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PII: S1350-4177(17)30271-7
DOI: http://dx.doi.org/10.1016/j.ultsonch.2017.06.006
Reference: ULTSON 3729

To appear in: *Ultrasonics Sonochemistry*

Received Date: 16 May 2017
Revised Date: 7 June 2017
Accepted Date: 9 June 2017

Please cite this article as: S. Kheirandish, M. Ghaedi, K. Dashtian, F. Pourebrahim, Design of a new technique based on combination of ultrasound waves via magnetite solid phase and cloud point microextraction for determination of Cr(III) ions, *Ultrasonics Sonochemistry* (2017), doi: http://dx.doi.org/10.1016/j.ultsonch.2017.06.006

Design of a new technique based on combination of ultrasound waves via magnetite solid phase and cloud point microextraction for determination of Cr(III) ions

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Abstract

In this work, we focused on development of a new techniques by coupling of ultrasound irradiation, cloud point method and magnetite solid phase microextraction for the extraction and preconcentration of Cr(III) ions from aquaes solutions. In order to reduce cost and improve practicability of proposed process a new efficient and regenerable magnetite sorbent (functionalized chitosan grafted-amino graphene oxide (GO) decorated by zinc ferrite nanoparticles (CS-GO-Zn: Fe_2O_4)) was synthesized through hydrothermal method and then characterized by FT-IR, FE-SEM, EDS and XRD analysis. Effect of initial sample volume and type, volume and concentration of eluent on the $ER\%_{Cr(III)}$ were investigated and optimized using one at a time method. Correlation between the main and interaction effects of other operational parameters such as Cr(III) ion concentration, CS-GO-Zn: Fe_2O_4 mass, sonication time, pH and solution temperature on the $ER\%_{Cr(III)}$ were investigated and optimized by central composite design coupled with desirability function approach. The results revealed that there were significant effects for most investigated terms on the $ER\%_{Cr(III)}$ and maximum ER% of 88.09% was obtained in desirability value of 1.0. This maximum efficiency was obtained at 0.035 µg/mL Cr(III) ion concentration, 40.16 ºC temperature, 0.016 g of CS-GO-Zn: Fe_2O_4, pH 6.36 and 9.20 min sonication time. In addition, under the optimal conditions the linear range, limit of detection, enrichment factor and relative standard deviation were found to be 0.02-4.4 µg/mL, 0.002 µg/mL, 23.23 and 1.68 % respectively. Finally, the method was successfully applied to the separation and preconcentration of Cr (III) ion from tap, river and mineral waters.

Keywords: Functionalized chitosan polymer; graphene oxide; cloud point extraction; ultrasound irradiation; magnetite solid phase microextraction

1. Introduction

The Cr (III) is one of the toxic metals can easily enter the environment via the wastewater of such industries including metallurgical, electroplating, battery manufacturing, surface finishing, agrochemicals, basic steel, petrochemicals, fertilizer industries and tanneries [1, 2]. The large release of Cr(III) ions into the environment via the wastewater of these industries easily entered to food chain organisms and highly dangerous to human beings (carcinogenic, allergenic and mutagenic effects), even at low concentration level [3, 4]. Therefore, it is necessary to design a safe and clean procedure for the efficient separation and determination of Cr (III) ions before their arrival in organisms. There are several separation procedures for trace Cr (III) ion determination such as liquid–liquid extraction [5, 6], coprecipitation [7] and solid phase extraction (SPE) [8, 9]. Among these, the developed solid phase extraction techniques are attractive owing to their high adsorption capacity, the small