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NEW SCINTILLATING MEDIA BASED ON SiO_2-AEROGELS SATURATED WITH LIQUID SCINTILLATORS

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Abstract

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Scintillation properties of SiO_2-aerogel samples saturated with both Ar and liquid scintillators based on 1-methylnaphthalene have been studied. Under high energy particles excitation a light output of about 14.1% in comparison with anthracene was attained.

Аннотация

Головкин С.В. и др. Новые сцинтиллирующие среды на основе SiO_2-аэрогелей, насыщенные жидкими сцинтилляторами: Препринт ИФВЭ 97-11. – Протвино, 1997. – 4 с., 3 рис., библиогр.: 6.

В работе представлены сцинтилляционные характеристики образцов SiO_2-аэрогелей, насыщенных одновременно Ar и жидкими сцинтилляторами на основе 1-метилнафталина. Световыход таких сцинтилляторов достиг уровня 14.1% от антрацена при возбуждении частицами высоких энергий.

Among promising materials that extend their applications for single charged particles detection are SiO_2-aerogels [1]. Doped with a wavelength shifter POPOP (1,4-bis-(2-(5-phenyloxazolyl))-benzene with λ_{em}=420 nm, where and λ_{em} is the maximum of emission wavelength) [2] such materials showed weak scintillation properties. Under high energy particles excitation their light outputs were only about 2 times higher in comparison with their aerogels initial Cherenkov radiation levels.

The main advantages of recently found green emitting light liquid scintillators (LSs) [3] are high levels of their light outputs which are up to $I \cong$50% in comparison with an anthracene scintillator (λ_{em}=447 nm), main short decay time constants 6.2-7.6 ns and high levels of radiation hardness >1MGy in vacuum or neutral atmospheres [4]. It is well known that porous media with diameter of pores < 100 μm absorb much more LSs. Taking an opportunity we propose here another way to improve SiO_2-aerogels scintillation properties [2] by saturating them with efficient LSs. Note that mechanical properties of these aerogels saturated with LSs are good enough to be applied in particle detectors. This work is devoted to the investigation of luminescent properties of such new scintillating media based on SiO_2-aerogels saturated with Ar and LSs as well.

Fig.1 shows the transparency T of a pure SiO_2-aerogel sample under study. Our aerogel samples of $\oslash$ 1.6x0.5 cm^3 were saturated (the procedure was presented in [3]) with both Ar at a pressure of 1.01 atm and LSs based on 1MN (1-methylnaphthalene) and R6 (a pyrazoline derivative with λ_{em} = 490 nm) scintillating dopant having several concentration levels, i.e. c=3 g/l and 9g/l. We have chosen Ar because in this neutral atmosphere LSs light outputs reach their maximum values [3]. Saturated with both Ar and LSs the aerogel samples were then exposed to air. The emission spectrum L of R6 in 1MN (for the excitation at 365 nm) is also presented in Fig.1.

The new scintillators light outputs at 20^{o}C in air were determined. For this purpose we measured relative positions in a crystal anthracene and new scintillator samples of their total absorption peaks for 976 keV conversion electrons from a ^{207}Bi radioactive source. The source and samples were fixed upon the entrance window of a photomultiplier (PM) FEU-84-3 having a multialcaline photocathode. The PM quantum efficiency Y is presented in Fig.1. There was no optical contact between the PM and samples. The integration time in our pulse height analyzing channel was about 400 ns.

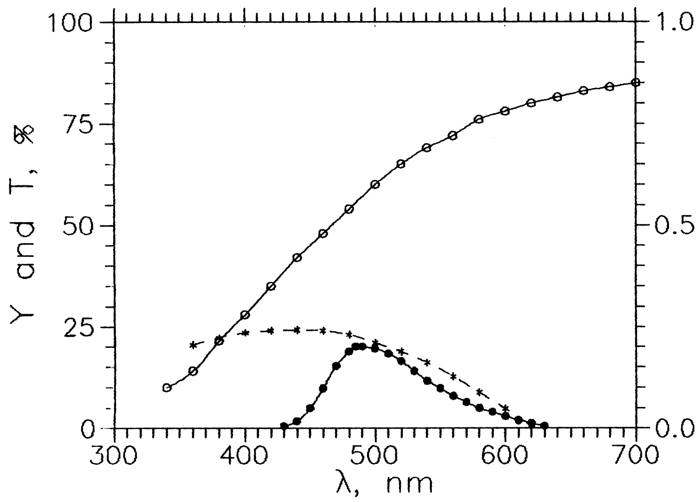

Fig. 1. Transparency T (solid line) of 0.5 cm thick SiO_2-aerogel sample (o), quantum efficiency Y (dashed line) of our PM (*) and luminescent spectrum L (solid line) of R6 dopant in 1MN (•) as functions of the wavelength λ.

Some experimental results on the pulse height measurements of our anthracene and new scintillators are presented in Fig.2. One can see that among the tested new scintillator samples the one containing both Ar and 1MN+9g/l R6 showed the maximum light output of I=10.9% (without taking into account the PM quantum efficiency) in comparison with the anthracene having a comparative size. Taking into account the PM quantum efficiency Y (Fig.1) the scintillator light output is about 14.1%. Note that the light output of our anthracene was set equal to 100%. The experimental error was determined on the base of repeated measurements and came to ±6%. High concentration of the scintillating dopant in 1MN+9g/l R6 improved this sample light output up to 30% in comparison with the light output of another aerogel sample containing 1MN+3g/l R6 due to subdueing the LS excitation quenching on SiO_2 in fine aerogel pores. Note that the light outputs of these LSs are practically the same [3].

