SAND2022-12152C

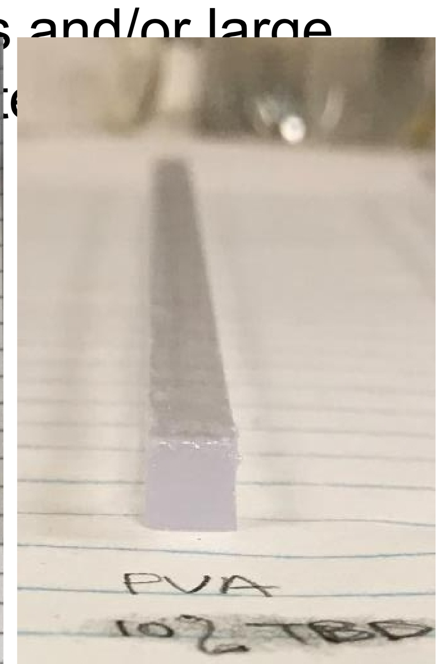
Sandia National Laboratories

calable Production Methods for Organic Glass Scintillator Detectors

Authors: Patrick Feng, Huu Tran, Annabelle Benin, Nicholas Myllenbeck, Ryan Witzke

Goals and Objectives

- Develop scalable production methods for Organic Glass Scintillators (OGS)
- Evaluate casting and thermomechanical processing methods to meet the need for custom shapes and/or large



Organic Glass Scintillators

OGS can be produced using melt casting or thermal processing methods using static or removable molds, injection molding, extrusion, and/or 3D printing. This project is concerned with evaluating these methods for potential large-scale production.

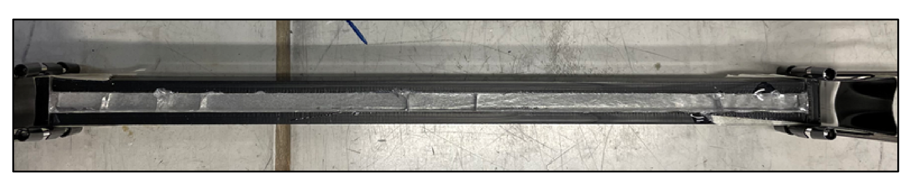
Material Class	Identical Molecules?	Thermoplastic?	Compatible with Additives?
Molecular crystals	✓		
Plastics		✓	✓
Liquids	✓		✓
(Molecular) Organic Glass	✓	✓	✓

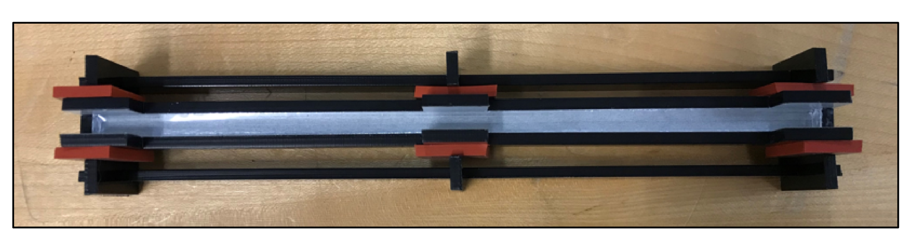
- OGSs are a random packing of identical molecules into stable amorphous phase
- Properties are a combination of crystals, plastics, and liquids
- OGS are fabricated by melt-casting or other thermal processing methods

Methods

Several fabrication methods have been evaluated to date:

- Melt casting into removable molds
  - Silicone
  - Lined acetal
- Casting into permanent static molds (pixelated arrays)
  - Reflector-lined interlocking arrays
- Melt casting into dissolvable 3D printed molds
  - Polyvinylalcohol
- 3D printing of OGS itself





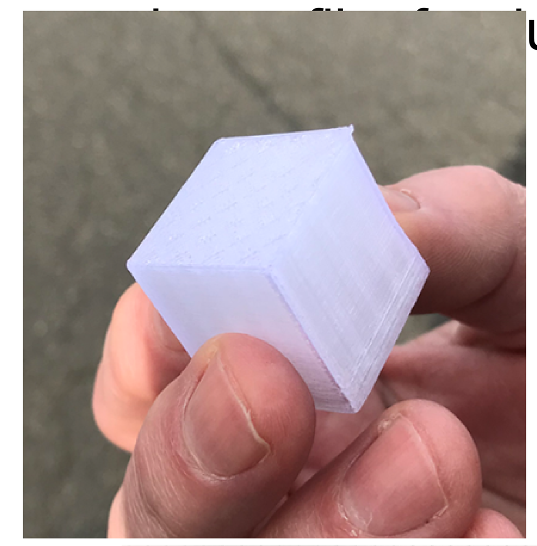
Major technical challenges include:

