International Atomic Energy Agency

INDC(VN)-4/GI
INT(85)-5

INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

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July 1985

ACTIVATION CROSS-SECTIONS OF (N,P) AND (N,N'P) REACTIONS INDUCED BY 14.8 MEV NEUTRONS ON CR ISOTOPES (+)

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ABSTRACT. 14 MeV neutron cross-sections of (n,p) and (n,np) reactions for Cr isotopes were measured by activation method using high resolution HP Ge gamma-ray spectroscopy. Corrections were made for coincidence summing effect and interference of (n,n'p) process to (n,p) reaction cross-section values.

INTRODUCTION. In the framework of a coordinated research program on "Measurement and analysis of neutron activation cross-sections around 14 MeV" supported by the International Atomic Energy Agency we carried out the measurement of cross-sections of (n,p) and (n, n'p) reactions induced by 14.8 MeV neutrons for Cr isotopes which were reactor structural material components and were requested in WRENDA-81.

EXPERIMENTAL. 3 samples of enriched isotopes of Cr (^{52}Cr, ^{53}Cr, ^{54}Cr) were prepared by pressing Cr (or Cr_2O_3 in case of ^{54}Cr) powder into polyethylene bags in disk form with diameter 20 mm. Table 1 gives the technical characteristics of the samples used. Each sample was sandwiched between 2 aluminium foils which were used as reference basing upon the reaction $^{27}Al(n,p)^{27}Mg$. The thickness of each aluminium foil is 51 mg/cm^2.

Table 1

Sample N°	Isotopic abundances % ^{52}Cr	^{53}Cr	^{54}Cr	^{50}Cr	Chemical form	mixture weight (mg)	element weight (mg)	sample thickness (mg/cm^2)
1	99.9	0.08	0.01	0.01	metal	1000	1000	318
2	1.85	98.0	0.12	0.03	metal	1000	1000	318
3	10.8	10.0	78.6	0.6	oxyde	1447	1000	461

(+) This work have been performed under IAEA contract number 3515/RB

Enriched isotopes were supplied by TECHSNABEXPORT, Moscow, USSR.

14 MeV neutrons used for irradiation were produced by the NA3-C neutron generator (KFKI, Budapest, Hungary). The accelerating voltage was 120 kV, the ^{3}H-Ti target had 40 Ci activity and 45 mm diameter with 0.3 mm molybdenum backing and was cooled by water. The neutron energy calculated for the irradiation geometry was 14.8 ± 0.2 MeV. The neutron yield was approximately 10^{10} n/s. The time variation of neutron flux was monitored by a fast scintillation detector connected to the ND-66B multichannel analyzer working in multiscaling mode. The count numbers in each channel were used to correct the time variation of neutron flux using a basic program performed on ND-66B.

The measuring system consisted of a 62 cm^3 coaxial high purity germanium detector (ORTEC) with resolution 2.1 keV at the 1332 keV line of ^{60}Co, an spectroscopy amplifier (ORTEC model 572) and the ND-66B multichannel analyzer (Nuclear Data). The measured data recorded on floppy disks were processed by the PDP-11/23 computer. Peak positions, peak areas and their standard deviations were determined by the program MORI. Dead time, pile-up losses were taken into account. Peak areas were corrected also for coincidence summing effect using the program KORSUM of Debertin and Schotzig (1979). Full energy peak efficiencies and total efficiencies (needed for the KORSUM program) at closed geometry were determined using single line gamma ray sources (Hg 203, Co-57, Cs-137, Mn-54, Sr-85, Zn-65, Y-88...) furnished by the Institute for Research, Production and Application of Radioisotopes, Prague, Czechoslovakia.

Nuclear data needed for calculation of cross-section values were taken from /1/. The cross-section value of the reference reaction ^{27}Al(n,p)^{27}Mg was accepted to be 72± 5 mb /2/. Table 2 gives the nuclear reactions under consideration together with related decay data of the products and coefficients for correction of summing cascade coincidence calculated by the program KORSUM. Self-absorption of gamma rays in the samples was taken into accont using attenuation coefficients given in /3/ with interpolation for

missing values.

