Calibration of Gamma-rays Detectors Using a New Trend to Calculate the Effective Solid Angle

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By

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Summary

Study the detector efficiency in different geometries is the basis to calculate the exact activity of radionuclides. Many applications are based on the studying of radioactive materials, like, studying of the nuclear structure, identification of radioisotopes and their activities, estimating the absorbed dose, and determination of the reaction cross sections. The new developments in gamma-ray spectrometry have expanded and have been applied in diverse fields such as astrophysics and medical therapy where highly accurate measurements of gamma-rays are needed. This has been achieved by way of tracing the interaction of gamma-rays in the semiconductor and scintillation detectors and the energy deposited within. This thesis is concerned with the determination of the effective solid angle of different source-detector arrangement, then calculating the detector full-energy peak efficiency by using the efficiency transfer principle. The thesis contains six chapters, (116) references, two appendices, plus English and Arabic summaries.

The First Chapter:

This chapter introduces a general introduction about the gamma-rays applications, nuclear instrumentation, interactions of gamma-rays with matter, studying the detection mechanism and the types of detectors. Special emphasis is given to sodium iodide scintillation detectors NaI(Tl) and associated auxiliary equipment to carry out the measurements. In addition, applications of gamma-ray spectroscopy are considered. Literature review on previous work has been presented. Also the aim of the work is presented at the end of this chapter.

The Second Chapter:

The theoretical background of this work has been introduced in this chapter. The definitions and explanations of different types of detector efficiencies have been introduced in this chapter; also the different factors which may affect the detector efficiency determination are discussed. The various methods used to determine those efficiencies (Experimental, Empirical, Monte Carlo, Direct Mathematical and Efficiency transfer) methods; have been presented.

The Third Chapter:

In this chapter, a new analytical formula to calculate the effective solid angle of different source- to-detectors arrangement is introduced. The effective solid angle calculations were done with the well type detectors. The effective solid angle of axially and none axially point sources that placed inside the well cavity or outside it is presented. The effective solid angle of the disk and the cylindrical shape sources of different dimensions that placed inside or outside the detector cavity are also presented in this chapter. Attenuation coefficients of all absorbers between the sources and the detectors active

medium, the source container and the source material have been taken into account in the effective solid angle calculations.

The Fourth Chapter:

This chapter contains a brief description of the setup parameters of used sources (point, small capsule and cylindrical shape sources). Cross sectional drawings of the Plexiglas holders used in the measuring process were presented. The specification of the used detectors details were mentioned beside their manufactory diagrams. A description of Genie 2000 data acquisition and analysis software used in spectrum acquisition, spectrum analysis and data management as well as short description of ANGLE 4 software used in comparison with the experimental Full energy peak efficiency results were presented.

The Fifth Chapter:

This chapter includes the values of the effective solid angle ratios that have been used to convert from certain calibration geometry to another one. Also, it contains the comparisons between the measured and the calculated full-energy peak efficiencies and the deviation percentage between them. Remarkably excellent agreements are clearly noticed between the measured and the calculated full-energy peak efficiency values. For more evidence a comparison was made with the full-energy peak efficiencies obtained using ANGLE 4 software, which also shows a very good agreement with the experimental values.

The Sixth Chapter:

This chapter includes the conclusions drawn out of the presented thesis.

The Appendix I

This appendix contains the basic programs that have been used in calculations of the effective solid angles of different sources-to-detectors arrangement.

The Appendix II

This appendix contains the list of publications.