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WAVELENGTH SHIFTERS FOR XENON PROPORTIONAL SCINTILLATION COUNTERS

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Relative efficiencies of p-terphenyl, sodium salicylate and p-quaterphenyl, as wavelength shifters for xenon proportional scintillation counters, are reported.

Gas scintillation counters can be of interest in different fields of nuclear physics. The spectroscopic information, either on the primary scintillation (no electric field applied) or on the secondary scintillation (under the influence of an electric field) is rather poor[1]). Nevertheless, the possibility of distinguishing widely different radiations, for example gamma rays and fission fragments, through the spectral distribution of its scintillations seems to arise[2]). On the other hand, if the energy resolution is the important parameter a high light output is essential.

Recent work with a xenon proportional scintillation counter (Xe PS counter) has shown that it features a good energy resolution; for example, full widths at half maximum of 500 eV and 100 eV are obtained for 5.9 keV [3]) and 277 eV [4]), respectively. Detector capacitance, electronic or photomultiplier noises do not give any significant contribution to its performance. From 277 eV till 25 keV there is no nonlinearity of practical importance; and no peak shift was detected till about 10^5 counts per second [5]).

For the particular counters used the photomultiplier contribution to the resolution is important, slightly larger than that arising from the intrinsic parameters, the Fano factor and the energy per ion pair. Then, to improve the energy resolution, a good light-collection system together with an efficient wavelength shifter should be used. In this work relative efficiencies of several wavelength shifters for a Xe PS counter are reported. The measurements were made using the counter in fig. 1 of ref. 3 with the following modifications: the upper quartz window was replaced by a stainless-steel cover; the reflector was taken out; the inside face of the lower quartz window was covered by a thin stainless-steel plate with a central circular aperture where a thin (2 mm) quartz disc of 29 mm diameter could be placed; the light coming out through this quartz disc was viewed by an EMI 9656QR photomultiplier. This arrangement is made in order to avoid reflections of the ultraviolet light emitted by the gas. The wavelength shifter was deposited on the inside face of the thin quartz disc and its thickness determined by weighing.

The wavelength shifters used were: p-quaterphenyl "purissimum grade" supplied by Fluka A.G., p-quaterphenyl "scintillation grade" and p-terphenyl "scintillation grade" supplied by Nuclear Enterprises Inc., and sodium salicylate from B.D.H. This last one was sprayed from a methyl alcohol solution[6]); all the other wavelength shifters were deposited by vacuum evaporation.

The counter was bombarded with X-rays, from a ^{55}Fe source through an aluminized mylar window of 2 mm diameter, and, for each thickness t of a particular wavelength shifter, the pulses were analysed with a multichannel analyser and the mean amplitude h was determined as a function of the anode voltage V.

For a certain wavelength shifter, the thickness for which the light output is maximum, t_M, was found to be the same for any value of the anode voltage within the range 2000–5000 V. It was also verified that, in the same voltage range, for each value of t, $h(t, V)/h(t_M, V)$ is constant with an uncertainty of about 2%; and for $V \leq 2000$ V definite and systematic deviations were observed. This effect may be due to an approximately constant spectral distribution of the emitted light for the larger values of the anode voltage. The presentation of the data is thus much simplified for any V between 2000 and 5000 V, the useful range of the Xe PS counter.

Fig. 1 shows $h(t, V)$ for the several wavelength shifters used, normalized for the light output of the most efficient wavelength shifter, the p-terphenyl, at its optimum thickness of about 2500 μg/cm^2.

The higher light output of the p-terphenyl relative to the other wavelength shifters is a useful result: similar detectors (see fig. 1 of ref. 3) one with p-terphenyl and no MgO reflector, and the other with p-quaterphenyl and with the troublesome MgO reflector, gave about

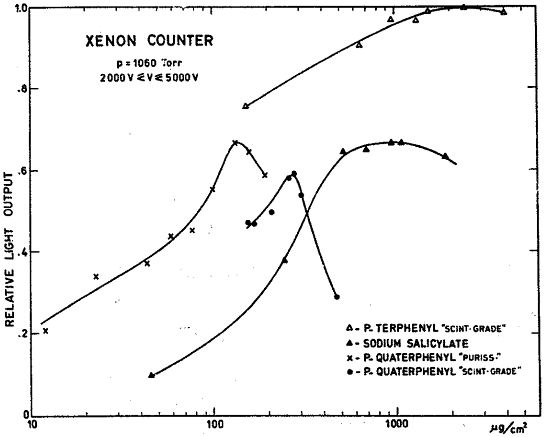

Fig. 1. Relative light output vs wavelength-shifter thickness.

the same light output. Under continuous purification[3]), the stability of the p-terphenyl wavelength shifter was checked during one week, no variation of pulse height being observed.

A useful feature of the p-terphenyl and of the sodium salicylate is that they have approximately a maximum efficiency over a wide range of thicknesses, and therefore layers that may have non-uniform thickness will be optically uniform.

It is very difficult to compare our results with previous data: for low electric fields, a variation of the spectral distribution was indirectly detected (see fig. 2 of ref. 7). Then most of the previous determinations of wavelength-shifters efficiencies that were obtained for primary scintillation are not directly comparable with our data. Nevertheless the main features of our results are in general agreement with data available from previous works with wavelength shifters. For p-quaterphenyl t_M is dependent on the purity of the product (see fig. 1) but it seems to be higher than the reported optimum thicknesses of 50–100 μg/cm^2 [8,9]).

The values of t_M and relative efficiencies for sodium salicylate and p-terphenyl are in agreement with the data of Mai and Drouin[10]).

Promising wavelength shifters could be tetraphenylbutadiene and diphenylstilbene[10–12]), and in order to prevent contamination of the gas a magnesium-fluoride coating could be applied[13]).

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