Scientific Research and Essays Vol. 7(1), pp. 86-89, 9 January, 2012
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE11.1717
ISSN 1992-2248 ©2012 Academic Journals

Full Length Research Paper

Efficiency and resolution of HPGe and NaI(Tl) detectors using gamma-ray spectroscopy

I. Hossain[1]*, N. Sharip[1] and K. K. Viswanathan[2]

[1]Department of Physics, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.
[2]Department of Mathematics, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.

Accepted 23 December, 2011

The energy dependence of efficiency and resolution of HPGe and NaI(Tl) detectors using gamma-ray spectroscopy were investigated in this paper. It was found that the resolution of the detector was directly proportional to the energy of gamma-ray and its efficiency was exponentially proportional to the gamma-ray energy. The resolution of HPGe detector (GC2018, diameter 60.5 mm and length 31.5 mm) is better than NaI(Tl) detector (ORTEC 905-3, size 2'' × 2'') and efficiency of NaI(Tl) is larger than HPGe detector.

Key words: HPGe, NaI(Tl), gamma ray, resolution, efficiency.

INTRODUCTION

Gamma ray is electromagnetic radiation produced by nuclear interactions. It is generally characterized as high energy radiation and short wavelengths within the electromagnetic spectrum. This high energy can cause serious damage when absorbed by living cells. Because of its deep penetration property, shielding of gamma ray requires large amounts of mass. Usually materials with a high atomic number and high density are used for better absorption (Knoll, 1989; Gilmore and Hemingway, 1995).

Gamma-ray spectrometry can be performed using different types of radiation. Ge-detectors combine high resolution with low background to an extent not achievable with thallium activated sodium iodide (NaI) detectors, despite the latter being widely employed for gamma-ray spectrometry. Calculating of the amount of radionuclide present requires knowledge of the efficiency of the detector in the counting geometry. Several methods of determining the efficiency in these unusual geometries have been developed over the years (Hult, 2007; Metzger et al., 2002). To quantify the efficiency variation as a function of energy, measurements have been made on several coaxial detectors of various crystal types and sizes in different geometries. The full-energy peaks from 60 keV to 1.3 MeV were used. In the present work, the energy and the range of activity use for each of these detector types, along with their efficiencies and energy resolutions were measured. Standard analytical gamma-ray peak shape codes were evaluated for both detectors. The goal of this work is to investigate the characterization of NaI(Tl) and HPGe detectors.

*Corresponding author. E-mail: imamhossain@utm.my.

EXPERIMENTAL METHODS

The experiments were carried out in the nuclear laboratory, Department of Physics, University of Technology, Malaysia using HPGe and NaI(Tl) detector, gamma rays spectroscopy methods, lead, copper and aluminum as shielding materials. The measurements were performed for HPGe detector using multi-nuclide source produced by Eckert and Ziegler Isotope Products (www.isotopeproducts.com). The source was obtained in a 500 ml Marinelli Beaker and activity is 2.995 µCi or 110.8 kBq. The radio nuclides used were Cd-109, Co-50, Te-123 m, Cr-51, Sn-113, Sr-137, Y-88, Cs-137 and Co-60. For NaI (Tl) detector sources Cs-137 and Co-60 with energy 662 and 1332 keV were used. With these sources the efficiency and energy resolution for each detector was determined as a function of gamma-ray energies. The time taken for data acquisition was 10800 seconds or 3 h. A diagram of the experimental setup used is shown in Figure 1.

