PICOSECOND PULSE RADIOLYSIS STUDIES ON BEHAVIOR OF SCINTILLATION EMISSION IN VARIOUS KINDS OF SOLVENTS

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Abstract

By using picosecond single electron pulse, scintillation behavior of excited 2,5-diphenyloxazole(PPO) in various kinds of solvents has been observed with 30ps time resolution. The emission from solute excited states could be devided into two formation processes, faster and slower ones from the view point of formation speed. From the points of combination of these two processes and emission efficiency, solvents could be classified into three groups; effective, moderate and poor ones.

Liquid scintillation counting is widely used for the radioassay of biological and other materials labelled with carbon-14, tritium or other radioisotopes. Since the discovery of liquid organic solution scintillators in 1949, many combination of solvents and solutes have been tested and a great variety of scintillators have been prescribed and used. In 1955, Furst and Kallmann[1] reported that solvents could be divided into three classes of scintillation efficiency; effective, moderate and poor. Most of the aromatic compounds were included in "effective" solvents. In a second class, so called "moderate" solvents, saturated hydrocarbons are placed with efficiencies within a factor of 2∿4 of aromatic hydrocarbons. The third class of "poor" solvents included aliphatic alcohols, and ethers with efficiencies almost two orders of magnitude lower than that of the "effective" solvents. Since most of the studies were based on steady state photolysis and radiolysis, scintillation behavior with time are not yet known clearly. To get new scintillation counters having rapid rise and decay and high efficiency, it is thought that studies on the formation processes of solute excited state in liquid hydrocarbon with high time resolution is very important.

The block diagram of picosecond single pulse radiolysis system is shown in Fig. 1. The present system is a combination of a fast detection system and a generation of a picosecond electron pulse. The fast detection system is composed of a streak camera(C979,HTV), a SIT camera(C1000-12,HTV), an analyzer(C1098,HTV) and display systems. The pulse width of electron beam was estimated to be less than 18ps. Time resolution of the system is about 30ps. Details of the system was reported elsewhere.[2]

In Fig. 2, time profiles of emission from excited 2,5-diphenyloxazole in ethylalcohol, cyclohexane and phenylcyclohexane. In ethylalcohol, growth of emission from the solute excited state was completed at the end of Čerenkov light pulse induced by elec-

tron pulse and the emission decays gradually with decay time of 1.6ns. As a lifetime of excited 2,5-diphenyloxazole in ethyl-alcohol obtained by photoexcitation was reported to be 1.6ns,(3) above experimental result suggests that most of the solute excited are already formed immediately after the pulse. This rapid growth of emission has been called the faster formation of solute excited state. In phenylcyclohexane, at a lower solute concentration, Čerenkov light is clearly seen and at the end of Čerenkov light pulse, a certain fraction of excited states are already formed and a slow growth is also seen over 1ns. This slow growth has been called the slower formation process. At 10mM 2,5-diphenyloxazole solution in phenylcyclohexane, ratio of the slower formation to the faster one is large and the faster one is hardly discriminated. On the other hand, in cyclohexane, both the slower and the fast formation can be seen, but the growth of the emission corresponding to the slower formation is faster as compared with those in phenyl-cyclohexane. Normally above two formation processes can be seen in any kind of solvent. However, contribution of each process is dependent on the kind of solvents and concentration of solute molecules. Based on above experimental results, solvents could be classified into three classes from the view points of formation processes and emission efficiency. Obtained classification is in a good agreement with Kallmann's one.

References

1) M.Furst and H.Kallman; J. Chem. Phys. 23 607 (1955)
2) Y.Tabata, J.Tanaka, S.Tagawa, Y.Katsumura, T.Ueda and K.Hasegawa; J. Fac. Eng. Univ. of Tokyo. 34 619 (1978)
3) I.B.Berlman "Handbook of Fluorescence Spectra of Aromatic Molecules" Academic Press (1971)

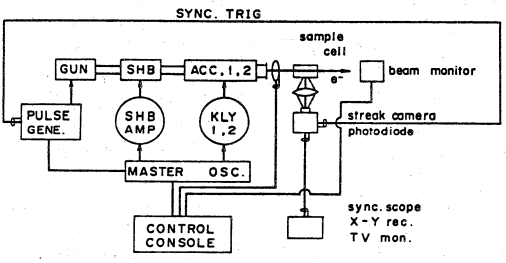

Fig. 1 Schmatic diagram of detection system.

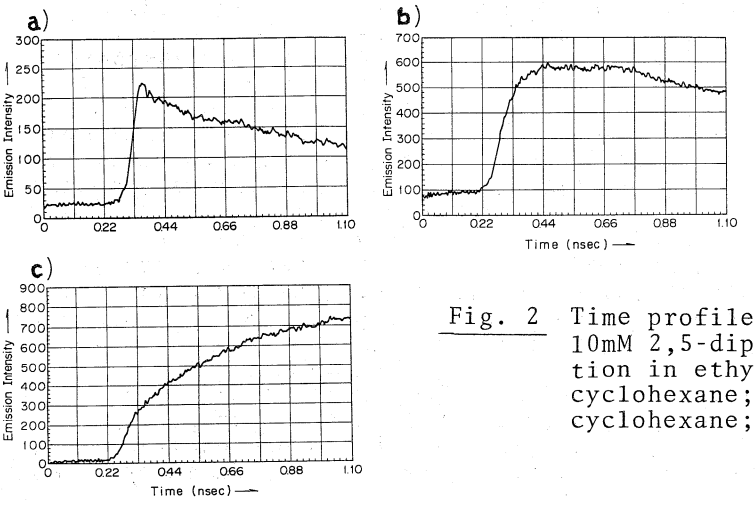

Fig. 2 Time profiles of emission from 10mM 2,5-diphenyloxazole solution in ethylalcohol; a), cyclohexane; b),and phenyl-cyclohexane; c).