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ORIGINAL PAPER

Detection of Sn(II) ions via quenching of the fluorescence of carbon nanodots

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Abstract We report that fluorescent carbon nanodots (C-dots) can act as an optical probe for quantifying Sn(II) ions in aqueous solution. C-dots are synthesized by carbonization and surface oxidation of preformed sago starch nanoparticles. Their fluorescence is significantly quenched by Sn(II) ions, and the effect can be used to determine Sn(II) ions. The highest fluorescence intensity is obtained at a concentration of 1.75 mM of C-dots in aqueous solution. The probe is highly selective and hardly interfered by other ions. The quenching mechanism appears to be predominantly of the static (rather than dynamic) type. Under optimum conditions, there is a linear relationship between fluorescence intensity and Sn(II) ions concentration up to 4 mM, and with a detection limit of 0.36 μM.

Keywords Starch nanoparticles · Carbon nanodots · Sn(II) ions · Fluorescence · Quenching

Introduction

Tin (Sn) ions is a type of heavy metal and it is naturally found in the environment at low level. Human are usually exposed to organic tin through packaged food, soft drinks, biocides, dentifrices, and little attention has been given to the toxicity of inorganic tin like Sn(II) ions as an environmental pollutant in natural waters. Although Sn is not a highly toxic element, high concentration of Sn(II) ions at about 0.1–1.0 gL^{-1}, may affect the flavor of the water and can also cause diarrhea [1]. It was reported that Sn(II) ions, such as stannous chloride ($SnCl_2$), could be readily taken up by human white blood cells and caused damage to DNA. The extent of damage observed was more extensive than that produced by exposure of cells to equimolar of chromium(VI), a known carcinogen and DNA damaging agent. In contrast, Sn(IV) ions was not taken up by cells, neither cause DNA damage nor inhibit the stimulation of DNA synthesis in cells [2]. Moreover, previous study on the effect of Sn(II) ions on mouse dams and fetus had reported that Sn (II) ions induced a significant decrease in the number of living fetuses, a significant increase in the number of post-implantation losses and also caused reduction in the ossification of the fetal skeleton [3]. Thus, it is desirable to have a reliable and sensitive analytical method to qualify and quantify the level of Sn(II) ions present in the environment and the ecosystem. The commonly used methods for Sn(II) ions determination include atomic absorption spectroscopy [4], electrochemical analysis [5], adsorptive stripping voltammetry [6], liquid chromatography [7], and spectrophotometry [8]. These methods have been shown to be high in accuracy and sensitivity, however they suffer from drawbacks of high operational cost, require complex sample handling, and usage of hazardous solvents. As such, it is necessary to develop analytical probes that are economical, user friendly, and of high analytical sensitivity and selectivity.

Among commonly used analytical methods, the fluorescence quenching has been one of the most successful approaches employed to detect and quantify various metal ions [9, 10]. Semiconductor quantum dots (Q-dots) fabricated from lead, cadmium and silicon as fluorescent probes are being extensively studied for optical sensing applications [11]. Such Q-dots exhibited several amazing physico-

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