PRECONCENTRATION METHOD USING AN ACTIVATABLE YIELD TRACER FOR NEUTRON ACTIVATION ANALYSIS

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(Received May 2, 1991)

Previously, the use of an enriched stable isotope as an activatable yield tracer in preconcentration steps has been tested by use of commercially available enriched \(^{116}\)Cd and \(^{156}\)Dy for biological standard reference materials.\(^1\)\(^2\) In the present work, this method has been further applied to the determination of lanthanoid contents in various kinds of samples: one coal fly-ash, three Japanese standard rocks, and eight standard soils. Samples were decomposed by alkali fusion in the preconcentration step. Thirteen elements were determined for coal fly-ash and soil samples, and 14 elements for rocks. The data obtained for coal fly-ash and standard rocks are compared with the data reported in literature. The data for soil samples have been newly determined in the present work. The ordinary instrumental neutron activation analysis and radiochemical neutron activation analysis were also performed to confirm the accuracy and usefulness of the present method.

Introduction

Instrumental neutron activation analysis is one of the simplest and most widely used methods for the determination of multiple elements in a variety of samples of various matrices. However, it is not suited for determination of many trace elements due to the simultaneous production of interfering radionuclides such as \(^{24}\)Na, which obstruct the \(\gamma\)-ray spectrometry of less abundant nuclides. For the determination of those elements, selective chemical separations are required and they are applied either after neutron irradiation, often called radiochemical neutron activation analysis, or before neutron irradiation, preconcentration method. The former method is commonly used, but it suffers from several disadvantages such as hazardous handling of a large amount of radioactivity, inadequancy for the determination of short-lived nuclides and limitation in the amount of samples to be irradiated. The latter method is free from those problems and especially superior from the standpoint of radio-
logical safety. However, it requires a careful treatment of the sample during the preconcentration process to keep it from the external contamination and, also, knowledge of the chemical yield in the chemical preconcentration steps. This chemical yield is sometimes determined by an addition of an appropriate radioactive tracer whose handling, however, has to be carried out in a restricted, radiologically controlled zone.

Many elements have more than two stable isotopes, one of which is of small natural abundance. If such an isotope is highly enriched, it can be used as an activatable yield tracer in the preconcentration steps. The method has been tested in previous work by use of commercially available enriched $^{116}$Cd and $^{156}$Dy for standard reference materials of known elemental contents.$^{1,2}$

The natural abundances of those isotopes are 7.5% for $^{116}$Cd and 0.057% for $^{156}$Dy. The enrichment of the isotope used in this work was 97.13% for $^{116}$Cd and 21.59% for $^{156}$Dy (see Table 1).$^1$ They can be tracers for the determination of chemical yields of Cd and lanthanoids in chemical separation procedures.

In the present work, the use of an enriched stable isotope as an activatable yield tracer in the preconcentration steps has been applied to the determination of lanthanoid

<table>
<thead>
<tr>
<th>Element</th>
<th>Mass number</th>
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<tbody>
<tr>
<td></td>
<td>156</td>
</tr>
<tr>
<td>Natural Dy</td>
<td>0.06</td>
</tr>
<tr>
<td>Enriched Dy</td>
<td>21.6</td>
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</tbody>
</table>

Table 1
Isotopic abundance of the enriched $^{156}$Dy used and that of natural Dy

Isotopic abundances were determined by the supplier, Oak Ridge National Laboratory.

contents in coal fly-ash, three Japanese standard rocks and eight Japanese standard soils. Decomposition of the sample is commonly carried out by alkali fusion for coal fly-ash$^3$ and rock samples, but it is usually done by aqua regia followed by HF or by mixed acids HCl and HNO$_3$ followed by HClO$_4$ for soil samples.$^3$

Soils, substantially heterogeneous, consist of both inorganic and relatively large amounts of organic matter, so that their complex composition may often inhibit an accurate determination of trace amounts of heavy metals. Accurate determinations of trace amounts of lanthanoids in the presence of such complex matrices may require, an appropriate sample pretreatment.