RAP CONFERENCE PROCEEDINGS, VOL. 8, PP. 97–99, 2023
ISSN 2737-9973 (ONLINE) | DOI: 10.37392/RAPPROC.2023.20
RAP-PROCEEDINGS.ORG

RESEARCH ACTIVITIES AT THE POLICE ACADEMY OF THE CZECH REPUBLIC IN PRAGUE ASSOCIATED WITH THE DETECTION AND ELIMINATION OF CBRN AND OTHER DANGEROUS MATERIAL THREATS

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Abstract. *The problems of potential threats of individual CBRN agents, which include chemical, biological, radiological and nuclear dangerous materials, are currently widely discussed. There are always some facilities and installations that are found where CBRN agents were used or stored during military operations which have been damaged or destroyed. As a result of such a situation, some of these agents were lost and went out of control. It is, therefore, essential to detect and identify these dangerous substances to control them and thus minimise their consequences on the local population's health. The principle for all CBRN agents is the same: to locate them, fix them in appropriate containers and store them in a secured place where they should be controlled. The paper summarises some research activities at the Police Academy of the Czech Republic (PA CR) explicitly aimed at areas related to radiological and nuclear components of the CBRN family.*

Keywords: *radiation and nuclear technology, CBRN, chemical, biological, radiological, nuclear, radiation exposure, protection, security*

1. INTRODUCTION

The research is ongoing at the PA CR, including the Faculty of Security Management (FSM) and the Faculty of Security and Law (FSL). Most activities in the area related to the CBRN are carried out at the Department of Crisis Management, FSM, where two research projects were carried out under the programme of the Czech Ministry of Interior of the Czech Republic [1,2]. Currently, the department is engaged in a new EU Horizon project [3] as one of 11 partners within the consortium led by the iTTi in Poznan [4].

It is obvious that the CBRN agents present a potential danger if they are misused by terrorists for malevolent action. They should be kept strictly under control, adopting appropriate preventive measures to avoid any attempts by criminals or terrorists. These materials should be kept secured and strictly controlled so that their access is maximally averted.

2. MATERIALS AND METHODS

The presence and even a tiny amount or traces of CBRN components should be detected, and appropriate methods should be applied to identify the material involved. For this purpose, many methods may be applied. One of the most efficient ways is using an instrumental neutron activation analysis (INAA), which proved to be a reliable and sensitive approach for assessing most CBRN components and evaluating other dangerous substances. This approach can also be applied to illegal drugs and narcotics seized by law enforcement authorities [5].

The method can be used for many chemical and biological samples containing the presence of specific trace elements shown in Tables 1 and 2.

The INAA is used to determine the concentration of trace and major elements in a variety of matrices. A sample is subjected to neutron flux, and radioactive nuclides are produced. As these radioactive nuclides decay, they emit gamma rays whose energies are characteristic of each nuclide. Comparison of the intensity of these gamma rays with those emitted by a standard permit a quantitative measure of the concentrations of the various nuclides [5,6].

A sample is subjected to neutron flux, producing radioactive nuclides (Fig. 1). As these radioactive nuclides decay, they emit gamma rays whose energies are characteristic for each nuclide. Comparison of the intensity of these gamma photons with those emitted by a standard permits a quantitative measure of the presence and concentrations of the various nuclides.

Since any contact with radioactive material may result in undesirable exposure, protection against external ionising radiation or radioactive contamination should be prevented or kept as low as reasonably possible and consistently below limits stated by the respective Regulatory Authority. This is why radiation levels at workplaces as well as personal exposure has to be monitored.

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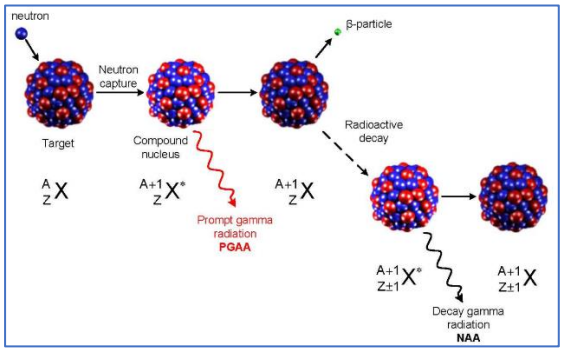

Figure 1. Principle of the INAA (based on [6])

Instrumentation for the INAA and radiation spectroscopy is principally similar: it consists of a detector, preamplifier amplifier, analogue-digital converter, multi-channel analyser and some additional digital electronics for the processing and evaluation of relevant parameters (Fig. 2).

