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Rapid and Highly Selective Detection of Heavy Metal Ions in Drinking Water using Nanosensor Based Colorimetric Assay

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Abstract

Owing to excessive usage, over time, heavy metal ions have brought on serious environmental issues as well as health hazards in living systems. Sources of drinking watergetting contaminated by heavy metals is one of the most prominent concerns among these. Hence, constructing an accurate method for the determination of heavy metals in water bodies is of great importance. In the current context, several quantitative techniques like atomic absorption spectrometry, high-performance liquid chromatography and chemiluminescence are available for this purpose. However, these methods have certain drawbacks such as long assay time, high cost and the need of sophisticated instruments and well-trained personnel. Therefore, the development of a simple, cost effective and efficient method for the detection of heavy metal ions is desirable in order to delimit its harmful effects. This study is conducted with the aim of developing a nanosensor to account for this cause. Out of various nanomaterials used in sensing applications, silver nanoparticles (AgNPs) are particularly outstanding as they possess unique optical performance. AgNPs were synthesised by reduction of silver nitrate using hydroxylamine hydrochloride. Synthesized AgNPs were then surface functionalised with two distinct ligands on two separate occasions, namely, L-cysteine and 4-mercaptobenzoic acid (4-MBA). Both these ligands contain a thiol group which displays high affinity for Ag surfaces and a carboxyl group which can interact with the surrounding, or in this case, to act as a sensor formetal ions. These nanoprobes were tested against standards of various metal ions. The presence of Cd^{2+} induces the aggregation of L-cysteine functionalised AgNPs whereas 4-MBA functionalised AgNPs undergo aggregation in the presence of Cr^{3+} ions. In both these instances, AgNPs get linked together by "carboxylate-metal ion-carboxylate" coordinative couplings, resulting in a colour change from yellow to deep orange. The concentration of the respective metal ion in each case could be monitored by the colorimetric response obtained by UV-Vis spectroscopy or even naked eyes and the detection limit is as low as 1 ppm. This novel detection system could be successfully applied to determine Cd^{2+} and Cr^{3+}in drinking water.

Keywords: Silver nanoparticles, Cadmium ions, Chromium ions, Nanosensor, Colorimetry