Journal of Molecular Imaging & Dynamics
ISSN: 2155-9937

Khan, J Mol Imag Dynamic 2017, 7:2
DOI: 10.4172/2155-9937.1000135

Mini Review Open Access

Radioactivity: Detection and Measurement

Nida Tabassum Khan*

Department of Biotechnology, Faculty of Life Sciences and Informatics, Balochistan University of Information Technology Engineering and Management Sciences, (BUITEMS), Quetta, Pakistan

***Corresponding author:** Nida Tabassum Khan, Department of Biotechnology, Faculty of Life Sciences and Informatics, Balochistan University of Information Technology Engineering and Management Sciences, (BUITEMS), Quetta, Pakistan, Tel: 03368164903; E-mail: nidatabassumkhan@yahoo.com

Rec date: Jul 29, 2017; **Acc date:** Sep 04, 2017; **Pub date:** Sep 07, 2017

Copyright: © 2017 Khan NT, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract

Detection and quantification of emitted radioactive particles such as alpha, beta or high energy gamma and X-rays from a contaminated sample or source can easily be achieved by using different qualitative and quantitative approaches. In contrast to qualitative approach, quantitative methods of radioactivity detection are widely used because of their potential to identify and detect high as well as low radioactivity levels with increased sensitivity and counting accuracy. Gamma /X-Ray spectroscopy, Alpha /r Beta counters, Scintillation detectors including GM counter and LSC detectors are the well-recognized quantitative methods employed for this purpose.

Keywords: Gamma spectroscopy; Quantitative methods; Scintillation detectors; Liquid scintillation counting

Introduction

Qualitative and quantitative methods are used for the identification of radioactive elements and measurement of their radioactivity.

Qualitative methods

Such approaches detect the presence or absence of radioactive emissions. Although, detectability of very low levels of radioactivity is still a challenge [1].

Quantitative methods

Since radioactive particles such as alpha and beta are short range radiations easily affected by minute amounts of dust or precipitation? Therefore, quantitative measurements of such radiations in the field are not that easy to achieve only simple identification is possible.

Though high energy X-rays and gamma particles are less affected by field environment still exact estimate of radioisotopes is not accomplished. Scintillation detectors, gamma and X-ray spectroscopy and alpha-beta counting are lab based quantitative methods for radioactivity measurement [2,3].

Gamma and X-ray spectroscopy

Spectroscopy involves the use of high-resolution gamma or X-ray detector and a multi-channel analyzer to precisely estimate the energies of the gamma and X-rays emitted by a contaminated sample [4].

Such techniques are mostly not recommended for exact quantification of radioactivity. However, by regulating the detection efficiencies and by using standard spectral unfolding techniques, relative concentration of various isotopes present in the contaminant sample may be determined accurately. For example, FIDLER spectroscopy techniques estimates relative abundance of Am-241 to Pu-239 [5,6].

Alpha and/or beta counting

Another quantitative technique for accurate quantification of contamination in a sample. Alpha and/or beta counting apparatus consists of a thin ZnS layer coupled to a photomultiplier tube which is positioned in a shielded vacuum chamber to remove background radiation and radiation absorption by air [7].

A thin sample is placed into the chamber under the detector to measure the count rate which is then interpreted to an absolute evaluation of sample activity, depending on the geometry of the experiment. Besides gas-flow proportional counters are also used in which sample is placed into the chamber of a proportional counter. Any emitted radiation causes gas ionization that is automatically amplified and counted. One common problem of both the counters that extremely thin sample preparation is required to reduce self absorbtion, preparation of which is time consuming. It often involves dissolving the sample onto a sample holder then evaporation of the solvent leaving a very thin, negligibly absorbing sample. For example, Ludlum Model 3 with a Ludlum 44-9 “pancake” (GM) probe is a typical beta and/or gamma detector which is sensitive to gamma particles and detects field radiations that produces readings two to three times greater than the background reading [8,9].

Scintillation detectors

Scintillation detectors are basically gamma detectors or gas ionization detectors which consist of ionization chamber, proportional counters, or GM counters.