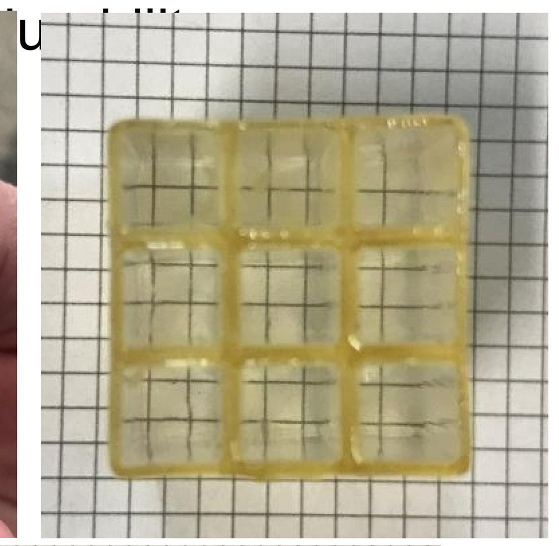
- Minimizing stress introduced during the casting/cooling process
- Surface properties- adhesion, release, optical quality
- Compatibility with industrial processing equipment

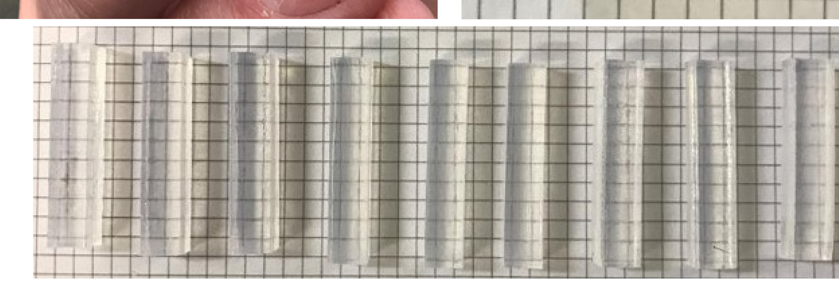
Results or Major Findings to Date

Surface properties

Results to date have shown that the OGS retains the surface properties of the mold in which it was cast. Exposed surfaces can be coated with

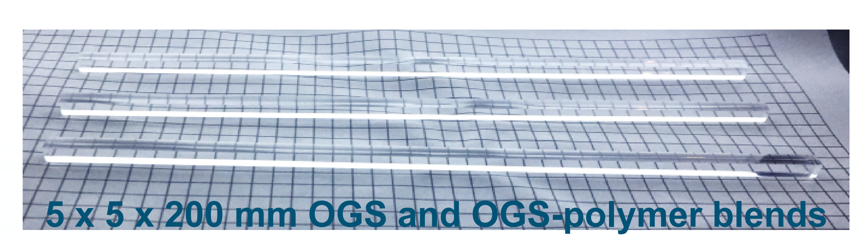


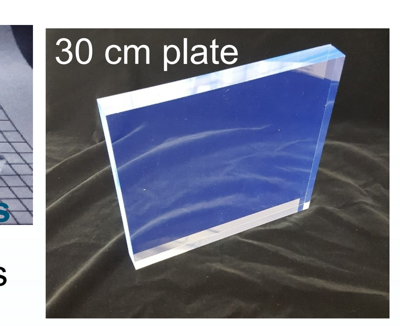




Casting Parameters

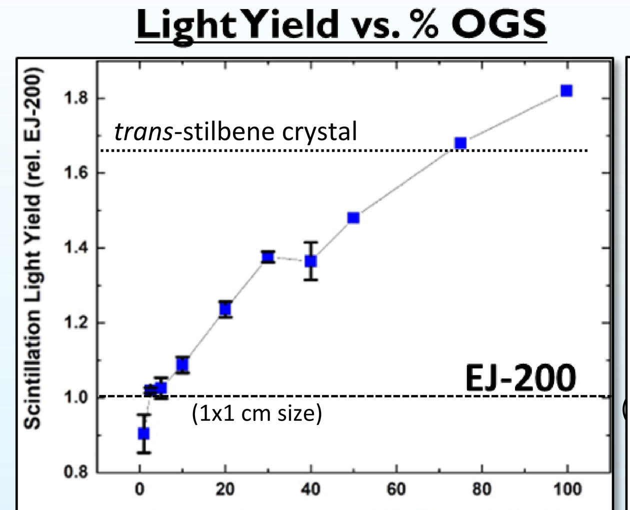
Thermal gradients should be minimized to prevent stress from being introduced to the specimen. This can be implemented using a thermal relaxation step after pouring or mitigated by strengthening additives (e.g. 3 wt. % polycarbonate, blending with polyvinyltoluene).



