EFFECTS OF QUENCHING AGENTS ON THE β^- SPECTRA

PURPOSE

To illustrate the effect of the process of quenching on the β^- spectra.

THEORY

Quenching is a term used to describe the process by which the number of photons per β^- event is reduced. This process proceeds by way of an agent referred to as a quenching agent. This quenching agent is extraneous to the scintillation process in all nontrivial cases.

Attenuation of photon output is characteristic of color quenching where the absorption process dominates. At the submicro level, the absorption process occurs in a molecule when a resonance transition equal to the incident photons energy is permitted. The macro absorption process is therefore concentration dependent. Otherwise stated, as the concentration of quenching agent increases, the number of photons attenuated increases. Since the fluorescent materials used in liquid scintillation counting emit photons whose energies range from 365 to 420 nanometers, the absorbing molecule must be sensitive to this wavelength range. It is a worthwhile exercise to run UV-Visible absorption spectra on the components of the sample to determine in advance the extent to which the sample will absorb, and thus quench.

Chemical quenching influences (quenches) before the production of photons, by chemical interaction. This interaction can be so severe as to chemically alter some essential components in the energy transfer process. For example, when an alkaline sample is added to the p-dioxane scintillation mixture, the p-dioxane is oxidized to an epoxide, thus eliminating the solvent from participation in the energy transfer process. In some cases, the solvent eximer gives it's excitation energy to a material in the sample which, once excited, relaxes to ground state radiationlessly, thus converting β^- energy to heat and motion. These are the main types of quenching processes; the trivial type is termed dilution quenching. Anything which separates the transferors of energy is a dilution quencher; therefore, all the components of the sample may be considered to be dilution quenchers, since anything added to the toluene dilutes it.

MATERIALS

1. 36 scintillation vials, 1" X 2 1/2" (Low K)
2. 540 ml scintillation fluid whose composition is:
   a. 8 gms/l PPO = 2, 5-diphenyloxazole
   b. 0.4 gms/l dimethyl POPOP = 1, 4 - bis[2(4-methyl-5-phenyloxazolyl)]-benzene
   c. 1% (v) BBS-3
   d. toluene to volume
3. 2 ml CH_3NO_2
4. 2 ml H_2O
5. 2 ml methyl orange, 0.00001% (w) (al)
6. Several microliters of activity bearing solution:
   a. ^{3}H labeled toluene
   b. ^{14}C labeled toluene

PROCEDURE

Prepare the following array of samples with a constant amount of activity in each sample, i.e. 30,000 dpm of ^{3}H labeled toluene, and 15 ml each of the scintillation fluid.

TABLE I

Sample #	Methyl Orange(ml)	Sample #	CH_3NO_2 (ml)	Sample #	H_2O (ml)
1A	0.01	1B	0.005	1C	0.10
2A	0.02	2B	0.010	2C	0.20
3A	0.05	3B	0.015	3C	0.40
4A	0.07	4B	0.020	4C	0.60
5A	0.10	5B	0.025	5C	0.80
6A	0.20	6B	0.030	6C	1.20

2. Prepare another set of samples as indicated in Table II. The similarity of this set and those in Table I is apparent. However, each member of this latter set should contain constant amount of ^{14}C labeled toluene, i.e., 30,000 dpm, and 15 mls each of the scintillation fluid.

TABLE II

Sample #	Methyl Orange(ml)	Sample #	CH_3NO_2 (ml)	Sample #	H_2O (ml)
1A	0.01	1B	0.005	1C	0.10
2A	0.02	2B	0.010	2C	0.20
3A	0.05	3B	0.015	3C	0.40
4A	0.07	4B	0.025	4C	0.60
5A	0.10	5B	0.040	5C	0.80
6A	0.20	6B	0.070	6C	1.20

3. Count all of the samples in a wide open window for 1 minute each, and record the data from the ^{3}H labeled samples in Table III and the data from the ^{14}C labeled samples in Table IV.

4. From Table I and Table III:

   a. Plot volume of quencher vs. efficiency for each quenching agent on the same sheet of graph paper.

TABLE III

Sample #	^{3}H Samples	CPM	$\frac{CPM}{DPM}$ = Eff.
1A			
2A			
3A			
4A			
5A			
6A			
1B			
2B			
3B			
4B			
5B			
6B			
1C			
2C			
3C			
4C			
5C			
6C			

5. From Table II and Table IV, repeat 4a.

TABLE IV

Sample #	^{14}C Samples	CPM	$\frac{CPM}{DPM}$ = Eff.
1A			
2A			
3A			
4A			
5A			
6A			
1B			
2B			
3B			
4B			
5B			
6B			
1C			
2C			
3C			
4C			
5C			
6C			

6. From Table I, select 1A-6A, and 1C-6C.

7. Locate the endpoint for each sample by positioning a narrow window, i.e., 5% over the endpoint. The method is left to the student!

8. Record data in Table V in the space provided.

TABLE V

Sample #	Average Discriminator Setting	
	Methyl Orange	H_2O
1		
2		
3		
4		
5		
6		

QUESTIONS

1. Is there a difference in chemical and color quenching agents? Explain your data!

2. Are there differences in sensitivity to quenching agents? Illustrate by listing $\frac{d(Eff)}{d(Vol)}$ for each quenching agent.