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Morphology and fluorescence properties of dye-entrapped silica nanoparticles

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Abstract

Dye-entrapped silica nanoparticles can be used to label biological components in immunosensing since they are bright and photostable, less prone to stochastic blinking with sustained imaging, biologically inert and thus basically non-toxic, and compatible with aqueous system due to hydrophilic surface. Therefore, the objective of this study was to produce dye-entrapped silica nanoparticles and to determine the morphological and spectral characteristics of these particles. Silica spheres were produced by a base-catalyzed entrapment protocol, and were determined for their properties by particle size analysis, SEM imaging, and analyses for fluorescence emission spectra and fluorescence kinetics. By the above procedure, dichlorotris(1,10-phenanthroline)ruthenium(II) (Ruphen) was entrapped into the silica matrix successfully. However, the incorporation of fluorescein, rhodamine B and 5(6)-carboxytetramethyl-rhodamine was not possible. The yield, particle size and shape of the Ruphen silica nanoparticles were dependent upon reaction variables. Compared to free dye, the silica spheres generally showed higher fluorescence intensity and stability, which seemed to be very advantageous for a sensitive biomarker detection needed to evaluate food functionality.

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Keywords: morpholpgy; fluorescence properties; dye-entrapped; silica nanoparticles

1. Introduction

The importance of biomarker proteins related with a disease or metabolic syndrome in the blood of a model animal or human has been increasing in recent years for the dual purposes of diagnosis and homogeneous evaluation of food functionality. The detection of serum biomarker proteins has been conventionally carried out by HPLC, spectrophotometry and enzyme-linked immunosorbent assay. With the advent of efficient fluorescence labels, fluoroimmunosensing and fluoroimmunoassay based on the

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complex formation between antigen and antibody seems to be promising for biomarker detection due to its intrinsic sensitivity, specificity and rapidity.

Fluorescent silica nanoparticles (FSNPs) could be key nano-materials to label antibody or antigen for immunosensing since they are bright and photostable, less prone to stochastic blinking with sustained imaging, appropriate for size-selective analysis, biologically inert and thus potentially non-toxic, compatible with aqueous system due to silica surface, and suitable for multiple coding analyses. These properties make an optoelectronic immunosensor that exploits FSNP fluorescence extremely useful for the detection of serum biomarker proteins [1,2].

We have studied on various FSNPs that are manufactured by dye entrapment and core-shell procedure, and succeeded in producing silica nanoparticles that showed wide size distribution. By using these silica particles, we are going to develop highly sensitive fluorescence-based methods of immunosensing and immunoassay to detect biomarker proteins. In this study, we first report the morphology and fluorescence properties of the dye-entrapped silica nanoparticles that we have made with comparison to those of corresponding free dye.

2. Materials and Methods

2.1. Fluorescent dyes and FSNP preparation

The fluorescent dyes that were used to manufacture FSNPs comprised dichlorotris(1,10-phenanthroline)- ruthenium(Ⅱ) hydrate (Ruphen), 5(6)-carboxytetramethylrhodamine (CTMR), fluorescein and rhodamine B. The chemical structures of these dyes are shown in Fig. 1.

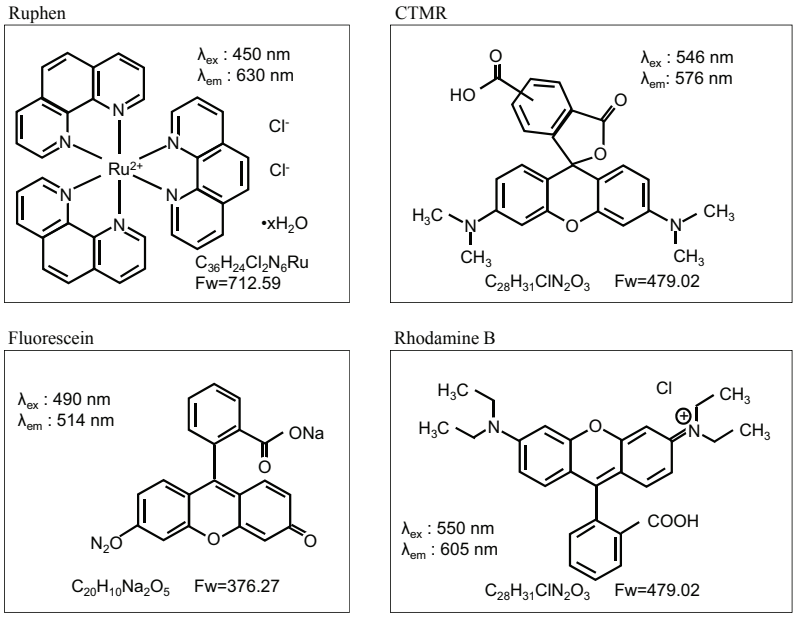

Fig. 1. Chemical structures of fluorescent dyes used to manufacture silica nanoparticles.