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Carboxymethylagarose-AuNPs generated through green route for selective detection of Hg^{2+} in aqueous medium with a blue shift

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ABSTRACT

We report here a facile, rapid, cost-effective method *via* a green route for the selective detection of Hg^{2+} in aqueous media. In this study carboxymethylagarose (CMA) is used to generate gold nanoparticles and subsequently to act as a stabilizer for the CMA-functionalized gold nanoparticles (CMA-AuNPs). The resulting CMA-AuNPs was characterized by UV–visible, X-ray diffraction, transmission electron microscopy (TEM), dynamic light scattering (DLS), atomic force microscopy (AFM) and zeta potential measurements. Zeta potential value (~ −73 mv) of CMA-AuNPs in the aqueous medium shows its higher stability. When CMA-AuNPs were exposed to an aqueous Hg^{2+}, a blue shift for its localized surface plasmon resonance absorbance (LSPR) band is observed along with significant colour change of the solution. The probe enables to detect Hg^{2+} in the range of 0.01–100 ppm even in spiked lake water samples. This study offers a sustainable and eco-friendly route for selective detection of Hg^{2+} in aqueous solution and may find potential application towards water purification.

1. Introduction

Mercury, a well-known highly toxic and dangerous environmental pollutant routinely released from small scale gold mining, coal-based power plants, metal refining plants, oceanic and volcanic emissions *etc*. The long atmospheric residence time of Hg (0) vapour and its oxidation to soluble inorganic Hg^{2+} provide a pathway for contaminating surrounding environment including water and soil. Bio-organism like bacteria living in an aqueous environments transform inorganic Hg^{2+} into methyl mercury, which is a powerful neurotoxin that concentrates through the food chain in the tissues of fishes and marine mammals. Subsequent ingestion of methyl mercury by humans from sea-food and other dietary sources is connected to the many serious problems such as sensory, motor, and cognitive disorders. The higher levels of Hg^{2+} can be dangerous to the brain, heart, lungs *etc*. of humans. According to an estimate the total mercury released into the environment reaches to ~7500 t/year (Hoyle & Handy, 2005). The United Nations ratified a new Convention on Mercury Control on January 19, 2013, following multinational dialogues that began on January 2013. Because toxic mercury ion contamination normally accumulates in existing organisms and slowly progresses over time, therefore timely detection of low concentrations of Hg in environmental water is a key issue for the researchers. Thus it is very important to develop an extremely high sensitivity, cost-effective and bio-based Hg^{2+} sensor that can provide real-time determination of Hg^{2+} levels in the environment, water, and food (Darbha, Ray, & Ray, 2007). A great effort has been exerted to detect Hg^{2+} using various detection techniques, including optical spectroscopy (Jiang et al., 2012; Lim, Escobedo, Lowry, Xu, & Strongin, 2010; Rusin et al., 2003; Wang et al., 2005; Wang, Heon Lee, & Lu, 2008), electrochemical methods (Liu, Nie, Jiang, Shen, & Yu, 2009; Spătaru, Sarada, Popa, Tryk, & Fujishima, 2001), high-performance liquid chromatography (Chen, Chen, Jin, & Wei, 2009; Lu, Zu, & Yam, 2007), inductively coupled plasma mass spectrometry, and so forth (Chen et al., 2009; Li et al., 2006). However, most of these techniques require expensive instrumentation and complicated sample preparation in certain cases, which make them inappropriate for point of use applications. To overcome these drawbacks, a variety of colorimetric sensors based on gold nano particles (AuNPs) have been attempted for the simple and rapid detection of Hg^{2+} (Kumar & Paul, 2014; Lee, Ulmann, Han, & Mirkin, 2008; Maity, Kumar, Gunupuru, & Paul, 2014; Xue, Wang, & Liu, 2008; Yu & Tseng, 2008; Zhang, Xu, Yuan, Yang, & Yang, 2011).

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