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Sensitive and selective colorimetric sensor for rapid determination of Cr^{3+} ion based on thiobarbitoric acid capped silver nanoparticles

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Abstract

A simple, rapid, sensitive and selective colorimetric sensor for the determination of Cr (III) in aqueous solution based on barbituric acid functionalized silver nanoparticles (BA- Ag NPs) has been developed. Cr (III) induces BA- Ag NPs aggregation and color of BA–AgNPs solution changes from yellow to red which is easy to detect by the naked eye. The Cr (III) can be detected rapidly based on the color change of the system. The ratio of UV-Vis absorption intensity at 520 nm to absorption intensity at 418 nm (A_{520}/A_{418}) is linearly proportional to the concentration of Cr (III) from 0.012 to3.25 ppm. The presence of Cr (III) leads to a marked red-shift of extinction bands, whereas a BA-AgNPs solution does not exhibit colorimetric response upon the addition of other cations. The mechanism of interaction between BA-AgNPs and Cr (III) was studied by UV-Vis spectrophotometry and transition electron microscopy (TEM). The proposed method has been successfully used for the determination of Cr (III) in petrochemical wastewater.

Keywords: silver nanoparticles, 2-thio barbituric acid, Cr (III), colorimetric sensor

1. Introduction

Chromium is commonly found in nature, existing in two stable oxidation states, Cr (III) and Cr(VI). The trivalent form of chromium at the low concentration levels is an essential element involved in the metabolism of carbohydrates, fats, proteins, nucleic acids, and the formation of hemoglobin[1]The mean daily intake of Cr (III) for adults is recommended at 50 to 200 µg/dl.[2] However, at elevated levels Cr(III) (>50-200 mg dl) can bind to DNA thereby affecting the cellular structures and damaging the cellular components that may even lead to mutation and cancer[3,4].

Both the chromium species enter the environment as a result of effluent discharge from tanning industries, electroplating, cooling water towers, oxidative dyeing, chemical industries and steel works. In addition, there are possibilities for the transformation of Cr(III) into more lethal Cr(VI) under oxidizing conditions[5] Thus, the detection of Cr (III) in various samples has great significance.

A variety of detection techniques, such as atomic absorption spectrophotometry (AAS) [11-14] electrochemical methods [6-8] spectrophotometry [9, 10] and inductively coupled plasma-atomic emission spectrometry (ICP-MS) [15] have been reported for the determination of Cr (III). However some of these methods are complicated, expensive, and not suitable for routine analysis. Furthermore, they require sophisticated instrumentations. Therefore developing new methods is of great interest for the quick and specific detection of Chromium.

Due to their operational simplicity, low cost, high sensitivity and real time monitoring, colorimetric methods, especially colorimetric sensor based on metal nanoparticles have been interested in recent years. Because of the color changes