannejad Z (2017) Dual Mode Atomic Force Microscopy and Interferometric Scattering Imaging of Single Au@Fe_3O_4 Nanoshell Synthesized for Biomedical Applications. Nano Res Appl. Vol. 3 No. 2:5

Abstract

Imaging based on interferometric scattering (iSCAT) enhances the accuracy and temporal resolution in comparison to single-emitter-based techniques. In this research, we describe a combined method, which measures the size of individual magneto plasmonic Nano shells (MPNSs). The maghemite (Fe_3O_4) nanoparticles (SPIONs) with core diameter of 9.5 nm ± 1.4 nm is prepared by co-precipitation and coated by gold. The final dimension of polyvinyl pyrrolidine (PVP) stabilized MPNSs are 15.8 nm ± 3.5 nm measured by TEM. UV-Vis spectrophotometer and vibrating sample magnetometer (VSM) were used to study the optical and magnetization properties. The size of these nanoshells is determined independently by correlating their iSCAT and atomic force microscopy (AFM) images. By analyzing the number of single MPNSs, an interference intensity distribution is obtained with a nominal diameter of 15.8 nm in agreement with the size distribution recorded by TEM. It seems, the combination of iScat and AFM is capable of producing high resolution images of individual nanoparticles.

Keywords: Gold nanoshell; Optical imaging; Correlative Microscope; iScat; AFM

Received: August 01, 2017; **Accepted:** August 22, 2017; **Published:** August 25, 2017

Introduction

Currently, there is a great interest in the development of nanoparticles that combine multiple functions or properties not obtainable in homogeneous bulk materials. Recent advances in nanoengineering enables different moieties to be integrated into a single carrier with controlled optical and magnetic properties which in turn can be utilized for variety of interesting biomedical applications [1]. Unique to gold Nanoshells (AuNSs), is their Localized Surface Plasmon Resonance (LSPR) which greatly intensifies their interaction with the electromagnetic field at the metal surface. Based on the Mie theory one can expect to achieve a tunable nano system by varying the core-shell ratio, ranging from visible to the near infrared using different shape and size of Nanoshell [2]. Other significant factors when considering AuNSs include their biocompatibility because of inert surface, nontoxicity, surface chemistry i.e., they can be conjugated by specific ligands for targeting, imaging and therapies, absence of photobleaching or blinking as it is observed in the case of quantum dots, and very low oxidation [3,4]. As a result, AuNPs and equally AuNSs have been extensively used in applications like bioimaging [5,6] mainly due to their ability to convert absorbed light into heat (i.e., photothermal efficiency). Other aspect of MPNSs is due to presence of iron oxide core which enables them to move under direct controlled and influence of external magnetic field, thus can be easily used in applications such as guided drug delivery.

Studying microscopic dynamical process by single particle or an

