REVIEW OF THE EVOLUTION OF SAFETY, ECOLOGICAL AND ECONOMICAL ASPECTS OF LIQUID SCINTILLATION COUNTING MATERIALS AND TECHNIQUES

D.A. Kalbhen* and V.J. Tarkkanen**
*Institute of Pharmacology and Toxicology
University of Bonn
D-5300 Bonn 1, West Germany
**Research Laboratories
Lumac/3M b.v.
6372 AD Schaesberg, The Netherlands

INTRODUCTION

The wide applicability of liquid scintillation techniques for counting weak β-emitters and other radionuclides has led to the daily use of a large number of liquid scintillation counter instruments in research and control laboratories. The total number of such counters in use is estimated at between 15000-20000. Of the solvents used in liquid scintillators, xylene, toluene and trimethyl benzene are most common. To a minor extent, dioxane, methylglycol, ethanol and methanol are also used. The estimated annual total volume is around 2-3 million liters of scintillation cocktails. This is equivalent to 200-300 million disposable counting vials. The present situation clearly demonstrates a problem in laboratory safety and concomitant cost for waste treatment, usually not recognized. The use and handling of these inflammable and irritant solvents can induce certain risks to personnel and laboratory safety.

Obviously, a significant reduction of the ecological and health risks is important. In recent years, some progress has been made by using smaller volumes and smaller sizes of vials. These miniaturizing techniques may contribute to a reduction of the overall costs, including that for waste treatment by more than 60%. Since most of the presently used liquid scintillators are flammable and are able to penetrate through the wall of the plastic vials, the introduction of non-flammable scintillator solvents, which do not penetrate through polyethylene vials and do not escape into the laboratory atmosphere, certainly adds to the safety process.

I. ASPECTS ON LABORATORY SAFETY

Solvents, being the major components in liquid scintillators, have until now only been regarded concerning their usefulness in liquid scintillation counting. Often forgotten or neglected areas concern the vapors of toluene, xylene and trimethyl benzene, which may produce irritation of the upper respiratory tract, and in larger concentrations dizziness, nausea, etc[1].

These toxicological problems became more evident after the introduction and predominant use of plastic vials, which are penetrable by these aromatic solvents. Due to its high toxicity, the use of dioxane is now restricted in a number of countries. In other industrial or professional uses, aromatic solvents are often replaced by less toxic solvents. Surprisingly, in liquid scintillation counting techniques the possible health hazards due to exposing the laboratory personnel to solvents and their vapors is treated but sparsely in the scientific literature, although it is well known that liquid scintillator solvents can penetrate through the plastic vial wall into the laboratory atmosphere.

Because of the high vapor pressure and inflammability of these solvents, the handling and storage of large numbers of filled plastic vials represents an additional fire risk.

For personnel and laboratory safety, it was very desirable to develop new liquid scintillators which are non-flammable and which cannot penetrate the plastic wall of counting vials. During 1980, an advanced liquid scintillator (SAFEFLUOR™), based on polyalkyl benzene, was introduced onto the market.

As shown in Figure 1, a comparative study of the penetration of liquid scintillators through the plastic vial wall clearly demonstrates that even after 4 months this new liquid scintillator has not evaporated from the polyethylene vial. Comparing the flammability of various solvents (see Figure 2), the high flashpoint of polyalkyl benzene is an additional feature for safe handling and storage of liquid scintillators in the laboratory[2].

Figure 1. Evaporation curves for liquid scintillators at room temperature in 6 ml polyethylene vials[2].

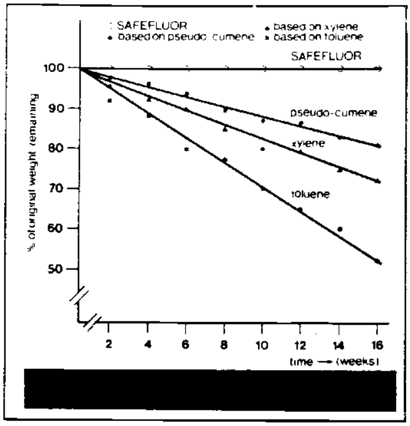
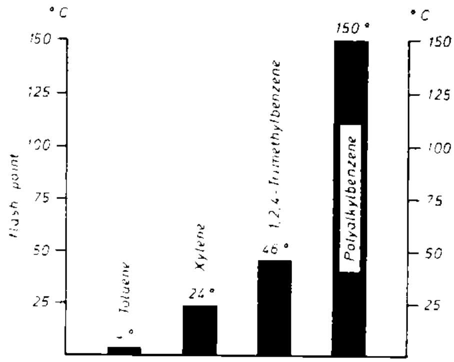


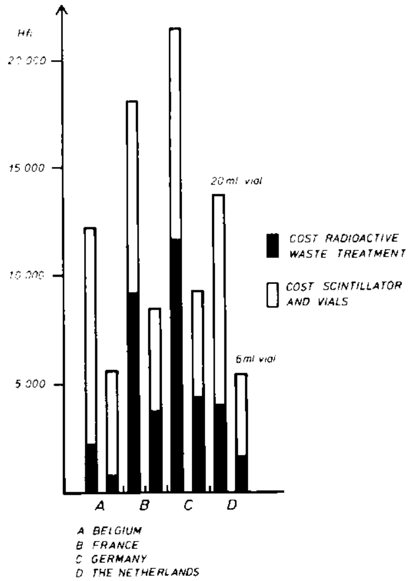
Figure 2. Flashpoints of scintillator solvents.



II. COMMENTS CONCERNING WASTE

As already mentioned, the annual amount of waste from liquid scintillation counting has reached the remarkable volume of 2-3 million liters of liquids and about 200-300 million disposable counting vials. The major environmental hazard of this waste is the amount of organic solvents rather than a low level of radioactive compounds. Now in many countries, incineration of the complete sample and plastic vials is a safe and convenient waste treatment method. Earlier, a considerable part of the aqueous-organic waste was poured into the laboratory sewage system, disregarding the consequent environmental problems.

Figure 3. Total costs for 20000 LSC samples (in Dutch Guilders, 1982).



III. SOME COMMENTS ON COSTS

Today the handling of waste is covered to various extents by governmental regulations in all countries, causing considerable costs, and in many countries these costs are close to that of the scintillators[3]. Because the cost for waste treatment is mainly based on volume, the development of miniaturized systems in liquid scintillation was an important development. The introduction of high capacity liquid scintillators and the use of smaller counting vials (6 ml) can considerably reduce the overall costs, as demonstrated by the comparative data presented in Figure 3.

IV. CONSEQUENCES AND CONCLUSION

The necessary change of the counting procedures and sample preparation techniques is generally appreciated but remains still a common concern to many users. Miniaturizing from 20 ml to 6 ml samples will not cause any substantial loss of accuracy in liquid scintillation counting. For measuring radioactivity and for calculating DPM, it is only necessary to establish and apply a new quench correction curve.

The presently available miniaturizing techniques and new chemicals for liquid scintillation counting provide a significant increase in laboratory safety and economy, while at the same time, reducing the ecological burden.

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