

# POLYCRYSTALLINE ORGANIC SCINTILLATORS WITH IMPROVED OPTICAL PROPERTIES

*I.V. Lazarev\**, *Ya.I. Polupan*, *A.V. Krech*, *I.F. Khromiuk*, *E.V. Martynenko*,  
*S.V. Makhota*, *S.S. Minenko*  
*Institute for Scintillation Materials, National Academy of Sciences of Ukraine,*  
*Kharkiv, Ukraine*  
*\*E-mail: lazarewgosha@gmail.com*

The optical and scintillation characteristics of polycrystalline organic scintillators based on *p*-terphenyl and *trans*-stilbene, obtained by pressing grains or plates, were studied. The main drawback of polycrystalline organic scintillators is low optical transmittance, which limits the use of thick detectors. A correlation between the optical and scintillation characteristics was established. The scintillation and optical characteristics of polycrystalline samples obtained from stilbene and *p*-terphenyl grains are almost the same. Polycrystalline samples made of *trans*-stilbene plates demonstrated the best characteristics. Using plates as a material for creating polycrystalline samples is advantageous for *trans*-stilbene and undesirable for *p*-terphenyl.

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## INTRODUCTION

The priority scientific focus is the development of cutting-edge scintillation materials and detectors based on them to address a wide range of modern problems in scintillation materials and devices. This includes the development of detectors for high-energy physics experiments and solutions to environmental radioecology problems. Increasing the scintillator's light output improves the detector's operational reliability. This is particularly important for low-energy radiation detection tasks, where the signal amplitude becomes comparable to the equipment's noise pulse amplitude. However, a significant disadvantage of organic polycrystalline scintillators is that their scintillation characteristics deteriorate significantly with increasing thickness [1].

Polycrystalline scintillators are promising materials for solving a number of specific problems. However, their disadvantage is that the optical characteristics deteriorate significantly with increasing scintillator thickness. This study examines the scintillation and optical properties of polycrystals of stilbene and *p*-terphenyl of varying thicknesses. Among all the materials used, stilbene plates obtained by recrystallization from an organic solvent are the best and most promising for producing polycrystals with the best scintillation and optical characteristics.

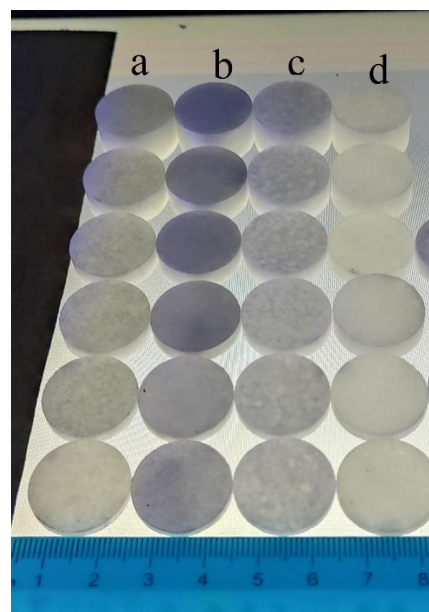
While material for polycrystal production in grain form is prevalent in most studies, material for polycrystal production from plates has received very little attention. The largest number of studies focuses on how grain size affects the properties of polycrystalline scintillators. At the same time, most studies focus on thin polycrystals with thicknesses of no more than 5 mm. Notable works related to the study of thicker polycrystals include [1, 2]. However, these studies are limited to *p*-terphenyl grains. The work aims to study and compare the scintillation and optical properties of a series of polycrystals of various thicknesses made from stilbene and *p*-terphenyl grains and plates.

## 1. RESULTS OF STUDIES

The material used to obtain grains of stilbene and *p*-terphenyl was fragments of a single crystal grown by the Bridgman method. The single crystal ingots were cryogenically ground. The material for obtaining the plates: stilbene powder was synthesized, and *p*-terphenyl

powder was purchased from ACROS ORGANICS BVBA. To obtain the material in plate form, stilbene and *p*-terphenyl powders were recrystallized from 1,2-dichloroethane.

