



# Neutron Activation Analysis (NAA) of Food and Non Food Samples

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**Introduction** Activation analysis is based on the production of radionuclides by nuclear reactions. Most frequently radionuclides are activated by reactor neutrons (thermal neutrons). The efficiency of the activation process depends on the flux density of the neutrons, the cross section of the nuclear reaction and the atomic mass of the element. The activity and therefore the detection limit

depends also on the half-life of the activated nuclides.

The bromine content of food such as tea, vegetables and spices gives information about the use of fumigants. E. g. the use of methyl bromide results in residues of bromine in the food. NAA is also a precise method for the determination of major elements such as sodium or potassium.

**Plastics** contain high amounts of flame retarding agents such as decabromo-bisphenylether, tetrabromo-bisphenol A and hexabromo-cyclododecane. The NAA can be used to determine the total bromine content expressed as the sum of the flame retardants. Synergists such as antimonytrioxide can also be quantified with NAA via the total antimony content.

## Principle of NAA

### Activation with thermal neutrons

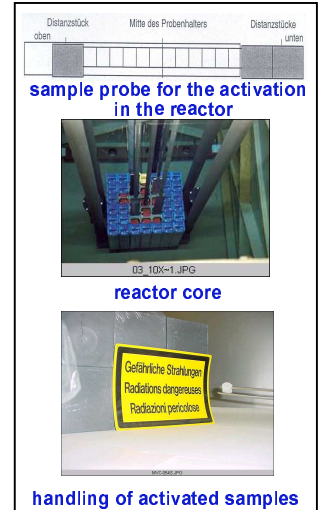
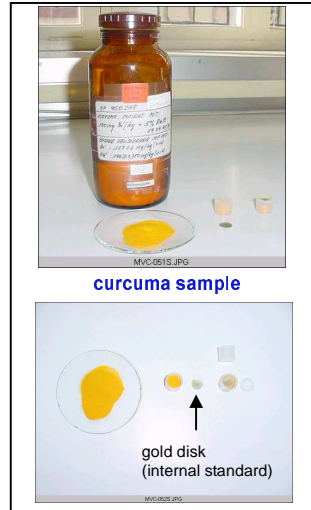
- $^{23}\text{Na} + n \rightarrow ^{24}\text{Na}$
- $^{79}\text{Br} + n \rightarrow ^{80}\text{Br}$
- $^{81}\text{Br} + n \rightarrow ^{82}\text{Br}$
- Internal standard:
- $^{197}\text{Au} + n \rightarrow ^{198}\text{Au}$

### Characteristics of the activated nuclides

Element	activated nuclide	half-life	mean $\gamma$ -Energy [keV]
Sodium	$^{24}\text{Na}$	14.96 h	1368.6
Potassium	$^{42}\text{K}$	12.36 h	1524.6
Manganese	$^{56}\text{Mn}$	2.58 h	846.8
Arsenic	$^{76}\text{As}$	26.32 h	559.1
Bromine	$^{82}\text{Br}$	35.28 h	776
Antimony	$^{122}\text{Sb}$	64.8 h	564.1
Gold	$^{198}\text{Au}$	64.56 h	411.8

Gold is used as an internal standard

## Sample preparation

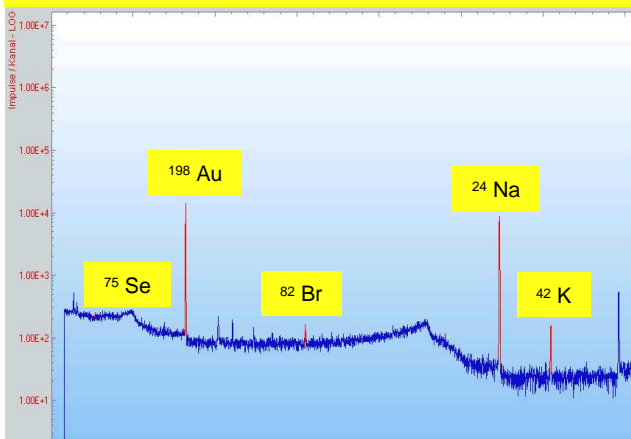


## Sample preparation

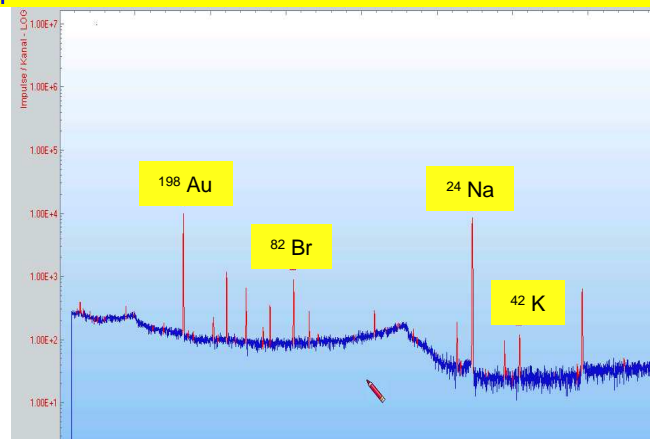
- The sample is cut into small pieces or grinded to a fine powder.
- 0.3 – 0.5 g are weighted into a sample vial and protected with a polyethylene foil.
- The corresponding gold disk (calibrated for a certain position in the sample probe) is set on top of the vial. The vial is closed.
- 12 vials are set into the sample probe at the defined positions.

- The samples are activated in the reactor for 30 minutes (power of 2 kW).
- The activated samples are taken out of the sample probe under special precautions.
- The samples are left in the laboratory behind lead shielding before  $\gamma$ -spectrometry.
- $\gamma$ -Spectrometry for 1000 seconds with a Ge-Detector and defined geometry (dead time < 2%).

## $\gamma$ -Spectrum of an activated spice sample (curcuma with 5% sodium chloride) containing 100 mg/kg of bromine



## $\gamma$ -Spectrum of an activated spice sample (madras curry) containing 11 mg/kg of bromine, 8.4 g/kg of sodium and 11g/kg potassium



## References

- V. P. Guinn, J. C. Potter: Determination of total bromine residues in agricultural crops by instrumental neutron activation analysis. Agric. Food Chem. **10** (1962), 232-236.
- A. Wyttenbach, S. Bajo, K. Farrenkothen: Bestimmung einiger anorganischer Stoffe in Süßwasser mit Hilfe der Neutronenaktivierungsanalyse. Gas Wasser Abwasser **59** (1979), 509-512.
- Eidgenössisches Departement des Innern: Verordnung über Fremd- und Inhaltsstoffe in Lebensmitteln (FIV) vom 26. 6. 1995 (rev. 21. 5. 2002).

## Statutory principles (Ordinance on Contaminants and Ingredients)<sup>3</sup> All values in mg/kg

food	tolerance value for bromide
Tea	50 mg/kg
Spice	100 mg/kg
Kakao beans	50 mg/kg
Coffee beans	50 mg/kg
Mushrooms	400 mg/kg
Cereals	50 mg/kg
Dried vegetables	100 mg/kg



A sample is placed into the  $\gamma$ -detector for the  $\gamma$ -analysis