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Author	本間, 義夫(Honma, Yoshio) 村瀬, 裕子(Murase, Yuko)
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Energy Resolution of Liquid Scintillator for α-Particles and Internal Conversion Electrons at Lower Temperatures*

Yoshio HOMMA and Yuko MURASE

本間義夫，村瀬裕子

The use of liquid scintillation methods for the energy analysis of an α-spectrum has been demonstrated by several investigators. Horrocks reported a 5.8% energy spread for α-particles energies between 4 and 7 Mev using a specially constructed single-phototube instrument. With the experimental means available, at ordinary temperature, there seems to be little hope to improve the resolution of liquid scintillation systems significantly beyond the limit mentioned above.

However, in the course of the spectral studies described in the preceding papers, we have found that the pulse-height for α and β-particles and for internal conversion electrons in several kinds of organic scintillator solutions increases markedly with decreasing temperature: The energy resolution of α-particles from ^{241}Am, ^{222}Rn, ^{218}Po and ^{214}Po and internal conversion electrons from ^{131m}Xe with a liquid scintillation system has shown to give better energy resolutions with decreasing temperature.

In early experiments that may be compared with the present study, most investigators have reported line width of 24—50% for approximately 5 MeV α-particles, which are much poorer than the present values listed: The energy resolution for α-particles measured even at 13℃ is 13.7% for 5.48 MeV which is the average α-particle energy of ^{241}Am, 10.8% for 7.69 MeV (^{214}Po). Furthermore, the energy resolutions for these α-particles are much higher at lower temperatures. It seems that the reported poorer results could be due, in part, to quenching effects, because aqueous solutions of the α-emitter were used in most early reports.

The experiment on the energy resolution for electrons has been done by Flynn et al. Based on the pulse-height spectra measured by them, we can estimate graphically the energy resolution for 0.184 MeV internal conversion electrons from ^{114m}In at 33.1% and for 0.379 MeV (^{113m}In) at 26.2%. Whereas, in the present study, the energy resolution obtained for 0.164 MeV electrons is estimated 44.3% at 13℃ and 30.0% at −65℃. The difference between the value from the present study at 13℃ and the reported value could be reasonably explained on the basis of the fact that a specially constructed single-phototube has been used in the early study. It is noteworthy, however, the results obtained especially at lower temperatures are comparable to those by Flynn et al.

In the present study all these factors, except the temperature of the sample, are kept

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the same, thus, the difference in the energy resolution between at ordinary temperature and at lower temperatures is attributed to the temperature dependence of pulse-height distributions both for α-particles and internal conversion electrons. As has been previously reported, the increase in energy transfer between solvent molecules, and hence, in light output of liquid scintillator occur at lower temperatures. Therefore, it is concluded that the improvement in energy resolution observed at lower temperatures is attributed to the increase in light output upon lowering the temperature from 13℃ to -65℃, because the energy resolution is inversely proportional to the square root of the number of light quanta produced per particle emitted.