Large Scale Production of Siloxane-Based Scintillators for Neutrons Detection

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INTRODUCTION

Recently published results on the synthesis of siloxane based scintillators [1,2] proved the reliability of this organic system, as for sensitivity towards alpha, gamma and both fast and thermal neutrons. Moreover, the radiation hardness of the scintillators was tested by Ion Beam Induced Luminescence (IBIL) and compared with that of standard plastic scintillators, such as EJ212 (Bicron), and the results pointed out the remarkably higher resistance of siloxane based scintillators towards 1.8 MeV $^{+}$He particles. Further tests on radiation resistance are being scheduled by using the gamma source Calliope at the ENEA research center of Casaccia (Rome).

Meanwhile, the promising results obtained with the small scintillators so far produced should be verified on large volume scintillators of the same composition, in order to assess the possibility to use them as ionizing particles and/or neutrons monitors on large scale.

In this report, we present the production techniques and some results of light yield measurement for two large volume samples of siloxane based scintillators.

SAMPLES PREPARATION

A blend of different siloxane precursor resins was used in order to increase the amount of phenyl groups present along the siloxane chain. In particular, 22% diphenyl-dimethyl vinyl terminated siloxane (22% molar percentage of diphenyl groups) was mixed with phenyl-methyl vinyl terminated siloxane resin in a 90:10 weight ratio.

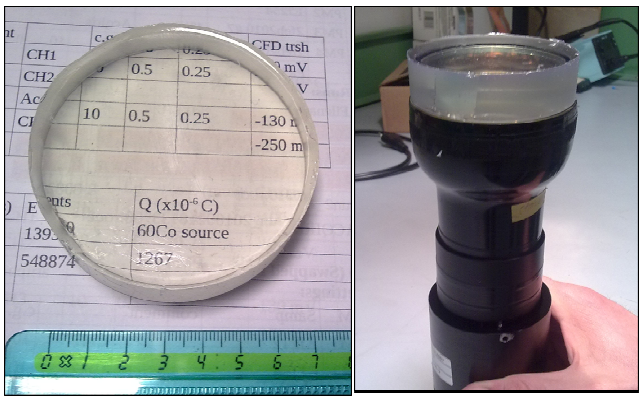

Fig. 1. Photo of the large volume siloxane scintillator produced (on the left) and of the same mounted on the PMT.

As already described in LNL Annual Report 2009, the base resin was added with the proper amount of primary and secondary fluors, namely PPO and LV with concentration 1% and 0.01% wt. respectively, and the mixture was allowed to stir overnight for complete dissolution of the solutes. Thereafter, the Pt catalyst and the cross-linker resin were added and, after further 1 hour of thorough mixing, the clear solution was outgassed in vacuum prior to casting in an Aluminum mold.

The sample, denominated as L1, was extracted easily from the mold after 24 h of cross-linking reaction at 60°C and a cylindrical shaped slab with diameter of 76 mm (3 inches) and thickness of 10 mm was obtained for the tests.

As can be seen in figure 1, the sample was highly transparent, firm and solid, though elastic. The elasticity allowed optimal coupling with the photomultiplier entrance glass window without the use of coupling media such as optical grease.

A similar sample with the addition of o-carborane for testing with thermal neutrons was also produced, the amount of natural boron being 3.4% wt. We will refer to this sample with the name of L2_B3.

EXPERIMENTAL

The two samples have been directly coupled to two different Hamamatsu R6233 photomultipliers, without light guides or optical media. The wrapping was made by aluminized Mylar (1.5 μm) on the front face and white Teflon on the side. To avoid exposure to light the Teflon was covered by black ribbon. The front face Mylar thickness was chosen to allow measurements with ^{241}Am α source.

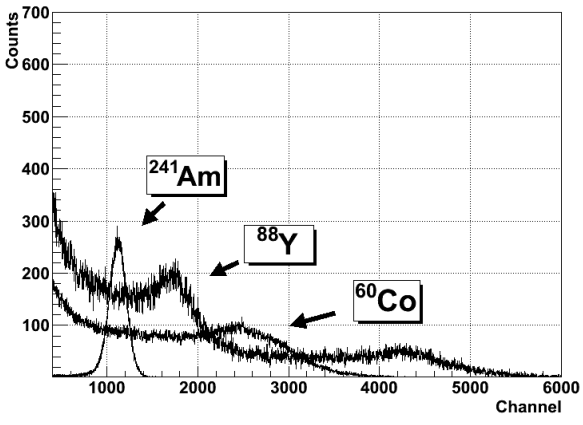

Fig. 2. Non normalized α particle (^{241}Am) and γ ray (^{88}Y, ^{60}Co) spectra for the L1 sample.

A simple analog electronic chain was used: the signal coming from the anode output of the PMT were amplified by a Canberra 2024 Spectroscopy Amplifier (shaping time = 0.5 μs; gain = 36) and acquired by a FastcomTech Multichannel Analyzer.

Spectra have been collected with α (^{241}Am) and γ (^{88}Y, ^{60}Co, ^{137}Cs, ^{133}Ba) sources for both the samples. Figure 2 displays an example of the spectra obtained for the L1 sample. The results are compatible with the one obtained with previously produced smaller samples in terms of resolution and light output.

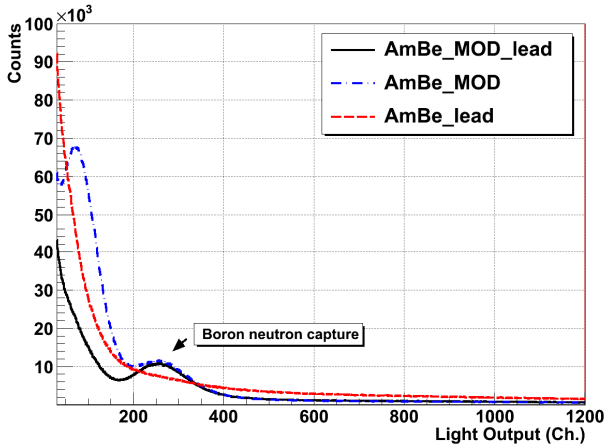

Fig. 3. Spectra from the AmBe source for the L2_B3 sample: fast neutron spectrum obtained with Lead shielding on the detector (dashed line); partially moderated (through HDPE) neutron spectrum without lead shielding (dot-dashed line); partially moderated neutron spectrum with lead shielding.

For the L2_B3 sample also AmBe neutron source measurement have been performed. A typical spectrum is shown in figure 3 where the boron neutron capture peak is visible when a block of HDPE (High Density Polyethylene) was placed between the source and the detector to get some moderated neutrons. To avoid the γ rays from the AmBe source (59 keV ^{241}Am), the detector was screened by some lead blocks.

CONCLUSIONS

Large volume siloxane-based scintillators have been synthesized and their performances have been tested in terms of light output and resolution under radioactive sources exposure. One of the produced scintillators has been doped with 3.4% wt. of natural Boron.

Good response to α particles and γ rays has been observed for both L1 and L2_B3 samples. The latter one demonstrated its capability of detecting moderated neutrons. Efficiency and radiation damage measurements will be performed in order to compare quantitatively their response towards commercially available materials.

ACKNOWLEDGMENTS

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