EFFECT OF REAGENT CONCENTRATION ON CERENKOV COUNTING EFFICIENCY

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Cerenkov counting is often regarded as a modified version of liquid scintillation counting in which chemical quenching is not manifested. However, the mechanism of Cerenkov counting is such that changes in the concentration of reagents in the counting medium results in changes in Cerenkov counting efficiency. Large changes in counting efficiency occur for nuclides with low average beta energy values ($E_\beta$). The percent increase in Cerenkov counting efficiency in 4M HCl (relative to water) for various nuclides was found to be a smooth function of $E_\beta$. The relative change in counting efficiency for $^{24}\text{Na}$, $^{32}\text{P}$, $^{43}\text{K}$ and $^{204}\text{Tl}$ in HCl, NH$_4$Cl and/or NaCl media are presented. The data emphasizes the need to keep the concentration of various chemicals in Cerenkov counting media constant, especially for nuclides with low $E_\beta$ values, in order to reproduce counting efficiency.

Introduction

Even though Cerenkov radiation was first observed by Mme. CURIE in 1910, it was not utilized for measurement of beta radiation until mid-1960’s. Since then the use of this technique has increased and it has become a routine method for the assay of high energy beta emitters. A number of excellent reviews of Cerenkov counting technique as applied to beta radiation have appeared in the literature.$^{1-8}$ Recently GUZZI et al.$^9$ published Cerenkov counting efficiencies for a number of radionuclides formed by $(n, \gamma)$ reaction.

Commercially available liquid scintillation systems, designed for assaying low-energy beta emitters, are used for detection and measurement of Cerenkov radiation. Use of such systems and use of liquid samples has led to comparison between the well-known liquid scintillation counting and the less-known Cerenkov counting. Even though the mechanism of the two counting techniques are very different, the Cerenkov counting technique is often regarded as a modified version
W. L. RIGOT, K. RENGAN: EFFECT OF REAGENT CONCENTRATION of liquid scintillation counting in which the scintillator is omitted in the preparation of samples for counting. While discussing quenching, authors point out that color quenching occurs in Cerenkov counting as in liquid scintillation counting. However, it is generally pointed out that unlike in the case of liquid scintillation counting, chemical quenching is non-existent in Cerenkov counting. Several workers have shown that addition of different chemicals to the counting systems does not reduce the counting efficiency significantly. HABERER showed that addition of acids, salts or alkalies produced less than 5% change in count rate (including 30% NaOH). ELRICH and PARKER found less than 1% change in count rate even with concentrations of perchloric acid up to 6M in a $^{32}$P labelled sodium phosphate solution. FRANCOIS reports the observation of MASSON that addition of up to 2.5 g/l NaCl, 1.77 g/l KCl or 6.12 g/l Na$_2$HPO$_4$ with $^{32}$P, $^{42}$K or $^{143}$Pr did not change the count rate by more than +2%. FRANCOIS noted that addition of different amounts of pure H$_2$SO$_4$ (up to 18 ml for a total volume of 20 ml) to a $^{32}$P tracer solution increased the count rate 106% of the reference value in water and then decreased to 69%.

Changes in reagent concentration in a tracer solution is accompanied by corresponding changes in refractive index of the counting medium; this leads to increase in counting efficiency, the magnitude of which depend on $E_{\text{max}}$ of the tracer being counted. The effect is more pronounced for lower $E_{\text{max}}$ values. This paper presents the results of experiment in which increase in counting efficiency was studied as a function of concentration of different reagents and as a function of $E_{\text{max}}$ of the tracer. The data shows the necessity to maintain the concentrations of various components in the counting media constant (from sample to sample), especially when assaying beta emitters with low $E_{\text{max}}$, in order to obtain the same counting efficiency.

**Experimental**

**Preparation of tracer stock-solution**

The tracers $^{32}$P and $^{204}$Tl were obtained from New England Nuclear. $^{24}$Na and $^{42}$K were made by irradiation of Na$_2$CO$_3$ and K$_2$CO$_3$ respectively at Ford Nuclear Reactor of the University of Michigan. The carbonates were dissolved in HCl. The solution evaporated to drive off excess acid and the residue was dissolved in water.

**Sample preparation for counting**

At the time of experiment, the required volume of high specific activity tracer stock solution was diluted with water to intermediate specific activity and mixed.