

QUENCH CORRECTION CONSIDERATIONS IN HETEROGENOUS SYSTEMS

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Abstract

The behaviour of several commercial solubilizers (PCS, ReadySolv VI, Insta-Gel, and Aquasol) when quenched with an aqueous system was examined. The relationship between the external standard channels ratio (ESR) and the isotope channels (C/R) ratio was determined before and after phase change for both Tritium and Carbon-14. A comparison was also made between the response of quasi-logarithmic amplification and linear amplification operated in the summed or lesser pulse-height mode. Observed data revealed that neither the ESR nor C/R is a satisfactory method of Quench Correction after phase separation. It does not appear that the phase distribution of the Tritium radioactivity has any drastic effects on the results observed.

Introduction

The ever increasing use of commercial solubilizing fluors has certainly simplified counting procedures of aqueous samples. The use of such systems, however, could result in the formation of non-homogenous liquids whose scintillating characteristics are distinctly different from the standard Toluene/PPO/POPOP mixture. The use of counting solutions containing Triton X-100 has been described over ten years ago (1,2). The effect of increasing the percentage of water on the counting performance of such systems has also been determined (3,4,5). In general, such solutions are able to hold water as micelles, whereby the water is held by the hydrophilic end of the Triton molecule. The physical character of the micelle is a function of the amount of water added as well as the temperature of the environment. Reliability of automated quench correction procedures is therefore subject to the above limitations.

It was the purpose of this investigation to compare the accuracy of the isotope channels ratio and the external standard ratio as applied to various commercial solubilizers.

Materials and Methods

The following criteria were used in our evaluation:

- (a) The absolute counting efficiency as related to the sample channels ratio.
- (b) Comparison of the double ratio behaviour (6).
- (c) The figure of merit of the systems evaluated.

The selection of instruments, instrument settings, and sample preparation was as follows:

Fluors: Commercial solubilizers known as Biosolv VI (Beckman Instruments Inc.), Insta-Gel (Packard Instruments Inc.), PCS (Amersham/Searle) and, Aquasol (New England Nuclear Corp.) were used throughout this investigation. A standard Bray's cocktail was also prepared (PPO 4 g, POPOP 0.2 g, Naphthalene 60 g, Ethyleneglycol 20 ml, Methanol 100 ml, and Dioxane 1000 ml).

Instrumentation: The response of a Picker Liquimat Model 220 exhibiting a quasi-logarithmic amplification system and variable windows was compared with that of a Searle Mark II (Searle Instrumentation) modified for both lesser and summed pulse height analysis (7). Window settings on this latter instrument are fixed by the manufacturer. The adjustment of the window openings on the Liquimat 220 was such that the best E^2/B was obtained for a channels ratio of $A/B = 0.3$ where channel A represents the narrow window and channel B represents the wide window. The unquenched standard used was Aquasol.

Sample Preparation: Ten millilitres of each fluor were spiked with known radioactivity of either ^{14}C -Toluene, ^3H -Toluene, or Tritiated water. Distilled water was used as a quenching agent, and incremental portions of 0.2 ml volumes were added to the original solution of fluor. An average of nine samples were used at each dilution level. All samples were dark adapted for thirty minutes after each dilution, and the gelling point was noted visually. Each sample was counted to a 1% error in the channel exhibiting least counts. All counting was performed at room temperature.

Results and Discussion

We have ascertained that increasing the volume of the counting solution does not have any geometric effect on either the C/R or ESR. This is shown in Figure 1.

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Effect of Volume on External Standard Channel Ratio and Channel Ratio.

