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Solid phase preconcentration and determination of trace concentrations of total gold (I) and/or (III) in sea and wastewater by ion pairing impregnated polyurethane foam packed column prior flame atomic absorption spectrometry

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ABSTRACT

A low cost solid-phase extraction based protocol for the preconcentration and subsequent determination of gold (I) and (III) in various complex matrices was developed. The method was based upon the use of the ion pairing reagent tetraheptylammonium bromide ($THA^+.Br^-$) immobilized polyurethane foams (PUFs) sorbent in packed column for retention of ultra trace concentrations of gold (III) from aqueous chloride medium of pH 3–4 at 5 mL min^{-1} flow rate. The retained gold (III) species were recovered (98.5 ± 2.7) by thiourea–HCl at 5 mL min^{-1} flow rate. Gold (I) ions after oxidation to gold (III) with Br_2 water–HCl were also retained onto the reagent packed PUFs column and recovered (96.5 ± 2.1). A linear plot of gold (III) concentration in the range 0.0–20 ng mL^{-1} and a limit of detection of 0.06 ng mL^{-1}were achieved. The method was applied satisfactorily (>95%) for the analysis of total inorganic gold (I) and/or gold (III) ions in wastewater samples and anodic slime.

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1. Introduction

Gold is one of the most important noble metals due to its wide application in industry and economic activity. Gold occurs on Earth in very low natural contents and its concentration in natural water is extremely low, in the range of 0.05–0.2 ng mL^{-1} (Pal et al., 2006). In the Earth crust, gold is widely distributed at a background level of 0.03 mg kg (Pal et al., 2006; Merian et al., 2004). Hydrothermal ore deposits of gold occur in metamorphic rocks and igneous rocks e.g. alluvial deposits (Merian et al., 2004). It is also found in-situ or at the original location of deposition from mineralizing solutions in lode deposits (Medved et al., 2004). The gold level is about 4.0 ng g^{-1} and 1.0 ng g^{-1} in basic rocks and soils, 0.05 and 0.2 ng mL^{-1} in sea-and river water samples, respectively (Pourreza & Rastegarzadeh, 2005; Barecct & Van Loon, 1999). Thus, low cost, simple, and selective methods for the pre concentration and determination of traces of gold are of great importance.

Several articles have been published on the pre-concentration and subsequent determination of traces of gold (I) and gold (III) species in various matrixes using capillary electrophoresis, solvent extraction, ion chromatography, selective transport through liquid membrane, activated carbon of apricot stones, modified multi-walled carbon nanotubes, modified organo nanoclay sorbent, 2-carboxyl-1-naphthalthio-rhodanine, Spheron (R), (biphenyl) dimethane thiol, modified octadecyl silica membrane disks, Spheron (R) thiol 1000, Amberlite-2000 and co-precipitation with nickel(II)-5-methyl-4-(2-thiazolylazo) resorcinol complex (Corma et al., 2008; Haddad & Rochester, 1988; Oleschuk & Chow, 1996; Soylak et al., 2000; Behpour et al., 2005; Li, 2006; Ertas & Ataman, 2006; Zhao et al., 2006; Hu et al., 2006; Dasaram, 2006; Medved et al., 2006; Chen et al., 2006; Morales & Toral, 2007; Elci et al., 2007; Farag et al., 2007; El-Shahawi et al., 2007; Konečná & Komárek, 2007; Tuzen et al., 2008; Soleimania & Kaghazchi, 2008; Pyrzyriska, 2005; Liang et al., 2008; Bozkurt & Merdivan, 2008; Afzali et al., 2010a). Most of these methods are too expensive, unselective; require careful experimental conditions and not compatible with the limits of gold in natural samples.

The potentialities of PUFs for trace analysis and chemical speciation of metal ions are promising (Farag et al., 2007; Braun et al., 1985; Saeed & Ahmed, 2004; Portugal et al., 2010). The applications of ion exchange PUFs and untreated PUFs have been reported for the pre concentration of traces of gold (I) species (Farag et al., 2007). The kinetics and sorption characteristics of gold (III) retention from aqueous media onto PUFs immobilized with onium cations have shown good retention and rapid equilibrium of gold (Bashammakh et al., 2009). In this context, the present article is focused on studying the retention profile and the most probable sorption mechanism of gold (III) from aqueous media onto ion pairing reagent immobilized PUFs and finally

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