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OVERVIEW OF LIQUID SCINTILLATION COUNTING

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I. History

Liquid scintillation counting is a relatively new tool in the field of nuclear radiation instrumentation. It was first introduced in the early 1950's by the work of C.T. Reynolds, etal, and H. Kallman and M. Furst. Like so many newly developed methods it did not just appear one day, but evolved through a series of discoveries and waited for technological advancements to make it possible. Before describing the liquid scintillation method and counters we use today, it might be best to retrace the evolution of this counting method to give you a feeling how the method was developed, why it was needed and the role it plays today in the field of nuclear radiation measurements.

The earliest reported means for detecting the poorly understood radiations that were emitted from uranium and radium compounds was to expose photographic film. Although this method of detection was discovered by pure chance it set the theme around which all future nuclear radiation detection instrumentation would be designed. This being that nuclear radiation was not to be measured directly but through a secondary measurement of its effects on matter. In the early 1900's just such a device was devloped using a fluorescent screen composed of ZNS crystals. The alpha radiation, emitted from a radioactive material held close to the screen, would impinge on the screen and produce scintillating light flashes. In the darkened room these light flashes could be seen using an optical scope and the events recorded.

As time passed and continued work brought the discovery of other new nuclear radiations, such as beta particles and gamma rays, new counters were developed to detect and measure these new radiations. In the 1920's, new counters were perfected containing specific gases that would ionize when acted upon by these newly discovered nuclear

V. Liquid Counters

The first liquid scintillation counters were one PMT counters as is shown in Figure 2. Samples were contained in 60 milliliter vials and optically coupled to the face of the PMT with oil or grease. A description of the counter and its capabilities can best be summarized in the following tabulation:

Single PMT upright
Sample optically coupled to PMT
PMT gain controlled by H.V. ($\times 10^6$)
Pre-amp gain x 30
Amp gain x 3000
Single channel - variable discriminators
Background count rate approximately 1000 cpm
(thermionic PMT noise and vacuum tube electronics)
C.E. ^3H approximately 20%
^{14}C approximately 40%
Calibration of LSC by internal standards

The first significant revisions to be incorporated into the liquid scintillation counters were that of background count reductions. This was accomplished with two modifications. First, a coincidence system of counting was introduced by F.N. Hayes whereby two PMT were used to view the sample rather than one PMT. One PMT was called an analyzer tube which recorded photon events in the vial and the other was called a monitor tube which verified the presence of the event occuring in the vial. Coincidence electronics imposed the criteria on the liquid scintillation system that only pulses from two PMT arriving within a time interval of approximately one microsecond would be considered

and activated by high specific activity tritium we can examine the preparations with resolutions of approximately 0.1 micron. This examination must be done with an electron microscope and allows us to look at separated strands of DNA.

The last area that we will look at in this discussion is taking the data produced by radioactive atoms decaying as measured by nuclear instrumentation and converting this information into meaningful applications oriented data. If the experiment is a purely qualitative analysis where you are merely trying to determine the presence of radioactivity, no special considerations need to be made. However, the great majority of biological and medical experiments require quantitative information - either relative quantitative data or absolute quantitative data. In the former case, the detection efficiency must be constant throughout the experiment and in the latter the efficiency must be determinable.

DETECTION EFFICIENCY

$$\text{EFF} = \frac{\text{COUNT RATE (CPM)} - \text{BACKGROUND (CPM)}}{\text{DISINTEGRATION RATE (DPM)}}$$

As seen on this slide, the detection efficiency is defined as the count rate minus the background divided by the disintegration rate.

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model 3

LIQUID SCINTILLATION EQUIPMENT