Table 2

Nuclear Reaction	Main gamma line energies, keV	Half-life	Intensity %	Coefficient for correction of summing effect
$^{52}Cr(n,p)^{52}V$	1434.1	3.75 min	100	1.0012
$^{53}Cr(n,p)^{53}V$	1006.3	1.61 min	89.3	1.0041
$^{54}Cr(n,p)^{54}V$	834.8	49.8 s	97	1.1407
	989.0		80	1.1533
	2259.4		45.6	1.3173
$^{27}Al(n,p)^{27}Mg$	834.7	9.46 min	70	1.0039
	1014.4		30	0.9981

Table 3 gives possible major sources of systematic errors and statistical errors in relative standard deviations. All errors were summed up quadratically in calculating total error.

Table 3

Source of errors	Relative standard deviation ,%
Flux monitoring	3
Efficiency of detector	3
Irradiation and counting geometry	0.5
Nuclear Constants	5
Sample attenuation	0.5
Instrumental errors(timing,dead time losses...)	1
Counting statitics	2-5

Fig.1(a,b,c gives gamma spectra of irradiated samples.

In calculating the (n,p) cross-sections for ^{52}Cr and ^{53}Cr correction was made for the contribution of the (n,n'p) reactions for ^{53}Cr and ^{54}Cr respectively basing upon the known values of isotopic abun-

-dances of the samples and using the linear least square method to resolve the contribution of different reactions leading to the same activation product.

Table 4 gives the cross-section values obtained in comparison with those given by other authors.

Table 4

Nuclear Reaction	Cross-section (mb)		
	This work	Ref.	
$^{52}Cr(n,p)^{52}V$	82 ± 8	$8C\pm6$	/4/
		94 ± 10	/5/
$^{53}Cr(n,p)^{53}V$	46 ± 6	48 ± 7	/4/
		40 ± 7	/5/
$^{54}Cr(n,p)^{54}V$	14 ± 2	18 ± 3	/4/
		15 ± 4	/5/
$^{53}Cr(n,np)^{52}V$	14 ± 3	12 ± 3	/4/
$^{54}Cr(n,n'p)^{53}V$	6.5 ± 1.5	3 ± 0.8	/4/

From the above table we can see that except the last case our results are in good agreement with those given by /4/ within errors limits quoted.

Acknowledgment. We would like to thank Dr.I.Ribansky and Dr.M.Mohawk from the Institute of Physics,Bratislava,Czechoslovakia for their precious help in experimental work and data processing.We are thankful also to Dr.Nguyen Khac Thi and Dr. Le Cat Tuong from the Institute of Physics,Hanoi,Vietnam for their computer assistance.

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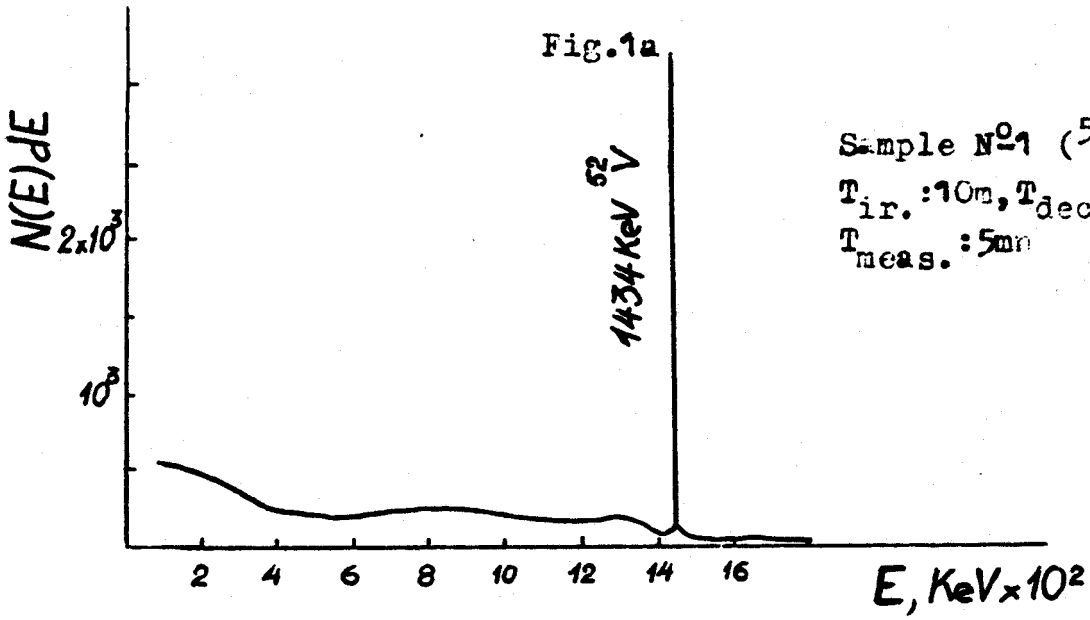
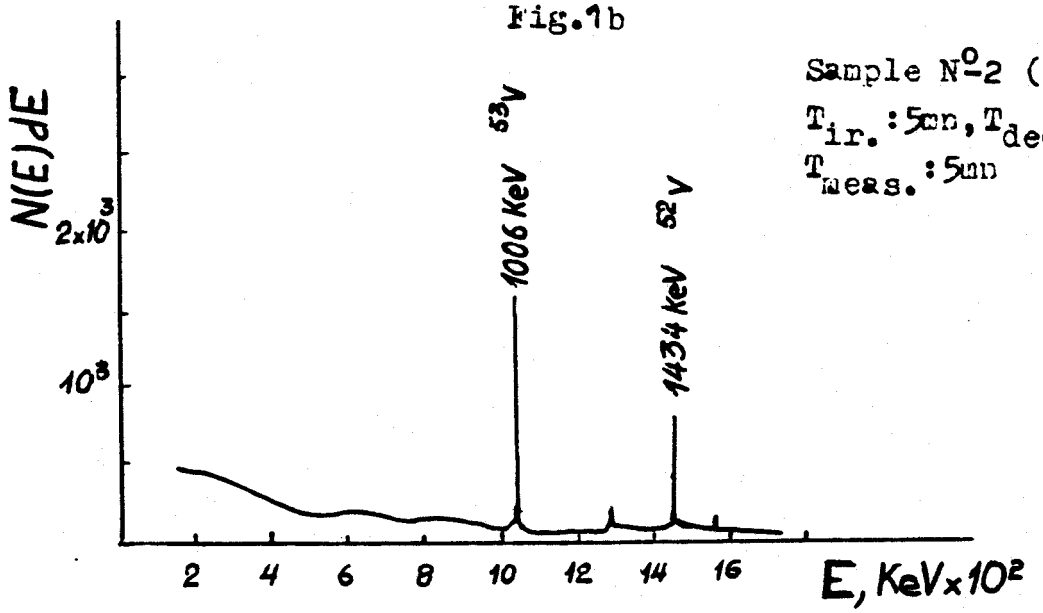
Fig.1a



