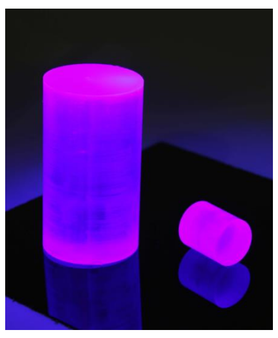
Commercially Available Solution-Grown Stilbene Crystals for Fast Neutron Detection

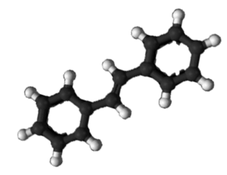
Overview



The organic scintillator trans-stilbene ($C_{14}H_{12}$) has long been recognized as having excellent properties for direct (unmoderated) fast neutron detection in a gamma-ray background.

Fast neutron spectroscopy, counting and imaging have applications in medicine, industry, research, defense, and homeland security. Though stilbene has superior neutron-gamma pulse shape discrimination (PSD) properties when compared with organic liquid and plastic scintillators, its use in these applications has been limited. This is largely because the traditional growth method (Bridgman melt) could not support commercial availability of high quality stilbene single crystals.

Inrad Optics now grows and fabricates stilbene single crystals using low temperature solution growth techniques.



Trans-stilbene molecule

Direct Detection of Fast Neutrons

Stilbene is highly sensitive to fast neutrons, hence they do not need to be moderated to lower energies to be detected.

- Measurements can take advantage of the low background, long attenuation length, and minimal number of benign sources of fast neutrons.
- Signal from unmoderated neutrons contains information about initial neutron trajectories and energies which is destroyed by moderation.

Neutron Temperature	
Thermal	~ 0.025 eV
Epithermal	0.025 – 0.4 eV
Fast	> 1 MeV
Relativistic	> 20 MeV

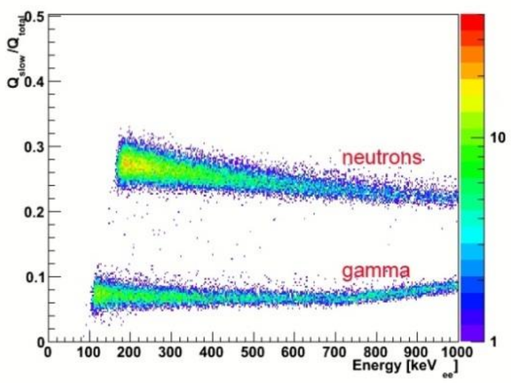
Excellent Neutron-Gamma Discrimination

- Facilitates counting fast neutrons without false positives from gamma rays
- Permits use of significantly lower energy thresholds

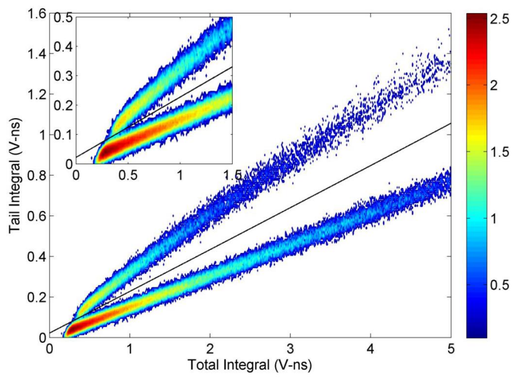
Scintillation signal consists of a prompt and a delayed fluorescence. The fraction of light resulting from the slow component often depends on the type of particle interacting with the crystal. Pulse shape discrimination (PSD) methods exploit this effect to separate events arising from neutrons and gamma-rays. Only a few materials exhibit a difference in decay rates sufficiently large for efficient counting of fast neutrons in a gamma background.

Stilbene grown at Inrad Optics using low-temperature solution growth technique has been shown to have a FOM of 4.7 for energies between 412 and 562 keVee. This value is equivalent to the FOM for melt-grown stilbene and is superior to values reported for other commercially available materials, such as liquid and plastic scintillators.

$$FOM = \Delta\ \gamma\text{-}n\ /\ \gamma_{FWHM} + n_{FWHM}$$



Pulse shape discrimination pattern from stilbene with a ^{252}Cf source [Zaitseva , LLNL]



Tail-vs-total integral plot for stilbene measuring ^{252}Cf at a 60-keVee threshold [Pozzi , U Mich]

Safe and Easy to Handle and Transport

- Stilbene is a stable, solid-state material
- Non-hygroscopic, non-flammable, and non-hazardous
- The handling challenges associated with liquid scintillators are eliminated

Scintinel™ Stilbene Crystal Configurations

Stilbene crystals are now available in a wide variety of formats to suit the diverse and challenging applications of the nuclear science community.

SHAPES
- Cylinders
- Cones
- Cubes, Rectangular Prisms

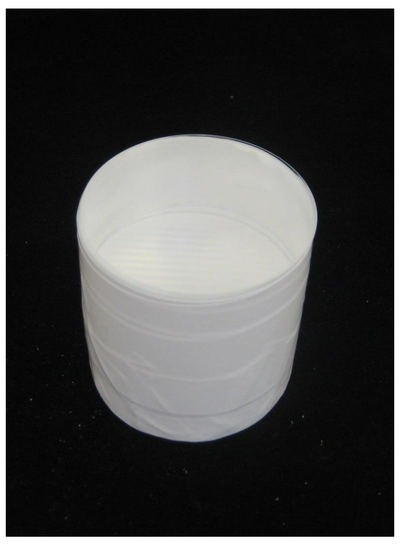
SIZES
- From 3 mm to 130 mm [5"] in diameter

10mm stilbene cubes mounted in aluminum housings, crystallographic orientation indicated for anisotropy studies

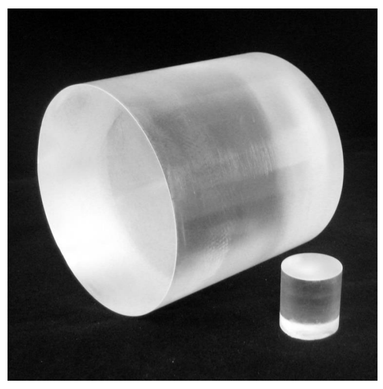
HOUSING & FINISHING
- PMT-coupled assemblies
- Wrapped in PTFE tape
- Crystallographic orientation specified and indicated for anisotropy studies
- Mounted in aluminum housings
- Polished face coupled to a protective fused silica optical window

PMT coupled assembly

2" conically tapered cylinder

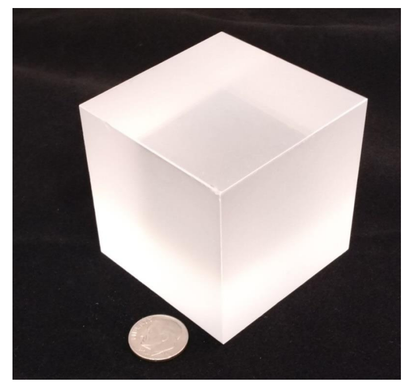


Cylinder wrapped in PTFE tape with a fused silica output window



4"x4" and 1"x1" stilbene cylinders

Assorted cylindrical and rectangular pixels



50 mm cube, 1 face polished

Awards & Recognitions

2015 - **CLEO/Laser Focus World Innovation Award**
Category: Optical Components

2015 - **SPIE Prism Award**
Category: Materials & Coatings

2015 – **Popular Science "Best of What's New"**
Category: Security

2014 – **SBIR Tibbetts Award**

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