Appendix IX LIQUID SCINTILLATION COUNTING (LSC)

A. INTRODUCTION

The process by which radioactive decay energy is converted to visible light and measured in an organic liquid environment is called LIQUID SCINTILLATION COUNTING (LSC). In Liquid Scintillation Counting, the amount of light produced is proportional to the amount of radiation present in the sample and the energy of the light produced is proportional to the energy of the radiation that is present in he sample. This makes LSC a very convenient tool to measure radioactivity.

B. THE SCINTILLATION PROCESS

The radioactive sample to be measured is combined with a scintillation cocktail. Scintillation cocktail is a mixture of an organic solvents; an emulsifier which ensures proper mixing of aqueous samples in the organic solvents; and a fluor, a substance which has the capability of fluorescing when excited by the radioactive substance. The light that is produced from the excitation of the cocktail by the radioactivity is directed to the photomultiplier tubes, which then convert the light into a measurable electrical pulse (see Figure 1). The amplitude of the pulse is proportional to the amount of light that has reached the photomultiplier tubes. Therefore, the pulse height at the output of the tubes is proportional to the energy of the radioactive sample. In order to discriminate between true radioactive decay events and the electrical background noise of the photomultiplier tubes, LS counters have a *coincidence gate* which allows measurement only of those events which occur simultaneously at both photomultiplier tubes.

The pulses from the photomultiplier tubes are analyzed, converted to digital form, and stored in the appropriate channel of a multichannel analyzer, corresponding to the radiation energy (Figure 2). This ability to sort the pulses detected according to their amplitude allows discrimination between emissions of different energies. For example, three commonly used isotopes ^{3}H, ^{14}C, and ^{32}P have beta energies of 18.3, 156 and 1,710 keV respectively. By setting windows judiciously, it is possible to specify which energy range is to be measured.
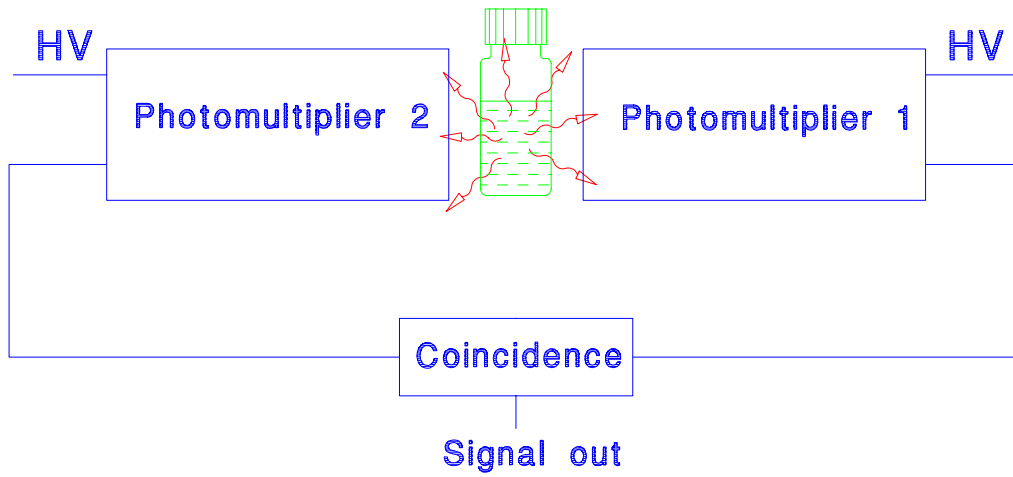
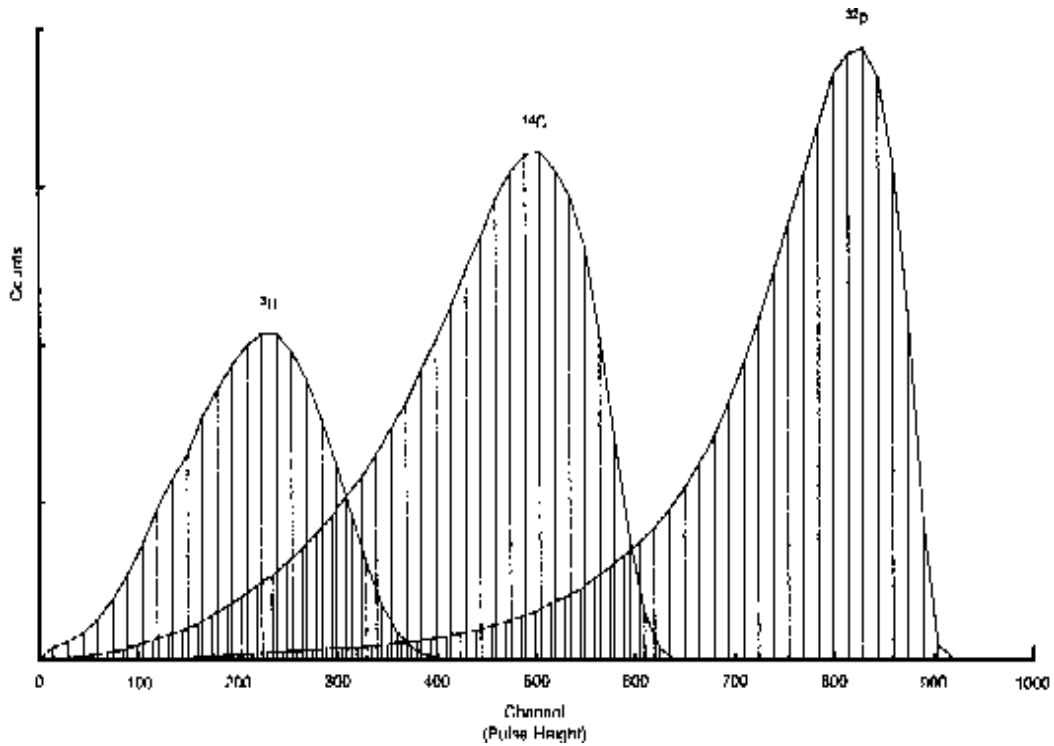Figure I A block diagram of a scintillation counter

