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Silica–silver core–shell nanoparticles incorporated with cellulose filter paper as an effective colorimetric probe for mercury ion detection in aqueous media: Experimental and computational evaluations

Abstract

This study investigates the facile and rapid detection of mercury ions using silica–silver core–shell nanoparticles (SiO2–AgNPs) incorporating a paper-based colorimetric sensor strip. A strong surface plasmon resonance peak at λ = 430 nm was observed for the resultant SiO2–AgNPs. The attachment of the AgNPs to the surface of SiO2 and the deposition of the AgNPs on the paper strip were confirmed using an electron microscope. The sensing of the SiO2–AgNPs toward the mercuric ion (Hg2+) in an aqueous solution indicated a rapid response in terms of a color change from yellowish-brown to colorless with a response time of 5–10 s. The prepared SiO2–AgNPs deposited on the paper strip exhibited high selectivity toward Hg2+ compared with other metal ions. The limit of detection for this assay was 1.13 nM, with an excellent correlation value of R2 = 0.9936. In addition, the complexation mode of the SiO2–AgNPs with Hg2+ was also elucidated via theoretical calculations using the density functional theory approach. This approach also provides insight into the complexation structure in terms of the electronic alteration of the SiO2–AgNPs prior to and following their interaction with Hg2+. Overall, the study demonstrates that SiO2–AgNP-based sensor materials can be utilized for the selective recognition of Hg2+ in aqueous solutions.

Keywords

Colorimetric sensor; DFT; Mercury detection; Silica–silver; SPR