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Voltammetric Study of the Affinity of Divalent Heavy Metals for Guanine Functionalized Iron Oxide Nanoparticles †

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Abstract: The smallest concentrations of heavy metal ions can be harmful to both the environment and human health. They are non-biodegradable and can accumulate all along the food chain, thus their onsite monitoring and removal is of great importance. In this work, a novel material based on (3-aminopropyl) triethoxysilane (APTES) coated iron oxide (Fe_3O_4) nanoparticles functionalized with guanine hydrazide (GH) was elaborated. Fourier transform infrared spectroscopy, energy-dispersive X-ray analysis and X-ray diffraction were used to control the synthesis and functionalization steps of the nanoparticles. The morphology and particle size were studied by scanning electron microscopy. Spherical nanoparticles with an average diameter of 45 nm were obtained. A boron-doped diamond electrode coated with GH-APTES-Fe_3O_4 nanoparticles was used to evaluate the electrochemical interaction of some divalent heavy metal ions with guanine hydrazide. Adsorption isotherms were investigated electrochemically and it was shown that the adsorption capacity of the nanoparticles towards heavy metals decreased in the following order: Cu^{2+} > Pb^{2+} > Cd^{2+}. Moreover, the signals generated by square wave voltammetry exhibited two distinct linear response ranges; the first linear plot lies in the range of 0.209 to 1.03 µM with a sensitivity of 171.6 µA/µM for Cu (II), 0.232 to 0.809 µM with a sensitivity of 156 µA/µM for Pb (II) and 0.483 to 4.97 µM with a sensitivity of 101.4 µA/µM for Cd (II). Furthermore, an excellent reproducibility was achieved with relative standard deviation (RSD) values of 4%, 5% and 10% respectively over five independent measurements.

Keywords: Guanine hydrazide; Fe_3O_4 nanoparticles; heavy metals; adsorption isotherm; guanine-heavy metal interaction