Geiger-Mueller (GM) counter: One of the first and most sensitive devices employed to detect and measure low levels of ionizing radiation. The underlying principle is based on the emission of radiations that remove electrons from the atoms it strikes producing ions which passes through the oppositely charged plates resulting in a flow of current which is read on a meter. Geiger counter apparatus consists of Argon and Neon gas filled metal tube. A thin wire acts as a metal conductor with applied voltage of 500 volts, runs inside the tube to a connector on the tube body [10]. Charged particles when enters the GM counter tube, knock off electron (ionization) from gaseous atoms upon collision. The ionized gas produces current which is

Citation: Khan NT (2017) Radioactivity: Detection and Measurement. J Mol Imag Dynamic 7: 135. doi:10.4172/2155-9937.1000135

further amplified to be measured. Geiger counter also contains a quenching agent to stop current flow after few microseconds. Older GM tubes used methane gas which upon each detection break downs resulting in a limited tube lifetime. In contrast, modern GM tubes uses gases that does not break increasing tube dependability and reliability. Each gas discharge incident is measured in counts per minute (CPM) in GM counter with the capability to detect even a single emitted particle. However, ionization chambers cannot detect a single particle emission but requires high levels of radiations to be detected. GM counters are smaller in size with nearly 100% efficiency for measuring alpha and beta particles but only 1 to 2% efficiency is reported in case of gamma and X-ray's detection [11,12].

Liquid scintillation counting: A standard laboratory approach for radioactivity quantification of low energy radioisotopes emitting either alpha or beta particles or both. It requires specific combinations of compounds i.e., LSC aqueous-based cocktails to transform the energy into measureable light pulses [13]. LSC cocktails comprised of aromatic organic solvent, scintillator (fluors) and the surfactants. The underlying principle behind LSC detection involves the excitation of aromatic solvent through the energy emitted from a radioactive isotope. This energy is then absorbed through the scintillator causing electrons to be excited which subsequently decays to a ground state and produces a light pulse which is detected by the photomultiplier tube (PMT) of the Sp. In liquid scintillation detection method, background counting (radiations from external sources recorded as counts) is mostly low but background counts can contribute to experimental error if the number of actual counts is low. Currently used scintillation counters have a conveyor system that automatically introduces samples into the counter chamber for counting to reveal the measured output in printed form.

Uses of scintillation detectors: It is an important component of imaging and non-imaging devices such as scintillation well counters and thyroid probes. Thyroid probe is used in iodine bioassay to measure thyroid 131I uptake [14,15].

Conclusion

Both the qualitative and quantitative approaches are used for the identification and quantification of high and low levels of radioactivity. Each of these methods has their own benefits with recognizable drawbacks. Choice of radioactivity detection method entirely depends on the type of particle being emitted from the contaminated sample.

References

1. Knoll GF (2010) Radiation detection and measurement. John Wiley & Sons, NY, USA.
2. Friedlander G (1981) Nuclear and radiochemistry. John Wiley & Sons, NY, USA.
3. Currie LA (1968) Limits for qualitative detection and quantitative determination. Application to radiochemistry. Anal Chem 40: 586-593.
4. Jenkins R (1995) Quantitative x-ray spectrometry. CRC Press, UK.
5. Grieken RV, Markowicz A (2001) Handbook of X-ray Spectrometry (Edn) CRC Press, UK.
6. Gilmore G (2011) Practical gamma-ray spectroscopy. John Wiley & Sons, NY, USA.
7. Hine GJ, Brownell GL (2013) Radiation dosimetry (2nd edn) Elsevier, The Netherlands.
8. Krane KS, Halliday D (1988) Introductory nuclear physics. John Wiley & Sons, NY, USA. p.465.
9. Delaney CF, Finch EC (1992) Radiation detectors: physical principles and applications. Clarendon Press, Oxford, England, UK .
10. Papp Z, Daróczy S (1997) Measurement of radon decay products and thoron decay products in air by beta counting using end-window Geiger-Muller counter. Health physics 72: 601-610.
11. Corbin FT, Swisher BA (1986) Radioisotope techniques. Research methods in weed science. Southern Weed Science Society, Champaign, IL, USA. p. 265-276.
12. Altshuler B, Pasternack B (1963) Statistical measures of the lower limit of detection of a radioactivity counter. Health Physics 9: 293-298.
13. Patterson MS, Greene RC (1965) Measurement of low energy beta-emitters in aqueous solution by liquid scintillation counting of emulsions. Anal Chem 37: 854-857.
14. Hendler RW (1964) Procedure for simultaneous assay of two β-emitting isotopes with the liquid scintillation counting technique. Anal Biochem 7: 110-120.
15. Faires RA, Parks BH (1973) Radioisotope laboratory techniques, Abe books, Butterworths, London.