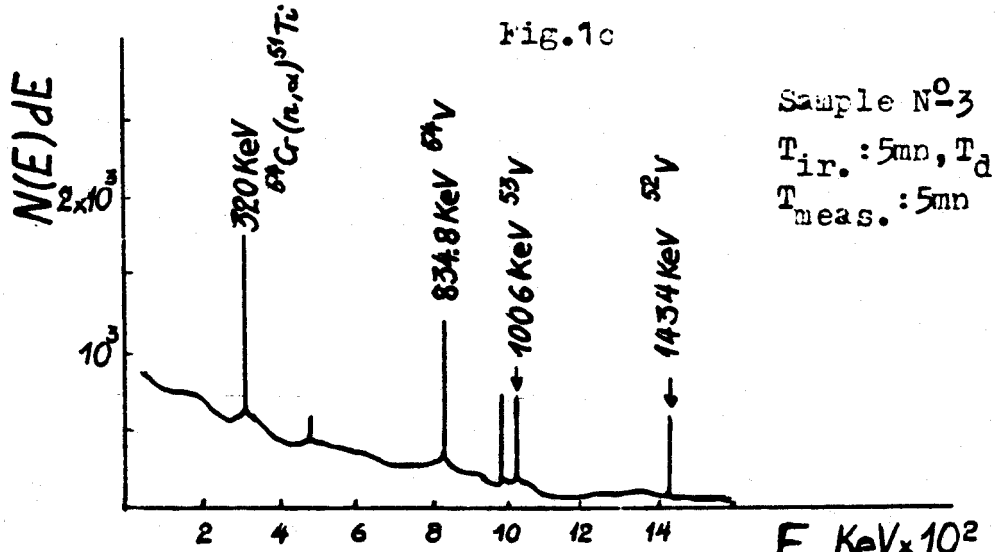
Sample N°1 (^{52}Cr)
$T_{ir.}$: 10m, T_{decay}: 30 s
$T_{meas.}$: 5mn

Fig.1b



Sample N°2 (^{53}Cr)
$T_{ir.}$: 5mn, T_{decay}: 20s
$T_{meas.}$: 5mn

Fig.1c



Sample N°3 (^{54}Cr)
$T_{ir.}$: 5mn, T_{decay}: 20 s
$T_{meas.}$: 5mn