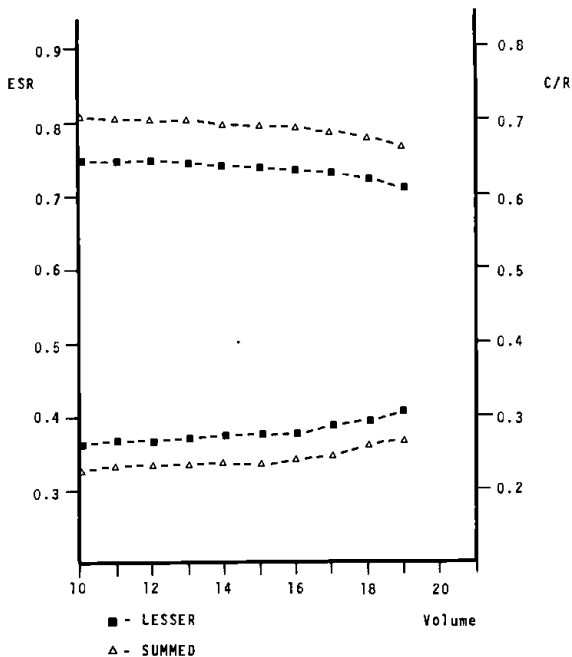


Figure 1. Effect of volume on external standard channels ratio and isotope channels ratio. Increments of 1 ml Toluene added. (Picker Liquimat 220).

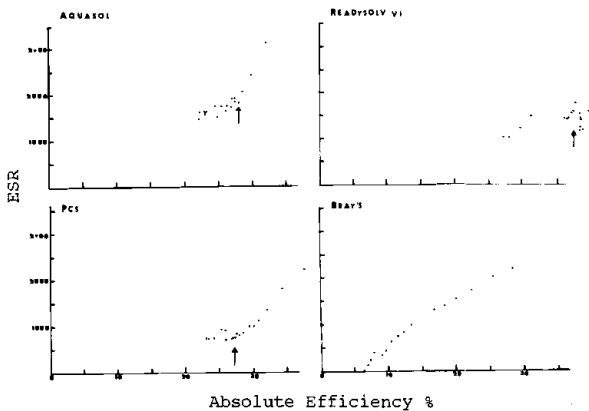


Figure 2. Effect of water addition on Toluene-³H ESR. Arrows indicate visual phase change. (Picker Liquimat 220).

Thus, any observed changes could only be attributed to differences in pulse height distributions as a result of the addition of quenching agents. Figures 2 and 3 show the relationship between the absolute efficiency of tritium and Carbon-14 in the lipid phase and either the ESR or C/R. The three commercial fluors tested are known to suffer from phase separation upon the addition of a certain percentage of aqueous liquids. When compared to the standard Bray's cocktail, both Aquasol and PCS show a predictable relationship prior to visual phase change. Such a relationship becomes completely erratic after gelling. Readysolv VI on the other hand, exhibits only marginal change in the ESR either prior to or after phase changes. In the meantime, the absolute efficiency changes little prior to phase separation and considerably thereafter.

It was interesting for us to note that we have obtained essentially identical patterns with all four fluors when the Tritium was present in the aqueous phase rather than the lipid phase. The relative figures of merit are shown in Figure 4. The Biosolv VI preparation shows a serious deterioration of this value upon phase change. As expected, when the double ratio technique was applied to the systems investigated, (Figure 5) the unreliability of quench correction after visual phase change was evident. In the case of Biosolv VI, it was obvious that no correlation could be established, even when the sample appeared to be clear. A comparison of the response of lesser and summed pulse height analysis circuitries to the addition of water is illustrated in Figures 6 and 7. In this case, the double ratio accuracy deteriorates much rapidly before any visual phase change when the lesser pulse height mode is used. This applied equally to the situation where the Tritium was either in the lipid or aqueous phase. On the other hand, the lesser circuit proved to be far superior when C-14 Toluene in Insta-Gel was quenched with water (Figure 3). From our observations, it is then obvious that it is extremely dangerous to generalize as to a specific method of automated quench correction for all phase-combining systems. A number of other conclusions could also be drawn. For example, Bush's technique (6) of double-ratio method appears to be imperative in order to test the limits of any system to be used. Quite often, a specific quench correction technique fails before a phase change is visualized. In the case of Tritium, when present in either the aqueous or lipid phase, neither the C/R or