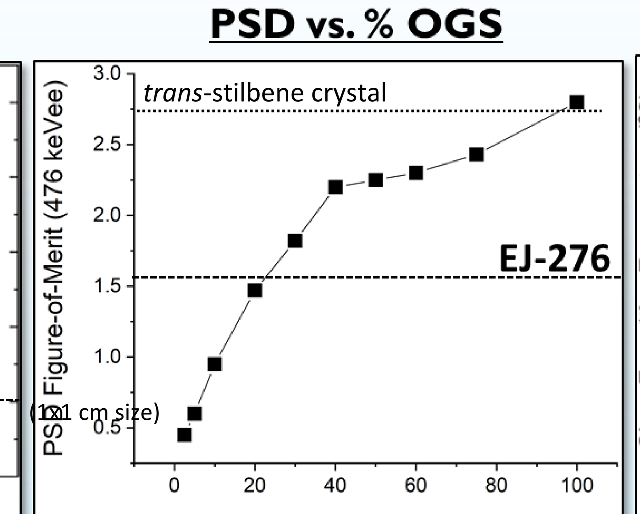


OGS fluorophores can be blended with polymers in all ratios (0-100%), leading to excellent scintillation properties and little to no change in T_g

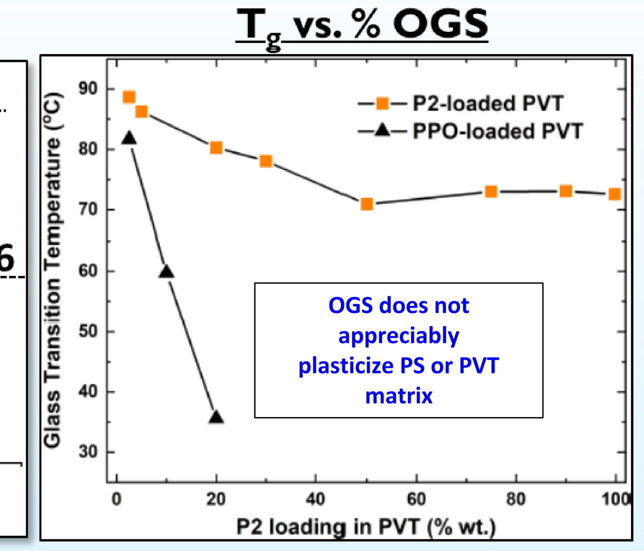
Light Yield vs. % OGS



PSD vs. % OGS



T_g vs. % OGS

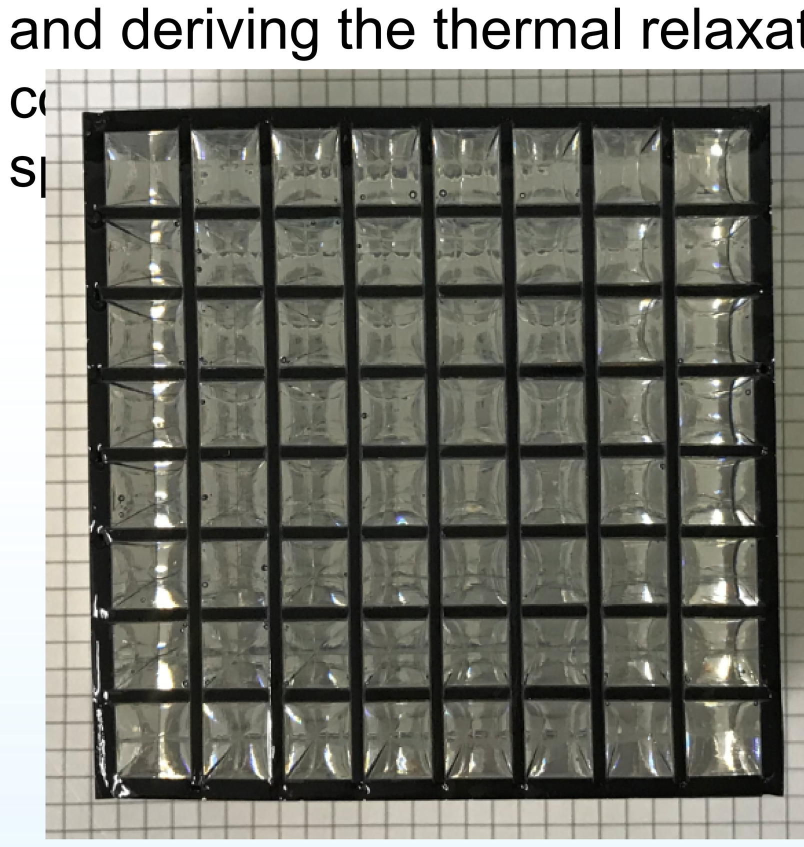


Discussion or Next Steps

Results to date have determined the principal considerations required for successful OGS detector production using the various methods. This includes:

- OGS formulation characteristics for strength, melt-flow characteristics, and required surface energy
- Material handling processes (melt temperature, transfer rate, cooling profile)
- Surface post-treatment for optical quality and long-term stability

Ongoing work will apply these properties to larger scale and/or automated production methods. Examples include parallelizing the lined acetal removable mold design, determining the parameters for injection molding, and deriving the thermal relaxation co sp



Epoxy-coated OGS in pixelated array

Conclusion and Relevance to Program Objectives

This project is motivated by the need for high-performance organic scintillators in a variety of detector sizes. This includes 'standard' geometries such as cylinders and cubes, as well as specialized configurations such as fibers, high aspect-ratio bars, segmented arrays, and potentially more exotic shapes (e.g. 'lens', cone, etc.).

Our intended goal is to determine and understand the specific processing parameters required for OGS production, as required for technology transfer to indu

This work was supported by the office of NA-22, NNSA, U.S. Department of Energy.