Lithium 6 vs Helium 3 for Neutron Detection

Neutron detectors enable a wide variety of critical applications in our modern society including large systems in a range of research applications, where new materials are explored using the unique properties of neutrons. Neutrons interact with matter via the nuclear force and not the electromagnetic force used by most other detection systems (e.g. x-ray, electron, and proton beams).

The unique properties of neutrons are now also utilized for security and non-destructive testing applications. In order to inspect large objects made from high Z elements (e.g., metals), higher and higher X-ray energies are required to penetrate the item to be inspected. Neutrons, however, bounce between the heavy atoms and maintain most of their energy to reveal content that would otherwise be concealed.

A second important application for neutron detection is prevention of nuclear proliferation. Elements that can be used for the manufacture of nuclear weapons are neutron emitters, and it is critical that these materials can be detected with high sensitivity and accuracy at borders and facilities. High sensitivity is required to ensure that even small quantities of neutron-emitting isotopes are detected, and accuracy is required to ensure that the measured response was due to neutrons and, in particular, not due to a gamma ray that could be emitted from a large variety of different sources.

Helium 3

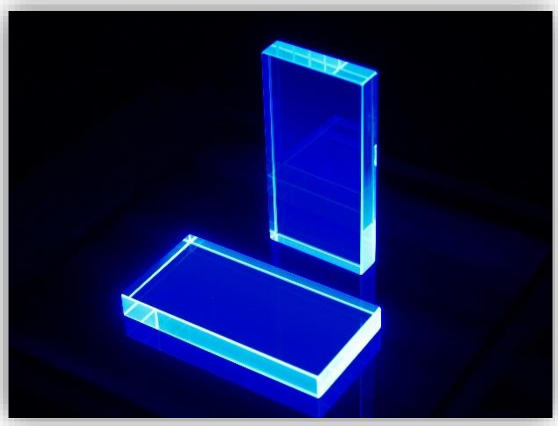
Helium 3 has been used as a neutron detector for many years, since 3He has a large cross-section for neutron capture and has a very low cross-section to react with a gamma ray. It is therefore well suited for applications preventing nuclear proliferation. However, 3He detectors have drawbacks:

- 3He is a gas and in order to have high neutron detection efficiency, a high-pressure container is required to get the 3He density needed.

- 3He is a very rare element, and most of the 3He is a byproduct of nuclear weapon production. The nuclear stockpile has been reducing since the beginning of the century, reducing the amount of 3He generated, and at the same time, the demand for 3He has increased. This has resulted in an enormous price increase of 3He. A shortage is expected, triggering plans such as the EUs to mine 3He on the moon.

Lithium 6

Lithium 6 is a very suitable replacement for Helium 3 for neutron detection. The thermal neutron cross-section for 6Li is 940mb (compared to 5330mb for 3He), however, this is high enough for most applications and 6Li has the great advantage that it can be incorporated into solids for easier incorporation into very robust detection products with high neutron detection efficiency.



Scintacor Lithium glasses have different amounts of 6Li dependent on customer requirements. The glass is thermal and chemical resistant, and its transparency enables thick glass layers with high neutron absorption efficiency. GS20® with a thickness of 1mm with 95% enriched 6Li has a thermal neutron detection efficiency of 77%, and a 4 mm thick GS20® piece has a neutron detection efficiency of 99.8%.

When large flat or curved area neutron detection is required, our Neutron Detection (ND) screens are the ideal solution. The ND screen consists of 6LiF embedded in a scintillator, For high light output, ZnS is used, and for high counting rates, up to 100,000 fps ZnO is incorporated. Scintacor ND Screens can be customized in shape with screen sizes up to 1m2. Our ND screens come in two standard thicknesses of 225 µm and 450 µm and in two different LiF to scintillator ratios, with the highest Li content and 450 µm thickness producing a thermal neutron absorption efficiency of 49%.