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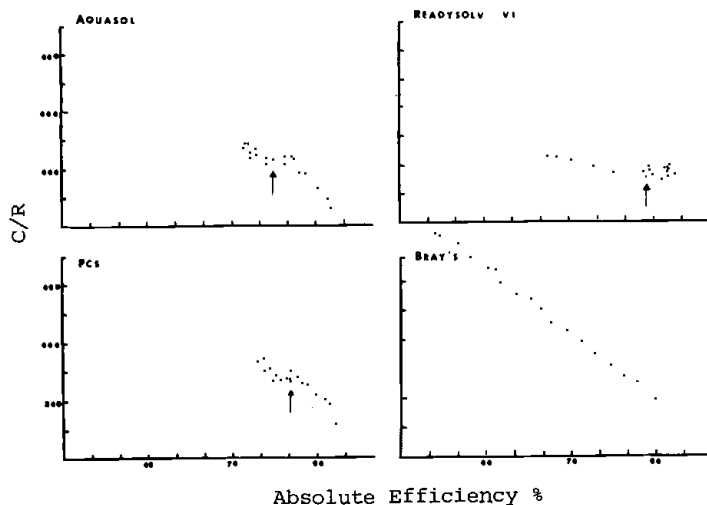


Figure 3.
Effect of water addition on Toluene C-14 C/R.
Arrows indicate visual phase change. (Picker Liquimat 220).

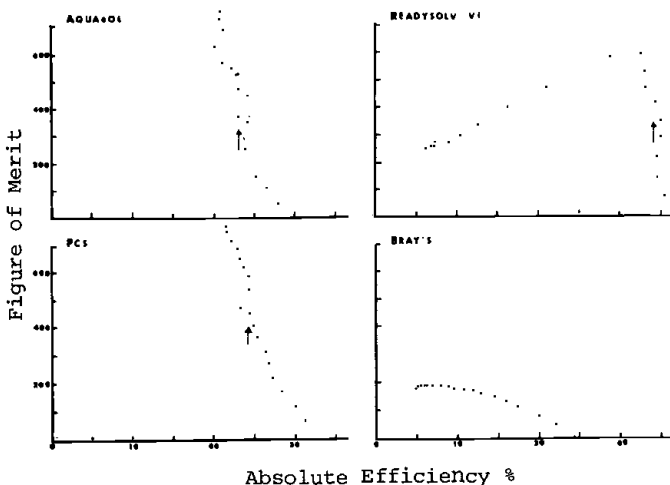


Figure 4.
Relationship between figure of merit (efficiency x % water added) and absolute efficiency.
Tritium present in aqueous phase in form of T_2O . (Picker Liquimat 220).

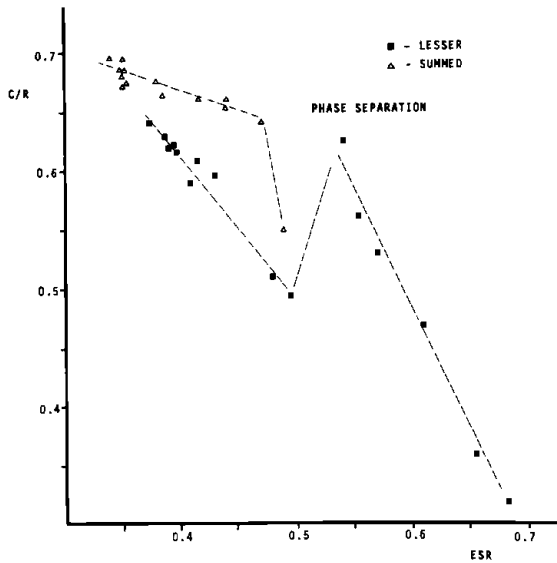


Figure 5.
 Relationship between C/R and ESR for Toluene C-14.
 Arrows indicate visual phase separation. (Picker Liquimat 220).

