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Eu:Y_2O_3 highly dispersed fluorescent PVA film as turn off luminescent probe for enzyme free detection of H_2O_2

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ABSTRACT

In this work, a novel sensing scaffold consisting highly dispersed Eu:Y_2O_3 fluorescent flexible film of poly vinyl alcohol (EYCP) was synthesized by simple mixing method and applied to facilitate non-enzymatic detection of hydrogen peroxide (H_2O_2) by turn off probe of fluorescence. The fluorescence spectra of EYCP consisting number of emission sharp transitions from excited, $^5D_0 \rightarrow {}^7F_j$ ($j = 0, 1, 2, 3, 4$) energy levels of doped Eu^{3+} ion in Y_2O_3 host. In the presence of H_2O_2, the fluorescence intensity of the EYCP film was quenched due to the reduction of electron–hole pair recombination in Eu centers by electron transfer from Eu–O excited state to H_2O_2 energy level rather than $^5D_0$ state of Eu^{3+}, which reduces the number of electron in $^5D_0$ state. The EYCP film shows excellent fluorescence quenching in presence of H_2O_2 by significantly increasing concentration of H_2O_2 and completely quenched at ~150 μM. A linear relationship is observed between 0.0 and 60 μM with a correlation coefficient of 0.989. H_2O_2 sensing is also compared with the EYC nanoparticles. This study is expected to have a significant impact on further study of the Eu:Y_2O_3 fluorescent flexible film for wide range applications.

1. Introduction

In recent few years, the sensitive detection of hydrogen peroxide (H_2O_2) has shown its importance because of its wide use in various field including food, biological analysis, and environment as well as its aberrant production under the serious pathological conditions such as cancer cells, ageing, diabetes and neurodegenerative diseases [1–8]. For the detection of H_2O_2, several sensitive methods have been developed based on enzyme (such as horseradish peroxidase) [3] and enzyme-free (like graphene oxide (GO) and graphene quantum dots (GQDs) based detection) [2,9]. However, the enzymes can critically degrade the durability and life of biosensors because of their highly reactivity with surroundings resulting changes in its physical and chemical conditions [10]. More importantly, they are easily denatured by even a small increase in temperature and are highly susceptible to presence of other chemical substances and PH. Therefore, the enzyme-free detection of H_2O_2 and other biomolecules has received much a significant interest for reliable and repeatable biosensors.

However, to date, many different approaches have been developed for detection of H_2O_2 including different electrochemical methods, spectrophotometry, UV–vis spectroscopy, chromatography, as well as fluorescence [1,2,9]. However, fluorescence-based method has paid much attention due to special advantages for biological analysis such as fluorescence is extremely sensitive and can be measured by varying different parameter and damage of host system is little or none after fluorescence measurements [11–13].

Among these fluorescence-based H_2O_2 sensors, traditional organic fluorophores (e.g. organic dyes) are widely used as recognition elements. Recently, fluorescent semiconductor or quantum dots (QDs) have also attracted much attention due to their broad absorption with narrow emission with high brightness and good stability [14–16]. However, the synthesis of QDs is little difficult with multiple step and need some specific equipment. Therefore, there is need of some other fluorescent nanomaterials which can be utilized for fluorescent sensing purpose with enhanced performance. Now days, rare earth ions doped luminescent nanomaterials are highlighted as fluorescent materials with high yield which have been used in various optoelectronic devices including solar cell, phosphor, color display etc. [17–20].

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