SUMMARY OF Ph.D. DISSERTATION

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Title

Glycothermal synthesis of rare earth doped $Y_3Al_5O_{12}$ nanoparticles and their applications for detecting biomolecules

Abstract

Since fluorescence is detected non-invasively and high sensitively, organic dyes are widly used for biological imaging and quantification of biomolecules in biochemistry and diagnosis. Organic dyes have several problems such as low resistance against photobleaching and small Stokes shift. Recently, CdSe/ZnS quantum dots are proposed as one of the novel probes overcoming the problems. However, it contains harmful Cd and its toxicity is considerable. In this thesis, the author synthesized rare earth doped $Y_3Al_5O_{12}$ (YAG) nanoparticles by glycothermal method and discussed the biological applications for detecting biomolecules.

Chapter 1 summarizes the background and previous studies.

Chapter 2 describes the methods for characterization.

Chapter 3 describes the influence of glycothermal conditions on the properties of YAG:Ce^{3+} nanoparticles. The mechanism on the glycothermal reaction was discussed from the formation of tetrahydrofuran and the increase of pressure with increasing the amount of starting materials. Glycothermal synthesis with citric acid decreased the primary particle size and increased the fluorescent quantum efficiency. These results were explained by the coordination of citric acid to metallic ion of the particle surface.

Chapter 4 describes the conjugation of YAG:Ce^{3+} nanoparticles with biotin to prepare the fluorescent probe. Biotinylated YAG:Ce^{3+} nanoparticles immunolabeled the avidin-immobilized beads using biospecific bonding. Their fluorescent image was observed by fluorescence microscopy. This result indicates that biotinylated YAG:Ce^{3+} nanoparticles can be used as fluorescent probes.

Chapter 5 describes the modification of YAG:Ce^{3+} nanoparticles with poly(acrylic acid) to improve their dispersibility in phosphate buffer saline. Carboxylic groups of poly(acrylic acid) were useful for the conjugation with streptavidin. Streptavidin-immobilized YAG:Ce^{3+} nanoparticles were applied for quantitative analysis of bovine serum albumin. This result shows that streptavidin-immobilized YAG:Ce^{3+} nanoparticles can be used for detecting biomolecules.

Chapter 6 describes the electrostatic adsorption of YAG:Ce^{3+} nanoparticles to poly(methyl methacrylate) beads to prepare the fluorescent beads for flow cytometry. The fluorescent intensity of the beads depend on the number of adsorption treatment. These beads were distinguished by flow cytometry. Fluorescent beads were conjugated with biomolecules and applied for detecting a biological reaction. As the result, it is confirmed that the fluorescent composite beads can be used for detecting biomolecules by flow cytometry.

Chapter 7 describes the glycothermal synthesis of YAG:Yb^{3+} nanoparticles and their characterization. YAG:Yb^{3+} nanoparticles showed near infrared emission due to the f-f transition of Yb^{3+} under the excitation of near infrared laser of 940 nm in wavelength. The decrease in the concentration of defects and the amount of organic species by calcination increased the fluorescent intensity.

Chapter 8 describes the synthesis of YAG nanoparticles co-doped with Yb^{3+} and Gd^{3+} (Gd-YAG:Yb^{3+}). Gd^{3+} ions are localized on the surface of YAG:Yb^{3+} using two step glycothermal synthesis. Gd-YAG:Yb^{3+} nanoparticles showed near infrared fluorescence and T_1-shortening effect. Therefore, Gd-YAG:Yb^{3+} nanoparticles can be used for multimodal imaging of fluorescence and magnetic resonance.

Chapter 9 summarizes the results of this study and further prospect.