Development of Fluorescent Hybrid Nanostructure for Influenza Virus Detection and Cell Imaging

（課程博士・様式７）（Doctoral qualification by coursework, Form 7）

学 位 論 文 要 旨

Abstract of Doctoral Thesis

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論文題目：
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論文要旨：
Abstract：

Fluorescent hybrid nanostructure materials have received substantial attention for their promising performance in nanobio technological applications. A combination of more than one nanocomponent into a hybrid structure gives rise to new collective properties different from the constituents. These behaviours make them to generally have potential applications in biomedical methods for biosensing, bioimaging. The functional fluorescent hybrid nanomaterials with combined plasmonic-fluorescent or magnetic-fluorescent structures have unique optoelectronic properties for biomedical applications. Several types of the hybrid nanostructures are potentially useful for biomedical applications. For example, the plasmonic-fluorescent materials would be interesting as dual-use biological tags, giving the ability to visualize labeled cells using both magnetic resonance and fluorescence imaging techniques, while external magnetic fields could be employed for the directed assembly of such materials.

In this study, Chapter one reviews the design, fabrication, and biomedical applications of the fluorescent hybrid nanomaterials with combined plasmonic-fluorescent and magnetic-fluorescent structures. New collected properties of the hybrid nanostructures arising from the particle-particle interactions and the geometries are discussed from specific results of recent publications. The subsequent conjugation of biomolecules with the coated nanohybrids afforded biosensing and the use of them as multimodal bioprobes for multimodal imaging and therapy are highlighted.

Chapter two describes the fabrication of plasmonic metallic film with surface roughness for fluorescent enhancement. Surface plasmon-induced emission of organic ZnS-capped CdSe QDs quantum dots (QDs) showed six-fold increase in the fluorescence intensity and striking reduction in fluorescence lifetimes on close proximity of rough Ag nanoneedle compared to the case of smooth surfaces. The methodologies and observations

reported in this chapter could be relevant for the design and construction of high-efficiency light-emitting diodes, platform fabrication of biological and environmental monitoring, and high-contrast imaging.

Chapter three describes the biosensing application of plasmonic-fluorescent hybrid nanostructure. In the present study, a rapid, sensitive and quantitative detection of influenza A virus targeting hemagglutinin (HA) was developed using hybrid structure of quantum dots (QDs) and nanoporous gold leaf (NPGL). Anti-influenza A virus HA antibody (ab66189) was bound with NPGL and amine ($–NH_2$) terminated QDs. These biofunctionalized NPGL and QDs formed a complex with the influenza virus A/Beijing/262/95 (H1N1) and the photoluminescence (PL) intensities of QDs were linearly correlated with the concentrations of the virus up to 1 ng/mL while no PL was observed in the absence of the virus, or in bovine serum albumin (BSA, 1 mg/mL) alone. In addition, it was demonstrated that this assay detected successfully influenza virus A/Yokohama/110/2009 (H3N2) that is isolated from a clinical sample, at a concentration of ca. 50 plaque forming units (PFU)/mL. This detection limit is 2-order more sensitive than a commercially available rapid influenza diagnostic test. From these results, the proposed assay may offer a new strategy to monitor influenza virus for public health.

Chapter four describes the preparation and cellular imaging application of new fluorescent-magnetic hybrid nanocomposites based on fluorescent CdTe QDs and Fe_3O_4 MNPs. Hybrid nanostructure were developed by a simple LbL fabrication technique which retains the magnetic and fluorescence properties and also showed good optical properties, decent saturation magnetization. Fragment antigen binding (Fab) region of hCC49 was conjugated with composites, which was used for specific cancer cell imaging. Fluorescence microscopy showed significant preferential binding of the NPs conjugates by cells and showing the ability of the FMNPs probes for imaging application. Ultimately, it is believed that these particles will provide a new class of multimodal NPs for the complex biologic systems.

Overall this dissertation introduced preparation of fluorescent hybrid nanostructure combined with plasmonic-fluorescent and magneto-fluorescent. Furthermore, this thesis expanded the physical study of plasmon–semiconductor hybrid nanostructure to develop a highly sensitive detection of influenza virus based on exciton-plasmon interaction. Also, bioimaging application of newly prepared magneto-plasmonic hybrid nanostructure has been shown successfully on cancer carcinoma cells. The demonstration of these multifunctional nanocomposites and their properties has stimulated a significant increase in the development of combined detection and treatment strategies in nanobiotechnology field.