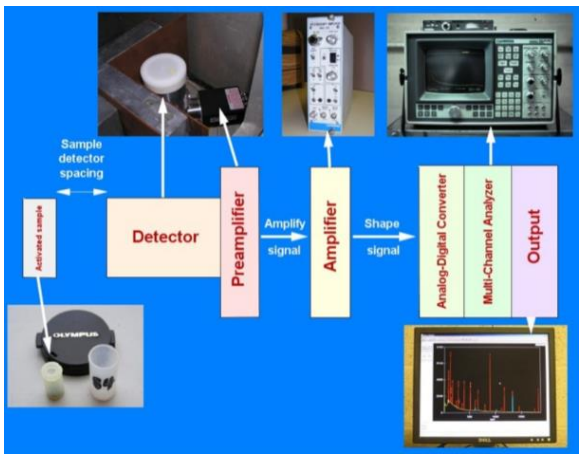

Figure 2. Flow chart of a basic gamma-ray spectrometric system

The activity arising from radionuclides determines the total amount of originally present elements. The INAA method has the following useful properties:

- very low detection limits for 30-40 elements,

- the possibility of carrying out production in a non-destructive manner without the need for storage,

- significant independence on the number of the analysed samples,

- high potential for the accuracy of results given by the principle of the method (in contrast to the electronic character of most analytical methods),

- the possibility of expressing the uncertainty of the result of an individual determination.

Neutron irradiation was carried out at a light-water tank-type research nuclear reactor LVR-15 operated by Research Centre Řež. The reactor has a maximal thermal power of 10 MW and a maximal thermal neutron flux in the reactor core of 1·1014 cm−2 s−1 [7]. For short-time irradiation (10 s–3 min), a vertical channel in the corner of the active core equipped with a pneumatic transport system is used to deliver samples in polyethylene (PE) rabbits to the laboratory within 3.5 s. For long-time irradiation (several hours to several days) in Al cans, three vertical channels located in a Be reflector at the outskirts of the active core can be used. The maximum neutron fluxes available in these channels amount to 3.1–7.0x10^{13} cm^{-2} s^{-1}, 8.4x10^{12} cm^{-2} s^{-1}–1.0x10^{13} cm^{-2} s^{-1}, and 5.6x10^{12} cm^{-2} s^{-1}–6.4x10^{13} cm^{-2} s^{-1} for thermal, epithermal and fast neutrons, respectively. Selective irradiation with epithermal and fast neutrons can be realised using special capsules made of or inlaid with 1 mm-thick Cd shielding. Short-time irradiation is carried out with individual samples, calibrators, and neutron fluence monitors. Long-time irradiation is performed batch-wise, with 20–25 samples, calibrators and neutron flux monitors in each batch.

More details about the instrumentation and calibrations were described in one of the previous papers [8].

3. Some Results

The feasibility of the INAA was demonstrated in the analysis of samples of heroin and cocaine (Table 1 and Table 2) which proved the use of this method also for some components of CBRN [8].

Table 1. Content of some elements in heroin samples based on the INAA [8]

