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Compatibility test of selected materials in liquid scintillator towards SABRE South detector design and fabrication to detect dark matter

Abstract:

The Sodium Iodide with Active Background REjection (SABRE South) detector experiment (Figure 1) in Australia aims to direct dark matter detection, and its detector design includes numerous materials that will be in contact with the liquid scintillator over the uninterrupted multi-year operation for around 5 years [1, 2]. The light yield of the liquid scintillator is easily degraded by the presence of contaminates, so compatibility testing was needed to ensure that liquid scintillator was not degraded by the materials used in the construction of the SABRE South detector design and fabrication and the light yield remains above an acceptable limit over the course of the experiment [2].

SABRE South particle detector's component compatibility tests in terms of scintillation light yield and optical absorbance analysis of liquid scintillator over ˜560 days are reported here. A key outcome of the compatibility test is that tested rubbers (MelbRub, NBR, EPDM and Neoprene) and bellows (BellowsWD, BellowsCL, BellowsWS and BellowsAct) materials are totally incompatible with liquid scintillator, which should not use in contact with liquid scintillator at any condition. In addition, Jubilee clip, polyolefin tube and potting compound degraded significant amount (more than 10 %) of light yield and optical absorbance of liquid scintillator over 560 days, which can ultimately reduce the SABRE South detector's energy resolution and detection efficiency. On the other hand, stainless steel, steel coated materials, Viton O-ring, BlackCable (coaxial cable), epoxy sealant, LuMirror, nylon made cable ties, nylon nuts, fluorinated ethylene propylene (FEP) cable, polytetrafluoroethylene (PTFE) tape, aluminium alloy (Al6060) and copper alloy (CuCF) gasket are fully compatible with liquid scintillator. Based on the carried out experimental study, if any liquid scintillator degradation scales as the surface area to volume ratio and scales linearly with time in contact with the material, then the lack of observable changes (at the 1 % level) over 560 days with the used test geometry, translates to a stability at the level of 0.6 % over the 5-year detector operation.

The obtained results from this study can be used to understand the effect of different materials on the light yield and optical absorbance properties of the liquid scintillator over the course of 3 to 5 years uninterrupted operation, and it can aid to design large scale scintillation detectors for nuclear science and particle physics applications.

[1] Rahman, M.S. et al., Investigation of Viton O-Ring Performance for the SABRE Dark Matter Experiment. J. of Materi Eng and Perform 29, 8359–8369 (2020). https://doi.org/10.1007/s11665-020-05259-x .
[2] Bignell et al., SABRE and the Stawell Underground Physics Laboratory Dark Matter Research at the Australian National University, EPJ Web Conf., 2020, 232, p 01002.

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Authors: Mr RAHMAN, Md. Shahinur (School of Science, The University of New South Wales (UNSW) and Australian National University (ANU), Australia); Dr HUTCHISON, Wayne D. (School of Science, The University

of New South Wales (UNSW Sydney)); Dr BIGNELL, Lindsey J. (Department of Nuclear Physics, The Australian National University (ANU)); Prof. LANE, Gregory J. (Department of Nuclear Physics, The Australian National University); Dr SEITENZAHL, Ivo Rolf (School of Science, The University of New South Wales (UNSW Sydney), Canberra BC 2610, Australia); Dr BARONCELLI, Tiziano (Department of Physics, University of Melbourne, Australia)

Presenter: Mr RAHMAN, Md. Shahinur (School of Science, The University of New South Wales (UNSW) and Australian National University (ANU), Australia)

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