RESULTS AND DISCUSSION

The energy resolution and efficiency of the HPGe and NaI(Tl) detectors were determined by measuring and

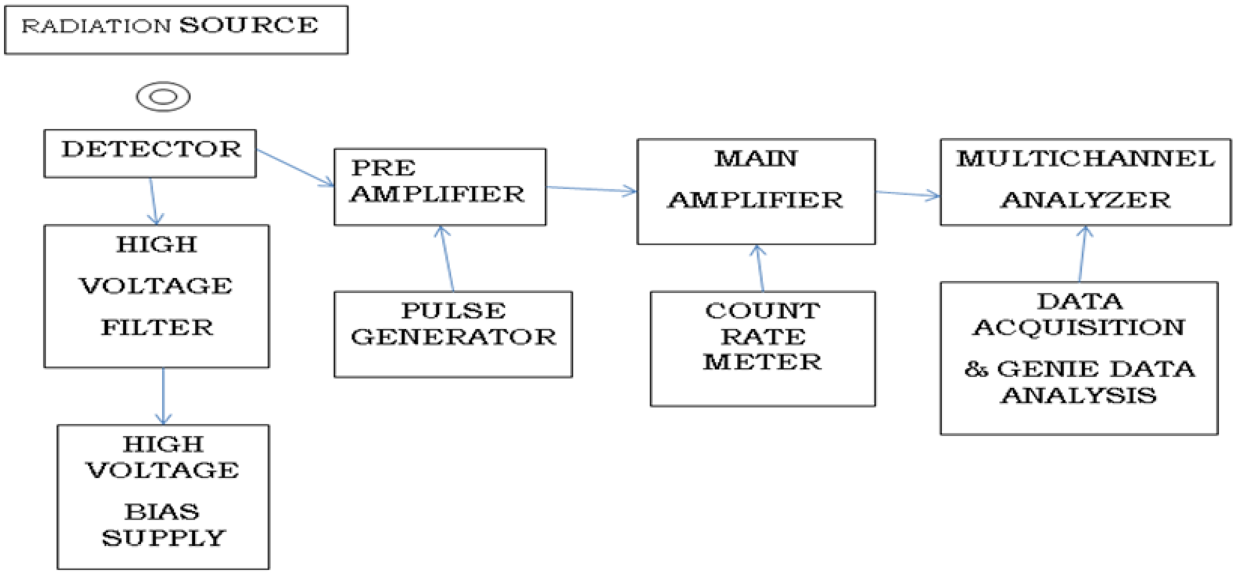

Figure 1. Block diagram of the experimental setup.

