HIGH-RESOLUTION GAMMA-RAY SPECTROMETRY IN THE DETERMINATION OF TRACE ELEMENTS IN HUMAN FINGERNAILS

A. A. Petushkov,* D. M. Linekin, J. F. Balcius and G. L. Brownell

Massachusetts General Hospital, Boston, Massachusetts

Trace-element concentrations in the human fingernail have been found to be related directly to trace-element concentrations in the blood (*1*). Consequently, *in vivo* activation analysis of human fingernails may prove to be useful in the diagnosis of disease states as has been suggested in cystic fibrosis (*2*). Kanabrocki *et al* (*3*) used neutron activation and NaI(Tl) gamma-ray spectrometry to detect gold, copper, manganese and sodium in the fingernails of 20 subjects. The use of lithium-drifted germanium [Ge(Li)] detectors offers higher resolution and the possibility of detecting a larger number of elements.

In this paper five elements were studied in the thumbnails of three subjects, using neutron activation and a high-resolution Ge(Li) gamma-ray spectrometer. Using this solid-state detection system, quantitative and qualitative determinations of sodium, bromine, gold, zinc and antimony were obtained without chemical separation.

Samples were obtained from three subjects using stainless steel clippers. All samples were taken from fingers of the left hand of adult subjects ranging from 22 to 38 years of age. The fingernails were washed carefully in 2 × distilled water and then finally washed in analytical reagent-grade acetone. The samples were then packaged in clean polyethylene vials (Olympics Plastics of California), and the caps were hermetically sealed by heat fusion. Irradiations of the samples were carried out at the M.I.T. 5-MW nuclear reactor. The samples were irradiated for 9 hr in a thermal neutron flux of 2×10^{13} n/cm²/sec. After irradiation the samples were transferred to cold poly-vials, and gamma-ray spectra were obtained as described by Cooper *et al* (*4*), except that the anti-Compton shield was not used. The sensitive volume of the Ge(Li) crystal was 35 cm³. Spectra were taken 9 hr and 10 days post-irradiation (Figs. 1, 2).

As seen in Figs. 1 and 2, the photopeaks of ^{24}Na, ^{82}Br, ^{198}Au, ^{65}Zn and ^{124}Sb are well defined and lend themselves to quantitative determination with reliable accuracy. The assays of the trace elements

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For reprints contact: Gordon L. Brownell, Head, Physics Research Laboratory, The Massachusetts General Hospital, Boston, Mass. 02114.

* Present address: Laboratory of Radiation Dosimetry, Institute of Industrial Hygiene and Occupational Diseases, Academy of Medical Sciences, Moscow, USSR.

TABLE 1. TRACE ELEMENTS IN THE HUMAN FINGERNAIL CONCENTRATION (μg/gm)

Element	Isotope	Present work*			Results in Kanabrocki, Ref. 3
		Subject 1	Subject 2	Subject 3	
Na	^{24}Na	240 ± 5	1,660 ± 33	3,900 ± 80	900 ± 537
Br	^{82}Br	3.8 ± 1.2	11.0 ± 2	15.0 ± 0.85	Not reported
Au	^{198}Au	0.006 ± 0.002	0.085 ± 0.004	0.059 ± 0.002	0.52 ± 0.58
Zn	^{65}Zn	1,200 ± 43	2,700 ± 135	2,300 ± 70	Not reported
Sb	^{124}Sb	10 ± 4.6	29 ± 14	57 ± 10	Not reported
Cu	^{64}Cu	Not detected	Not detected	Not detected	51.13 ± 22.84
Mn	^{56}Mn	Not detected	Not detected	Not detected	0.87 ± 0.31

* Statistical uncertainty given.