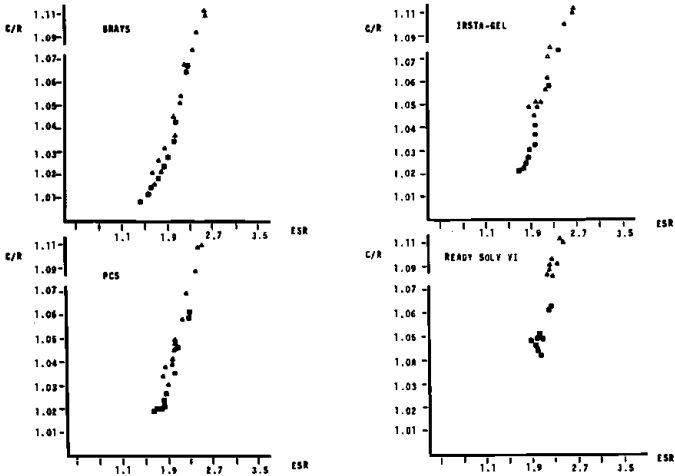


Figure 6.
 Relationship between C/R and ESR.
 Toluene-H³ quenched by addition of water until visual
 phase change.
 Δ = summed PHA, ■ = lesser PHA. (Searle Mark II).

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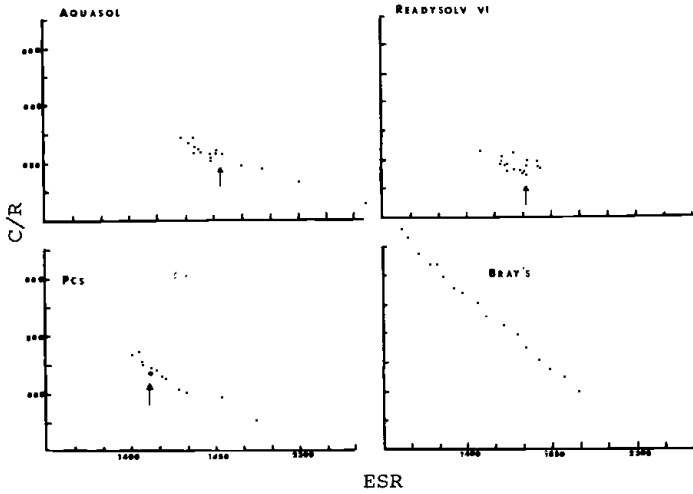


Figure 7.
 Relationship between C/R and ESR.
 Tritium present in aqueous phase in form of T_2O .
 Δ = summed PHA, \blacksquare = lesser PHA. (Searle Mark II).

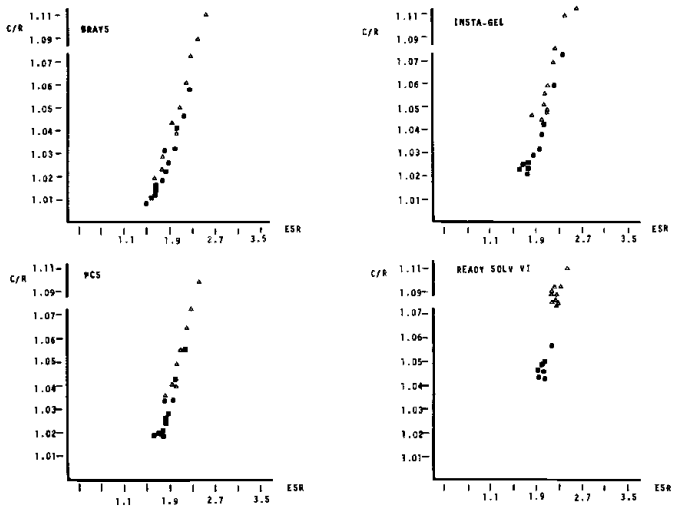


Figure 8.
 Relationship between C/R and ESR.
 Toluene C-14 in Insta-Gel. (Searle Mark II).

ESR is satisfactory after visual phase change. Internal standards should then be used under such conditions. The use of instruments with preset fixed windows in conjunction with phase-combining cocktails could limit the method of quench correction to the ESR technique, as the dynamic range of the C/R is seriously reduced.

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References

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