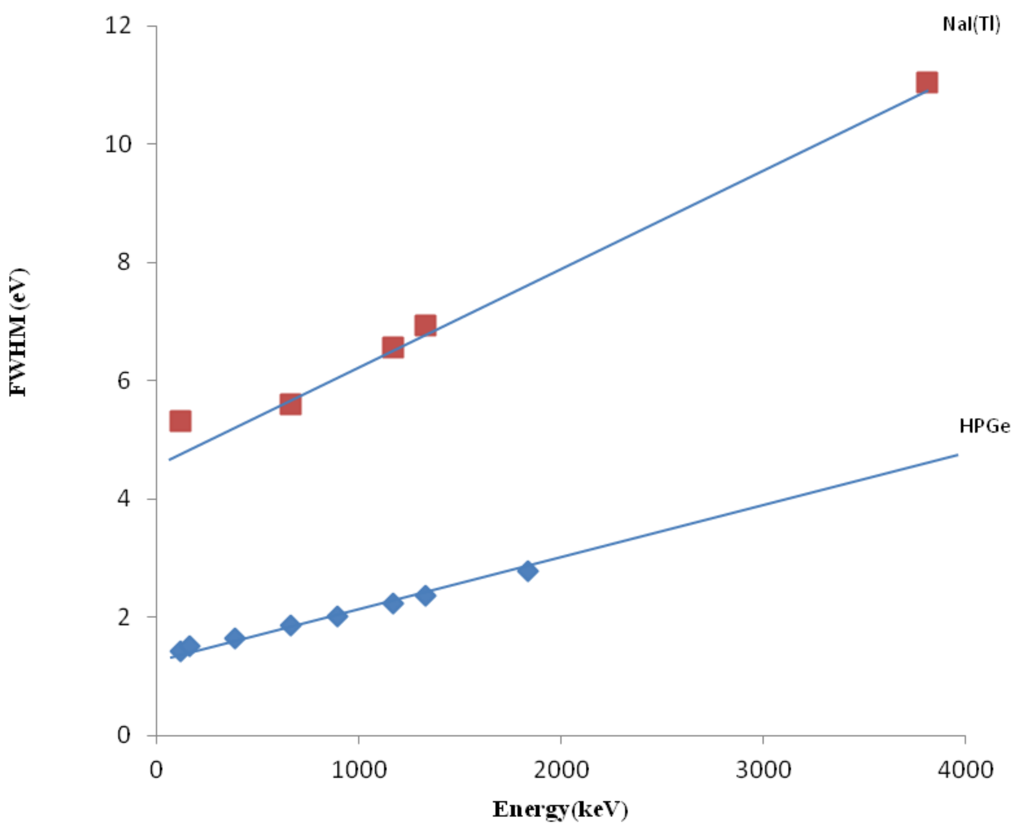

Figure 2. Resolution of HPGe detector and NaI (Tl) detector as function of energy.

analyzing the gamma ray activities of the radioactive standard sources. The data obtained was tabulated and graphically presented. Thus, the performance of both detectors was discussed by comparing the parameters. Multi-channel analyzer systems were used to collect and analyze the signal. The spectra were collected from the

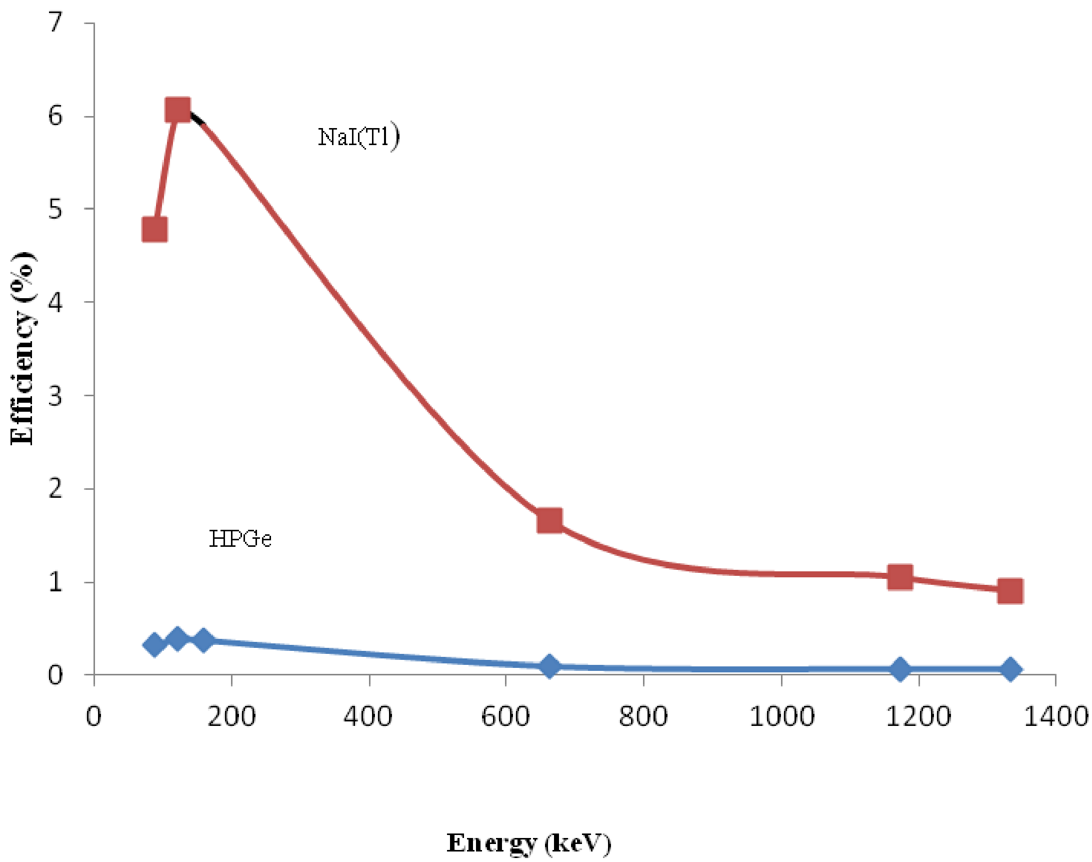

Figure 3. Efficiency of HPGe detector and NaI (Tl) detector as function of energy.