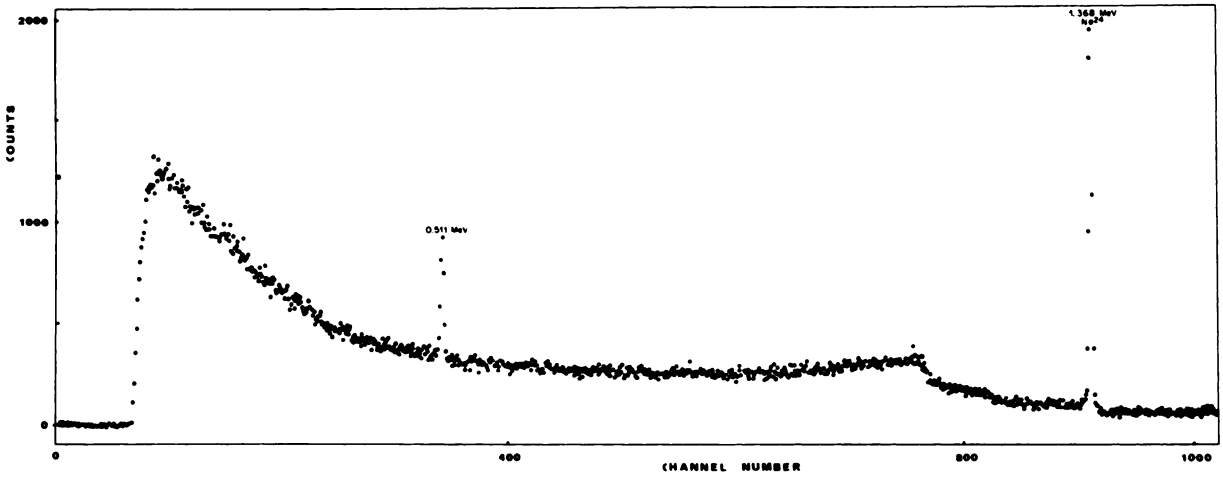

FIG. 1. Gamma-ray spectrum of thumbnail approximately 9 hr after 9-hr irradiation.

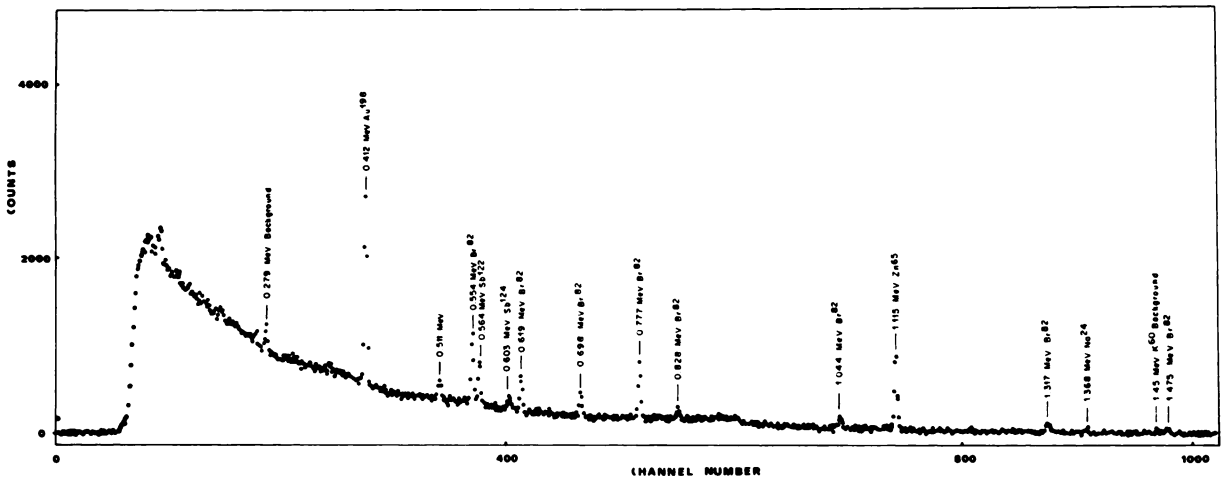

FIG. 2. Gamma-ray spectrum of thumbnail approximately 10 days after 9-hr irradiation.

were accomplished by using the comparator technique: that is, simultaneously irradiating a known standard (5% accuracy) with the unknown and comparing the area under the photopeaks.

In Table 1, trace-element concentrations are given in μg/gm of fingernail and compared with the results of Kanabrocki *et al* (*3*). Since the number of samples in our study is few, a quantitative comparison cannot be made with the average values obtained by Kanabrocki *et al.* However, it can be seen that ^{82}Br, ^{65}Zn and ^{124}Sb were detected and ^{56}Mn and ^{64}Cu were not detected in our study, whereas ^{82}Br, ^{65}Zn and ^{124}Sb were not reported by Kanabrocki. However, they detected high concentrations of ^{64}Cu and ^{56}Mn. Sodium-24 and ^{198}Au were found in both cases.

Although it is possible to take additional spectra at later periods for determination of lower level, longer lived isotopes, we have limited our study to the first week post-irradiation since our aim is to apply this technique as a possible clinical diagnostic tool. These data seem to indicate that such an application is feasible, but much more work is necessary before a correlation of trace levels and disease states can be made.

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