Nuclide, unit	Sample code				
	H963	H1056	H1210	H1317	H1354
Na, mg kg^{-1}	2080±30	296±4	701±11	220±30	279±4
Al, mg kg^{-1}	11±3	52±2	21±2	<60	48±4
Cl, mg kg^{-1}	686±21	44±14	25±14	77800±1300	37±11
K, mg kg^{-1}	<40	61±4	<24	<4000	<200
Ca, mg kg^{-1}	640±50	2260±100	3220±120	1360±150	760±50
Sc, µg kg^{-1}	1.2±0.2	11.4±0.3	5.2±0.3	2.3±0.4	1.9±0.2
Cr, mg kg^{-1}	<0.09	1.48±0.04	1.41±0.05	6.72±0.13	0.32±0.04
Mn, mg kg^{-1}	0.29±0.03	4.15±0.19	3.41±0.18	9.5±0.4	3.16±0.15
Fe, mg kg^{-1}	5.5±1.4	80±3	112±3	59±5	30.8±2.4
Co, µg kg^{-1}	<9	12±3	19±4	42±4	<10
Zn, mg kg^{-1}	2.91±0.10	2.85±0.09	24.7±0.4	12.4±0.3	8.98±0.20
Br, mg kg^{-1}	0.98±0.15	0.11±0.03	0.19±0.04	19100±400	0.11±0.03
Sr, mg kg^{-1}	<4	10.0±0.8	13.3±0.9	16.7±1.5	<5
I, mg kg^{-1}	15.08±1.1	<1.5	<1.5	<21	<1.0
Sm, µg kg^{-1}	<7	5.6±3	<5	NSC	<4
Th, µg kg^{-1}	<7	9±3	16±3	25±6	<8

Table 2. Content of some elements in cocaine samples based on the INAA

Nuclide, unit	Sample code				
	K1300	K1301	H1328	K1358	K1400
Na, mg kg^{-1}	189±3	8.64±0.14	2.27±0.06	20.9±0.3	31.3±0.5
Cl, %	10.39±0.17	8.95±0.15	10.31±0.17	10.89±0.18	9.57±0.16
K, mg kg^{-1}	8±3	55±0.7	<2.5	<2.1	<3
Sc, µg kg^{-1}	2.1±0.2	13±0.2	1.1±0.2	1.3±0.2	1.1±0.2
Cr, mg kg^{-1}	0.20±0.05	<0.1	<0.1	<0.1	0.49±0.05
Mn, mg kg^{-1}	5.6±0.4	1.5±0.3	<1.1	<1.1	<1.0
Co, µg kg^{-1}	<9	11±3	<8	9±3	10±3
Zn, mg kg^{-1}	9.6±0.2	19.3±0.4	0.81±0.05	30.0±0.5	16.1±0.3
Br, mg kg^{-1}	8.53±0.15	52±0.09	11.31±0.18	10.41±0.17	6.44±0.11

The achieved results show the different elemental compositions of the analysed heroin samples and cocaine. We were able to determine 16 elements in at

least one out of five of the heroin samples analysed samples (see Tab. 1); the contents of the other 28 elements were below the detection limit in all of them analysed samples. Detection limits for the elements Ag, Sb, Cs, Tb, Dy, Ho, Tm, Yb, Lu, Hf, Ta were in the range of tens of μg kg^{-1}, for the elements V, Ni, Cu, Ga, R s, Se, Rb, Mo, Cd, Ba, Pr, Nd, W and U this was within the sensitivity of detectors. For the elements Mg, Ti and S, the detection limits were between tens and thousands of ng kg^{-1}. One of the heroin samples (Hl317) differed significantly from all others.

4. Conclusion

It has been demonstrated that radiation and nuclear methods can be successfully used to analyse various environmental samples as well as specific components of CBRN. The advantage is that the procedure is essentially non-destructive and a similar measuring system can also be used for the detection and identification of radiological and nuclear components of the CBRN. The results of the presented data are comparable with those obtained by other authors [5,8].

As to the use of neutron activation analysis, certain complications may include the availability of strong neutron sources where usually research reactors are used.

During any work in a radiation environment, some strict measures related to radiation protection of personnel should be followed. It is especially necessary to avoid any exposures above the radiation exposure limits for workers (20 mSv per year). In any case, radiation exposure should be kept to the very minimum but still allowing the performance of the measurement.

Radiation doses in terms of effective dose equivalent and radioactive contamination should be continuously monitored, and results documented. In case of any unusual situation, relevant emergency plans and procedures should be observed. In the case of the INAA, the radiation field is mixed since it has both components: gamma photons and neutron radiation. This is why special attention should be paid to selecting appropriate dosimeters and detectors which can distinguish their response to gammas and neutrons separately.

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