Determining Elemental Composition with Neutron Activation Analysis (NAA)

TECHNICAL BULLETIN

Neutron Activation Analysis (NAA) is a sensitive and accurate analytical method that identifies and quantifies elements in a sample through analysis of characteristic gamma rays emitted during radioactive decay after being irradiated in a nuclear research reactor. These distinct energy-signatures provide positive identification of the targeted elements present, while their intensity is proportional to the concentration of the element in the sample.

The NAA Method

Samples are measured directly thus avoiding problems that are common with other techniques: incomplete dissolution, loss of volatile elements or contamination from laboratory chemicals.

NAA is considered a referee method, being based solely upon nuclear, not chemical properties. The chemical forms of elements present in a sample have virtually no effect on the results.

Applications of NAA

NAA is well suited to:

- **Quality control programs** testing for high purity – quartz and silica, carbon/graphite, chemicals, pharmaceuticals
- **Difficult matrices** – quartz, oils, plastics, textiles
- **Volatile elements** – bromine, chlorine, iodine, fluorine

It is also used to verify the homogeneity of reference materials given its multi-element capability and dynamic range of analysis. The accuracy of NAA makes it valuable for certification of elemental composition and for comparison with other trace element analytical techniques.

Advantages of NAA

Analyzing samples with this technique poses the following advantages:

- Free of contamination from lab chemicals
- Limited matrix effects
- No/minimal sample preparation
- Applicable for most matrices: soil, sediment, rock, vegetation, humus, moss, coal, ash, ores and concentrates, liquids, air filters – quartz, graphite, textiles, plastics/polymers, food, pottery and oil/petroleum products
- Cost effective analysis of 30+ elements[1]
- Ability to analyze large (40g) samples, minimizing subsampling error
- Effective for limited sample quantities where only milligrams of precious material are available
- Total sample analysis, not just extractable or surface analysis as with some other analytical techniques

[1] NAA is not suitable for the analysis of lead, bismuth, or phosphorus.

Geochemical Exploration Applications

Geological surveys use NAA to test stream and lake sediments for gold and associated elements, such as arsenic and antimony. Table 1 shows the typical analysis.

Table 1: Gold +33 package (typical detection limits)

ELEMENT	ppm	ELEMENT	ppm
Antimony	0.1	Nickel	10
Arsenic	0.5	Rubidium	5
Barium	50	Samarium	0.1
Bromine	0.5	Scandium	0.2
Cadmium	5	Selenium	5
Cerium	5	Silver	2
Cesium	0.5	Sodium	200
Chromium	20	Tantalum	0.5
Cobalt	5	Tellurium	10
Europium	1	Terbium	0.5
Gold	0.002	Thorium	0.2
Hafnium	1	Tin	100
Iridium	0.05	Tungsten	1
Iron	2,000	Uranium	0.2
Lanthanum	2	Ytterbium	2
Lutetium	0.2	Zinc	100
Molybdenum	1	Zirconium	200

Halogens

NAA is applied for measurement of total Chlorine and Bromine in rocks and ores because dissolution and contamination are a problem with other techniques due to the volatility of the elements and their use in mineral acids.

Platinum Group Elements (PGE)

NAA provides results for all six PGE compared to traditional fire assay techniques that commonly determine Platinum and Palladium as shown in Table 2.

Table 2: Platinum Group Elements

ELEMENT	ppb
Platinum	20
Palladium	20
Rhodium	5
Iridium	1
Ruthenium	50
Osmium	10

Biogeochemical Exploration

Table 3: Key Elements Analyzed in Vegetation and Humus[2]

ELEMENT	ppb
Gold	0.2 ppb
Antimony	0.02 ppm
Arsenic	0.1 ppm
Mercury	0.05 ppm
Selenium	0.5 ppm
Tungsten	0.5 ppm

Iridium

The unusual abundance of Iridium in a rock layer may indicate a meteor impact. NAA is used to investigate this Iridium anomaly because of its capability of measuring Iridium in the sub-ppb range.

[2] No ashing required