Multielement Analysis of Biological and Geological Materials by Charged Particle Activation

著者	Suzuki N., Masumoto K.
journal or publication title	CYRIC annual report
volume	1980
page range	199-202
year	1980
URL	http://hdl.handle.net/10097/48608

VI. 7 Multielement Analysis of Biological and Geological Materials by Charged Particle Activation

Suzuki N. and Masumoto K.
Department of Chemistry, Fuculty of Science, Tohoku University

Charged particle activation has important features as follows, that is, the incident particle and it's kinetic energy to induce an optimum nuclear reaction can be freely selected. Therefore, charged particle activation analysis (CPAA) will be expected to become useful and characteristic analytical method. CPAA has been used for the determination of light elements[1] or impurities[2-3] in high pure materials, so far. But its application to biological or geological materials has a difficult problem, because of the complex elemental composition of these samples. It is not easy to calculate the stopping power or range of charged particle in these samples.

In our work, this problem has been solved by introducing the synthetic multielement standards, one is a polyacrylamide gel matrix standard[4] for analysis of biological materials, and another is a silica gel matrix standard[5] for analysis of geological ones. These were prepared to become a similar matrix nature and elemental compositions to samples. In this report, 12-MeV proton activation analysis of plant materials will be dealt with as one example.

Two kinds of plant samples were analysed, those were NIES Pepperbush and NBS Pine Needles. Synthetic multielement standard was prepared by the copolymerization reaction of acrylamide and methylenebisacrylamide in an aqueous media homogeneously containing appropriate concentration of multielement standard solution. Samples and standard were pressed into disk (13 mm ϕ) to have an enough thickness to stop 12-MeV proton. After covered with alminium foil (4.5 mg/cm^2), these were mounted on an alminium sample holder, and bombarded by 12-MeV proton (0.5 μA) for 30 min. Total charge irradiated on samples was measured by current integrater. Induced activities in samples were analysed by γ-ray spectrometry using Ge(Li) SSD (eff. 16.9 %, FWHM 1.92 keV) coupled to Northan TN-4000 PHA.

Pertinent nuclear data for proton activation are listed in Table 1. According to the data by Žikovský and Schweikert,[6] the cross sections for (p,n) reactions using determination are close to their maxima at 12-MeV proton, while interference nuclear reactions, e.g. (p,pn) reactions are negligible. Elemental concentrations were calculated by the avarage cross section method.[1] Abundances of matrix elements and calculated proton ranges of polyacrylamide standard (PAA) and Pepperbush are shown in Table 2. Though nitrogen concentration of Pepperbush is ten times lower than that of PAA, concentrations of neighboring elements, carbon (z=6) and oxygen (z=8), are just compensate for lack of nitrogen (z=7). Consequently proton ranges in PAA and Pepperbush resulted in very similar values. Therefore, the element of interest can be determined directly from the activity ratio of corresponding nuclide in sample and standard. Table 3. gives the result of duplicate analysis of Pepperbush and Pine Needles, where the certified values given by NIES and NBS are also listed. Several elements were simultaneously determined with good accuracy. Practical detection limits in this experimental condition were calculated as the elemental abundances to give a full energy peak area that correspond to 3 times of the standard deviation of background counts. These values of calcium, zinc, arsenic, iron, strontium and titanium were 260, 10, 5, 4, 3 and 2 μg/g, respectively.

In order to analyse routinely and to improve accuracy, a rotating sample holder has been developed. By using this holder, particle energy and beam size fluctuation during irradiation will be neglected and a correction for irregularity of beam current and irradiation time for individual samples will be unnecessary.

References

1) Ricci E. and Hahn R. L., Anal. Chem. 39 (1967) 794.
2) Krivan K., Anal. Chem. 47 (1975) 469.
3) Debrun J. L., Barrandon J. N., Banaben P. and Rouxel Ch., Anal. Chem. 47 (1975) 637.
4) Masumoto K. and Suzuki N., Radiochem. Radioanal. Letters 42 (1980) 99.
5) Date A. R., Analyst 103 (1978) 84.
6) Zikovský L. and Schweikert E. A., J. Radioanal. Chem. 37 (1977) 571.

Table 1. Nuclear data for proton activation analysis

Element	Reaction	Half-life	γ-ray used (keV)
S	$^{34}S(p,n)^{34m}Cl$	32.0 m	145
Ca	$^{44}Ca(p,n)^{44}Sc$	3.92 h	1156
Ni	$^{61}Ni(p,n)^{61}Cu$	3.32 h	284
Ca	$^{44}Ca(p,n)^{44m}Sc$	58.56 h	271
Zn	$^{67}Zn(p,n)^{67}Ga$	78.3 h	185, 300
Sr	$^{87}Sr(p,n)^{87m}Y$	14 h	381
Y	$^{89}Y(p,n)^{89}Zr$	78.4 h	910
Zr	$^{90}Zr(p,n)^{90}Nb$	14.6 h	141, 1130
Ti	$^{48}Ti(p,n)^{48}V$	16.0 d	945, 983, 1312
V	$^{51}V(p,n)^{51}Cr$	27.8 d	320
Cr	$^{52}Cr(p,n)^{52}Mn$	5.7 d	744
Fe	$^{56}Fe(p,n)^{56}Co$	77 d	847
Cu	$^{65}Cu(p,n)^{65}Zn$	245 d	1115
As	$^{75}As(p,n)^{75}Se$	120 d	264, 280
Sr	$^{88}Sr(p,n)^{88}Y$	108 d	898, 1836
Zr	$^{92}Zr(p,n)^{92m}Nb$	10.16 d	934
Pb	$^{206}Pb(p,n)^{206}Bi$	6.24 d	803, 881

Table 2. Elemental compositions and proton ranges of PAA and NIES No. 1 Pepperbush

	Concentration/%					Range/mg·cm^{-2}	
	C	H	N	O	Ash	12 MeV	16 MeV
PAA	36.2	6.1	19.8	35	3.0	188.1	223.2
Pepperbush	46.4	5.6	1.5	41.5	4.9	187.7	223.2

Table 3. Proton activation analysis of Pepperbush and Pine Needles

Element(conc.)	Pepperbush			Pine Needles		
	This work		NIES	This work		NBS
Ca (%)	1.43	1.53	1.38±0.07	0.40	0.43	0.41±0.02
Ti (ppm)	16	17		18	17	
Fe (ppm)	230	240	205±17	180	230	200±10
Zn (ppm)	240	240	340±20	45	45	
Sr (ppm)	35	32	36±4	6.4	5.5	4.8±0.2
As (ppm)	1.6	2.3	2.3±0.3	ND	ND	0.21±0.04