Figure II Pulse Height Spectra of Three Radioisotopes from a Liquid Scintillation Counter

C. QUENCH

Anything added to a counting vial (colour, solvents, filters, swabs) can reduce the efficiency of the scintillation process. This reduction in counting efficiency is called ing or quench, for short. The three major forms of quench are:

1. <u>Chemical quench</u>. Some chemicals will affect the transfer of energy between the solvent and the fluors resulting in reduction in the amount of light and a subsequent reduced counting efficiency .

2. <u>Colour quench</u>. Solid and liquid scintillators emit light in the blue region of the spectrum. Red, green and yellow colors in the counting vial absorb the light, resulting in reduced efficiency.

3. <u>Self Absorption</u>.   This occurs when radiation emitted by an isotope remains undetected due to absorption of the radiation by the sample itself (e.g. in precipitates, cells).

D. QUENCH CORRECTION

All samples are quenched to some degree. The counts per minute observed (cpm) may differ substantially from the true radioactive decay rate, (disintegrations per minute, (dpm), depending on the efficiency of the counting process. The counting efficiency is by definition:

$$\text{counting efficiency} = \frac{\text{cpm}}{\text{dpm}}$$

$$\text{therefore, dpm} = \frac{\text{cpm}}{\text{counting efficiency}}$$

To determine the counting efficiency, the amount of quenching has to be known. Several methods are used to characterize and quantify the quenching for a particular sample. A common method uses the so-called "H-number" *proprietary technique by Beckman Instruments) which is assigned by an on-line analysis of the Compton electron spectrum generated <u>in</u> the sample by shing briefly an external standard source on this sample.

   A quench calibration curve can be constructed by plotting the counting efficiency versus the H-number using a set of samples of known constant activity but containing varying amounts of quenching agent. In modern instruments, the qunch curve can be stored in the

machine's electronic memory such that the quenching correction is made automatically to pride directly the output as dpm.

E. CHEMILUMINESCENCE

In some cases the sample may contain substances which can be excited by absorption of ambient light or other interactions. These excited states can have lifetimes in the 10's of minutes and can relax by emitting light (chemiluminescence). Such occurrences, although unrelated to radioactive events, will translate into false high activity readings for the sample. Events due to chemiluminescence can be easily discriminated as they show up at very low energy. This phenomenon may occur when counting swipe test samples of dirty areas like floors, swipe test samples of some paints or inks, and samples which have a high or low pH. Recounting, dark adapting, or changing counting parameters is sometimes necessary to clarify the difference between true radioactivity and chemiluminescence.

F. STATIC ELECTRICITY

On occasion, spurious, non-reproducible counts will be observed. The cause may be static electricity. Handling of plastic scintillation vials with surgical gloves can build up a charge on vial. It is advisable not to wear gloves when loading the LS counter.

REFERENCES

1. Hawkins, E.F. **Scintillation Supplies and Sample Preparation** Donald L. Horrocks Nuclear Applications Laboratory Beckman Instruments, Inc.

2. BECKMAN INSTRUMENTS **LSC Model LS3801 Manual.**