

PICOSECOND PULSE RADIOLYSIS STUDIES ON
MECHANISM OF LIQUID SCINTILLATION

Seiichi Tagawa, Yusuke Katsumura,
and Yoneho Tabata

Nuclear Engineering Research Lab., Fac. of
Engineering, Univ. of Tokyo
Shirakata Shirane 2-22, Tokai-mura, Ibaraki,
319-11, Japan

Liquid scintillators, which are widely used for measurement of tritium, carbon-14, other radioisotopes and their labelled compounds in medical, biological, chemical and fusion fields, offer the fastest response times and simplest and economical detectors.

A number of original (1) and review (2) papers have been published on the liquid scintillation. However, the studies on the mechanism of liquid scintillation have been limited to typical binary (and ternary) liquid scintillator systems based on aromatic solvents (e.g benzene, toluene, or xylene) and containing appreciable concentrations of solutes (and secondary solutes). The mechanism of liquid scintillation have not been made clear yet.

Recent picosecond pulse radiolysis studies have made the early events in radiolysis-induced reaction in aromatic (3,4) and saturated (3,5,6) hydrocarbon solutions clearer than before.

The present paper mainly describes the picosecond pulse radiolysis studies on mechanism of liquid scintillation, especially on the roles of solvents. Furst and Kallman (7) reported that solvents could be divided into three classes of scintillation efficiency; so-called "effective," "moderate" and "poor" solvents. Kinetic behavior of scintillation emission in various solvents in pico- and nano-second time region is reported in the present symposium (8) by us and solvents are classified into three classes from the view point of dynamic behavior of scintillation. These two classifications agree very well with each other (7,8).

The mechanism of liquid scintillation has been generally explained by energy transfer processes so far. Here, the mechanism of liquid scintillation have been examined based on picosecond pulse radiolysis experimental results (4,6). The role of charged species (containing geminate ion pairs, very reactive positive holes) and excited states have been examined in detail in aromatic and saturated hydrocarbon, and other solvents.

For example, energy transfer processes take most important roles in the liquid scintillation of aromatic solutions containing appreciable concentrations of solutes at room temperature. In saturated hydrocarbon solution, both charged species (geminate ion pairs) and solvent excited states must be considered. Especially very reactive positive holes (or very reactive ion-pairs like excitons) are considered to exist in very short time range (≤ 10 ps) in

saturated hydrocarbon solvents.

The roles of charged species and solvent excited states in liquid scintillation are strongly dependent on solvents, solute concentrations, and temperature.

Reference

- (1) H. Kallman, Z. Naturforsch, A2, 439, 642 (1947)
- (2) J. B. Birks, Photophysics of Aromatic Molecules, Wiley-Interscience, New York, (1970)
- (3) G. Beck and J. K. Thomas, J. Phys. Chem., 76, 3359 (1972)
- (4) S. Tagawa, Y. Katsumura, T. Ueda, and Y. Tabata, Radiat. Phys. Chem., 15, 287 (1979)
- (5) C. D. Jonah, M. C. Sauer, R. Cooper, and A. D. Trifanac, Chem. Phys. Lett., 63, 535 (1979)
- (6) S. Tagawa, Y. Katsumura, and Y. Tabata, Chem. Phys. Lett., 64, 258 (1979)
Y. Katsumura, T. Kanbayashi, S. Tagawa, and Y. Tabata, Chem. Phys. Lett., 67, 183 (1979)
Y. Katsumura, S. Tagawa, and Y. Tabata, J. Phys. Chem., 84, 833 (1980)
- (7) M. Furst and H. Kallman, J. Chem. Phys., 23, 607 (1955)
- (8) Y. Katsumura, S. Tagawa, and Y. Tabata, paper presented in the present symposium.