DOCTORAL THESIS

Prevalent instrumentation and material in trace elements analysis and speciations

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Prevalent Instrumentation and Material in Trace Elements Analysis and Speciations

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Abstract

In human kind, it has often been the same goal to develop with sustainability of well-being in social, economic and environmental dimensions. Without depriving of the living quality of future generations, anthropogenic development and exploitation should progress in a way to preserve environmental resources. The vision has caused the evolution of the new speciation discipline from the preceding total element concept. However, the speciation progress of mapping complex species interactions among biological and environmental systems, and eventually practical implementation in clinical health and industrial sectors, have been halted partly by the shortage of accessible instrumentations and methodologies.

A diversity of research work in this thesis, aim to facilitate convenient execution of speciation protocols in environmental and clinical monitoring, with massive research output from instrumental and material directions. The novelty of work is exhibited at four levels, featuring high-throughput instrumental methods, simplified extraction with commercial tools, modified material for specialized applications and modulation of selective material with ion-imprinting technique.

The thesis firstly described a simultaneous determination method for seven of the most environmentally concerning elemental species with high sensitivity instrument, liquid chromatography-inductively coupled plasma-mass spectrometry incorporating dynamic reaction cell technology (LC-ICP-DRC-MS), which has achieved environmental speciation at sub-ppb analyte levels. Aiming at clinical monitoring application, a solid-phase microextraction interfacing to LC (SPME-LC) was developed for simple and efficient isolation of organomercury species, with a confident 82.7–109.5% sample recovery from urine. Specific requirement for speciation, e.g. ultra-trace determination of inorganic selenium species in natural water, was duly addressed by appropriate surface functionalization of activated carbon material with tetrabutylammonium hydroxide. The 100-fold analyte enrichment of the preconcentration material enabled ppt-level Se speciation, justifying a robust application in complex natural water matrix. Material design has been proven very useful for modulating selectivity for trace element separation via the synthesis of ion-imprinted polymer (IIP), such as one demonstrated in this thesis by the scrutiny of imprinting quality among a precursor monomer series. An imidazole-based arsenic imprinted polymer, showing an exceptional selectivity towards the imprinted analyte, has extended its capability to simultaneous arsenic, vanadium, molybdenum and indium ion extraction in environmental applications.

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