^{137}Cs and ^{60}Co sources.

Energy resolution and efficiency

The average value of full width at half maximum, FWHM, corresponds to the resolution of the high purity germanium (HPGe) and sodium iodide (NaI (Tl)) detector. It describes how useful the detector is for clearly separating two adjacent energy peaks and hence, for unambiguous nuclide identification. Nevertheless, both detectors display a similar behavior with FWHM increasing with gamma-ray energy. Figure 2 indicates FWHM as a function of gamma ray energies for NaI (Tl) and HPGe detectors. It is shown that resolution is directly proportional to the gamma rays energies. But FWHM is much smaller in Ge detector compared to the NaI (Tl) detector. Therefore HPGe offers very good resolution and is a good instrument for nuclide identification compared to the NaI (Tl) detector.

Efficiency is a measure of the percentage of radiation that a given detector detects from the overall yield that is emitted from the source into a solid angle of usually 4π in the photo-peak. Equation 1 was used to calculate the efficiency of the detector:

$$\varepsilon_t = \frac{C_t}{N_\gamma} X100\% \qquad (1)$$

Where, C_t = the total number of counts per unit of time over the whole recorded spectrum (minus the background rate); N_γ = the number of γ -rays emitted by the source per unit of time.

The detector's diameter and thickness define the sensitivity. Thickness directly influences the energy beyond which the efficiency starts to decrease sharply. Figure 3 displays efficiency as a function of gamma ray energies for NaI (Tl) and HPGE detectors. It is shown that efficiency decreases exponentially with increases in gamma ray energy. But efficiency is much smaller in the Ge detector than the NaI (Tl) detector. The NaI (Tl) detector used has a large area detector and therefore it has a high probability of detecting γ-radiation. The HPGe detector offers less detection efficiency compared to the NaI (Tl) detector. It means that, HPGe is efficient in detecting nuclides with lower energy but not nuclides at higher energy. Na(TI) detector is a more efficient detector compared to HPGe detector although it has a very poor resolution.

Conclusion

High purity germanium detector has better resolution compared to the scintillation type of detector, Sodium iodide (NaI). The HPGe detector offers the advantage of resolving two closely located energy points and has the ability to detect a mixture of nuclear material. Even though HPGe has very good resolution, it is less efficiency than the NaI (Tl) detector. Its efficiency decreases exponentially with energy and only can detect nuclides with lower energy rather than nuclides at higher energy.

ACKNOWLEDGEMENT

The author would like to thank the Research Management Centre (RMC), Universiti Teknologi Malaysia for providing the research fund Universiti Grant Program (GUP) from the Ministry of Higher Education, Malaysia to complete this work.

REFERENCES

Eckert and Ziegler Isotope Products, Inc. manufactures, distributes, and supplies radioactive sources 24937 Avenue Tibbitts, Valencia, CA 91355 (USA) (www.isotopeproducts.com).

Gilmore G, Hemingway JD (1995). Practical Gamma-Ray spectrometry (New York: Wiley).

Hult M (2007). Low-level gamma-ray spectrometry using Ge-detectors. IOP publishing Metrologia 44: S87-S94.

Knoll GF (1989). Radiation Detection and Measurements (New York: Wiley)

Metzger RL, Van Riper KA, kearfott KJ (2002). “Radionuclide depth distribution by collimated Spectroscopy” ANS Topical Meeting, Santa Fe, NM.