Liquid Scintillation Counting

Objectives:	This experiment will acquaint you with the method of liquid scintillation counting and the use of a modern liquid scintillation counting system. You will investigate the problem of quenching, and use the liquid scintillation counter to measure Cerenkov radiation for a determination of the half life of ^{40}K.
References:	Ehmann & Vance: pp. 161, 225-226.

For this experiment, you will first determine the counting efficiencies for ^{14}C and ^{3}H activities and then determine a quench correction curve using the H number method. The Beckman 6500 system with which you will be working has a 30-µCi ^{137}Cs source as an external standard for this purpose. Absolute measurements will be made for ^{3}H and ^{14}C activity using calibrated, quenched standards. The effect of various quenching agents will be examined, and the amount of ^{3}H and ^{14}C activity in a doubly-labeled unknown sample will be determined.

^{40}K is a naturally-occurring radionuclide with a billion-year half life. Obviously, standard decay-curve type measurements cannot be used to determine the decay constant and half life of this radioactivity, however, one can make use of the basic expression for radioactive decay ($-dN/dt = \lambda N$) to do so if the disintegration rate can be determined. ^{40}K decays by both β^- emission (89.3%) and positron emission/electron capture (10.7%). The moderately high energy betas emitted by ^{40}K (E_β^{max} = 1.31 MeV) give rise to Cerenkov radiation in the presence of water (the minimum beta energy required for this is about 265 keV) and one can use a liquid scintillation counter to detect such radiation. An aqueous solution of KCl will be counted for a sufficiently long time to acquire good statistics, and, with knowledge of the Cerenkov counting efficiency (this will be provided to you by the instructor), you should be able to determine the absolute disintegration rate of ^{40}K in your sample. If the concentration of the sample is known, the decay equation above may be solved for λ.

PROCEDURE

A. Counting Efficiency for ^{3}H and ^{14}C

The instructor will demonstrate the use of the liquid scintillation counting system. Then count the unquenched ^{3}H and ^{14}C standards and reference blank and determine the counting efficiency for each activity. Count each standard so that the error due to counting statistics is 2% or less. This should require only 1-minute counts. A much longer background count will be necessary in order to obtain statistically significant data. A decay correction will have to be made for the ^{3}H standards.

B. Quench Correction Curves

Count the unquenched and quenched sets of standards and prepare quench correction curves for ^{3}H and ^{14}C based on H number. The H number is calculated automatically for you by the instrument.

C. Effect of Various Quenchers

Prepare a series of reference samples by adding 100 μL of the stock ^{14}C solution to 18 mL of the scintillation cocktail. Count each sample. Compare the effect of various quenching agents by adding successive 50 μL aliquots of quencher (e.g., acetone) to a reference (unquenched) sample and counting. Note how the sample count rate (cpm) is affected by the quencher and how effectively the instrument corrects for this quenching in the calculated disintegration rate (dpm).

D. Doubly-Labeled Samples

Prepare a reference sample containing ^{3}H by adding 100 μL of the stock ^{3}H solution to 18 mL of the scintillation cocktail. Count the sample using optimal ^{3}H counting conditions. Prepare a reference sample containing ^{14}C by adding 100 μL of the stock ^{14}C solution to 18 mL of the scintillation cocktail. Count the sample using optimal ^{14}C counting conditions. Prepare a sample containing both ^{3}H and ^{14}C by adding 100 μL of the stock ^{14}C solution to the ^{3}H reference sample. Count the sample using the doubly-labeled counting conditions and compare the measured dpm for each radionuclide to the expected values.

E. Cerenkov Counting of ^{40}K

Prepare a concentrated aqueous solution of KCl and take a 15-mL aliquot for counting. Count the KCl sample and a blank consisting of deionized water only with the ^{40}K counting program specified by your instructor. Choose counting intervals to provide less than 1% counting statistics error for the ^{40}K sample and statistically significant data for the blank. With the known counting efficiency, solution concentration and decay branching ratio, calculate the half life of ^{40}K and compare to literature values.