Determination of thiol traces in water samples based on the interaction between surfactant, hybrid magnetic core-shell nanospheres loaded with gold nanoparticles, and thiols

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Abstract

An initial research about the development of a simple, rapid and selective fluorescence resonance energy transfer (FRET) system for the determination of thiols in environmental samples, involving the interaction between a surfactant, a phenol-formaldehyde core-shell magnetic-gold nanoparticle and the thiol is presented. The procedure involves the following steps: 1) Optimization of the synthesis procedure to obtain hybrid magnetic core-shell nanospheres loaded with gold nanoparticles (AuNPs), 2) Characterization by using spectroscopy and microscopy techniques, 3) Study of the potential reactivity between the nanospheres and different types of thiol compounds with special interest on forensic environmental pollutants, 4) Characterization of the propose methodology by definition of its analytical features and, finally 5) Validation of the proposed methods by their application to the analysis of real environmental samples. The FRET system consists of a Fe₃O₄ core, a luminescent phenol-formaldehyde resin (PFR) shell, and AuNPs as FRET quenching agent, which were bound to the surface of the PFR shell. The luminescent Fe₃O₄@PFR spheres were exploited as donor, acting the AuNPs as acceptor. Different chemical systems in order to obtain an adequate local effective charge interaction between the surfactant/Fe₃O₄@PFR@AuNPs nanospheres/thiol were tested, choosing sodium dodecyl sulphate (SDS) for the development of the method.

The Fe₃O₄@PFR spheres exhibit native fluorescence which is quenched by AuNPs, but it rapidly increases in the presence of thiolic compounds. Excitation and emission spectra where performed for different analytes, choosing 389 nm and 445 nm as excitation and emission wavelengths, respectively. The dynamic range of the calibration graphs developed using batch methodologies were established for eight thiolic compounds (homocysteine, thioglicolic acid, glutathione, dodecanethiol, cysteamine, homocystine, cysteine and N-acetylcysteine) in the concentration range of 0.1 – 4000 µmol L⁻¹, with detection limits in the range between 0.06 to 0.71 µmol L⁻¹. The precision of the method, expressed as relative standard deviation, ranged between 1.9 and 5.1 %. The method was applied to the determination of glutathione in underground water samples with recovery values ranging between 88.7 and 104.6 %. The proposed research will progress by studying dynamic approaches and extending their potential application in other areas included in forensic analysis.