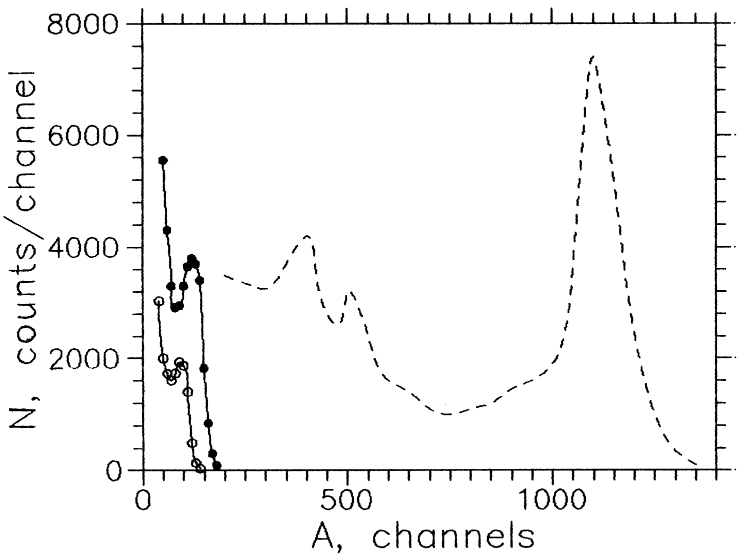

Fig. 2. Pulse height spectra (solid lines) of scintillation signals from ^{207}Bi in SiO_2-aerogel samples saturated with both Ar and 1MN+3g/l $R6$ (o), Ar and 1MN+9g/l $R6$ (•) and our anthracene (dashed line). These measurements were carried out in 20 hours after the air exposure had begun.

We also investigated temporal characteristics of the light outputs of these new scintillators at 20^{o}C in air. Some results of this investigation are presented in Fig.3. As has been expected the light output stability of SiO_2-aerogel sample saturated with both Ar and 1MN+3g/l R6 turned out to be higher in comparison the light output of the same amount of a LS (1MN+3g/l R6) saturated with Ar and then exposed to air [3]. After four months of observation the yellow tinge appeared in this SiO_2-aerogel scintillating sample.

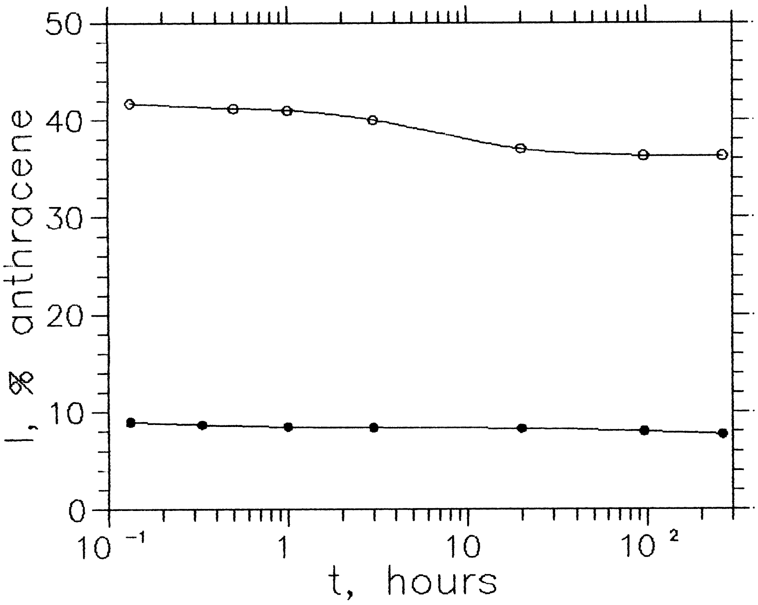

Fig. 3. Time dependencies of the light outputs of SiO_2-aerogel saturated with both Ar and 1MN+3g/l $R6$ (•) and the same amount of 1MN+3g/l $R6$ liquid scintillator saturated with Ar (o) as the exposition time to air.

In conclusion it should be noted that the light outputs of these new scintillators can be easily increased up to a level comparative with those of LSs in neutral atmosphers [3] by the use of LSs with higher scintillating dopants concentration levels and SiO_2-aerogel samples having higher diameter of pores > 20 μm. Note that other transparent porous media (ceramics, etc.) can also be used for this purpose.

Taking into account high levels of the radiation hardness of their components, i.e. $>$10 MGy for pure SiO_2 [5], > 0.1 MGy for SiO_2-aerogel [6] and > 1 MGy for vacuumed LSs [4], these new scintillators are promised to be very radiation resistant either, at least comparative with the levels of vacuumed LSs.

SiO_2-aerogel and other porous media can be doped at high concentration levels with different elements: Li, Cd, In, Pb, etc. Such scintillating media are needed to detect γ-quanta, neutrons, neutrino, etc.

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