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Trace detection of Ce^{3+} by adsorption strip voltammetry at a carbon paste electrode modified with ion imprinted polymers*

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Abstract

To develop a convenient method for sensitive and selective determination of Ce^{3+} in aqueous phase with complicated matrices, a carbon paste electrode (CPE) modified with ion imprinted polymers (IIPs) were fabricated. The polymers were prepared by precipitation polymerization using Ce^{3+} as template, allyl phenoxyacetate (APA) as monomer, ethylene glycol dimethacrylate (EGDMA) as crosslinker and azobisisobutyronitrile (AIBN) as initiator under the molar ratio of Ce^{3+}, APA and EGDMA as 1:4:40, respectively. Ce^{3+} was detected directly by differential pulse adsorptive stripping voltammetry (DPASV) and its oxidation peak appears at about 0.93 V. All parameters affecting the sensor's response are optimized and a calibration curve is plotted at a linear range of 1.0×10^{-6}–1.0×10^{-5} mol/L and 1.0×10^{-5}–2.0×10^{-4} with the detection limit of 1.5×10^{-7} mol/L. All other rare earth ions have no interference with the determination of Ce^{3+} even at a concentration 500 times higher than that of Ce^{3+}. This sensor was successfully applied to determination of Ce^{3+} in two catalyst sample solutions with RSD≤3.3% (*n*=5) and recoveries in the range of 99.2%–106.5% at our optimal conditions.

Key words: Cerium; Electrochemical sensor; Ion-imprinted polymers; Carbon paste electrode; Rare earths

1 Introduction

The rare earth elements (REEs) are widely distributed in the earth's crust in low concentration and have slight toxicity[1]. Cerium as the most abundant rare earth element has been used in many advanced materials science fields such as catalysis, chemical engineering, nuclear energy, metallurgy microelectronics, magnetism, agriculture and therapeutic application[2–5] because of its unique quality compared with other lanthanide elements. Moderate cerium can improve the crop's production[6,7] at some degree which has attracted more and more attention in recent years. However, rare-earth elements including cerium usually have accumulation toxicity; they can accumulate in human body and lead to a series of disease such as acute myocardial infarction, abnormal blood biochemical indices, leukemia and skin lesions[8,9]. Therefore, a method for selective and fast determination of cerium is in crying needs.

Many instrumental techniques have been used to detect cerium, such as neutron activation analysis (NAA)[10,11], X-ray fluorescence[12,13], inductively coupled plasma-atomic emission spectrometry (ICP-AES)[14], spectrophotometry[15], etc. All of them can detect the cerium effectively but lack of selectivity. Electrochemical methods, include spectrophotometry[16,17], potentiometry[18,19] and voltammetry[20–23], are better choices when determination of trace element due to their ease of handling, great sensitivity and selectivity as well as cost effectiveness. Generally, voltammetry analysis of cerium and other lanthanide ions are conducted via their complexes wave[24] because of their poor electrochemical response. But the selectivity of indirect method is often not satisfactory for the chelating agent can react with different metal ions at the same time. So studying a modified material to construct an electrochemical sensor for determination of cerium with perfect selectivity and high sensitivity is of great significance.

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