Anal Bioanal Chem (2003) 377 : 65–70
DOI 10.1007/s00216-003-2029-4

SPECIAL ISSUE PAPER

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High-throughput microwave-digestion procedures to monitor neurotoxic elements in body fluids by means of inductively coupled plasma mass spectrometry

Received: 4 March 2003 / Revised: 11 April 2003 / Accepted: 5 May 2003 / Published online: 24 June 2003

Abstract Microwave (MW) digestion procedures with high sample throughput (simultaneous digestion of 36 or 80 samples) and procedural simplicity (disposable plastic tubes, or re-usable liners with screw-cap) were investigated for their efficiency in routine analyses of biological samples. Different digestion vessel materials were tested for metal leaching/adsorption and thermal resistance: quartz, glass, polyethylene (PE) and polystyrene (PS). For the instrumental quantification of Al, Bi, Cd, Co, Cr, Hg, Mn, Mo, Ni, Pb, Sb, and Tl at ultra-trace levels in urine, serum, and whole blood, sector field inductively coupled plasma mass spectrometry (SF-ICP–MS) was used. The different pretreatment conditions and vessels were evaluated in terms of contamination risk, effective power of detection, accuracy, and precision. Results of analyses of serum, urine and whole blood certified reference materials (CRMs) were fully satisfactory for almost all the analytes. In the case of Hg, Mo, and Tl in serum digested in plastic containers the results were just below the lower limit of uncertainty of the certified range. On the basis of the present data the following MW procedures can be suggested:

1. for urine, digestion with nitric acid at atmospheric pressure in plastic vials;
2. for serum, digestion with nitric acid at atmospheric pressure in glass vessels; and
3. for whole blood, digestion under pressure in quartz tubes.

Because of the levels of the procedural blanks, Bi was not measurable at the concentrations expected in human fluids, and Al was accurately detectable in whole blood only.

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Keywords Neuro-toxic elements · Sample pretreatment · Microwave digestion · ICP–MS · Biological fluids · Urine · Serum · Blood

Introduction

There is evidence that metals such as Al, Cd, Hg, Mn, and Pb play a role in the aetiology of neuro-degenerative diseases [1, 2, 3]. In particular, some association between Parkinson's (PD) and Alzheimer's (AD) diseases and environmental or occupational exposure to certain elements has been recognized [4, 5, 6]. In order to determine the influence of the environment on neuro-degeneration it is essential to measure the content of trace elements in the body fluids of healthy subjects and of patients affected by AD or PD. To address this problem an epidemiological study was launched in Italy to determine the levels of different body metals in these population groups in order to assess the role of exposure to specific metals as a potential co-factor of risk in the onset of these pathologies.

Bio-monitoring campaigns generally involve the testing of a large number of specimens and the development of routine analytical procedures with high throughput is thus essential. The unique combination of multi-element measurement capabilities and excellent detection power of inductively coupled plasma mass spectrometry (ICP–MS) makes this the technique of choice for epidemiological screening purposes and for ultra-trace analysis. Biological fluids nonetheless cause some matrix-induced variations in the ICP–MS signal, such as:

1. signal suppression due to the high concentration of salts and, therefore, of easily ionizable metals (Na, K, etc.);
2. signal enhancement on some analytical masses caused by the high content of organic carbon; and
3. changes in sampling efficiency due to the gradual clogging of the torch injector and cones.

With regard to sample-preparation strategies, simple dilution of biological fluids could be preferred in order to min-