For the research, four series of polycrystals with diameters of  $D = 20$  mm and thicknesses of 2, 3, 4, 5, 7, and 10 mm were obtained, using *p*-terphenyl and stilbene grains and plates as the pressing material (Fig. 1).



*Fig. 1. Images of p-terphenyl and stilbene polycrystals with thicknesses of 2, 3, 4, 5, 7, and 10 mm (from bottom to top):*  
*a – p-terphenyl PC obtained from grains;*  
*b – p-terphenyl PC obtained from plates;*  
*c – stilbene PC obtained from grains;*  
*d – PC of stilbene obtained from plates*

Fig. 2 presents the results of optical transmission measurements for samples *p*-terphenyl and stilbene polycrystals made from grains and plates obtained from different starting materials of 5 mm thickness.

Fig. 3 presents the results of comparing the optical transmittance of different materials at 700 nm.

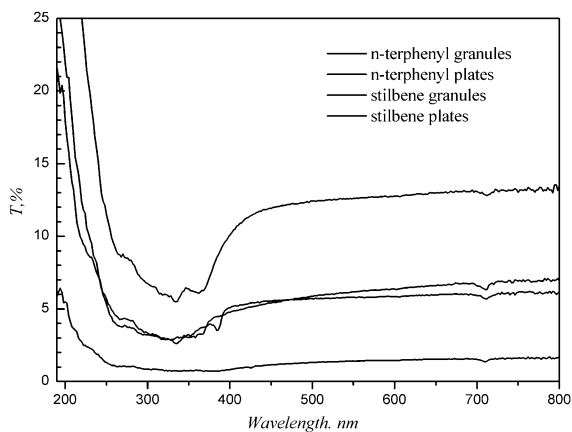


Fig. 2. Optical transmittance values for *p*-terphenyl and stilbene polycrystals made from grains and plates obtained from different starting materials of 5 mm thickness

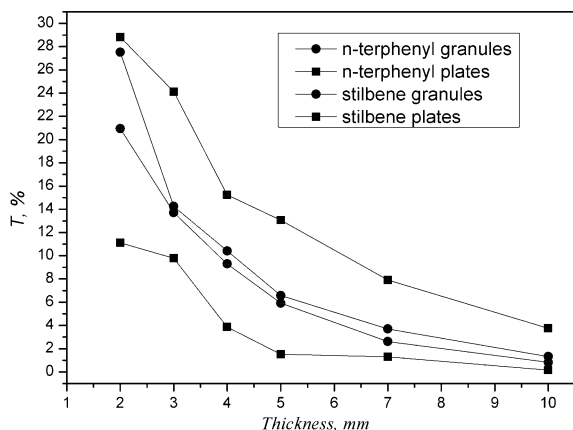


Fig. 3. Optical transmittance values at a wavelength of 700 nm for *p*-terphenyl and stilbene polycrystals made from grains and plates of different thicknesses obtained from different materials

Despite the apparent difference in transparency of the cryogenically crushed grains of stilbene and *p*-terphenyl, the optical transmittance values of the polycrystals obtained from them are practically the same. The use of plates obtained by recrystallization from 1,2-dichloroethane as a starting material for obtaining polycrystals is positive in the case of stilbene and negative in the case of *p*-terphenyl. This is due to the thickness of the plates obtained by recrystallization. As in the case of studies of the influence of the size of the grains on the optical properties of polycrystals, the maximum optical

transmittance values were observed for the material with a greater thickness. The possibility of obtaining thicker plates of stilbene, but not of *p*-terphenyl, is explained by the different crystal structures. The production of thick plates is characteristic of the herringbone crystal structure of stilbene. In contrast, the  $\pi$ -folded crystal structure of *p*-terphenyl makes it difficult to obtain thicker plates by recrystallization from commonly available organic solvents.

Among all the materials used, stilbene plates obtained by recrystallization from an organic solvent are the best and most promising for producing polycrystals with the best scintillation and optical characteristics. Use of plates obtained by recrystallization from 1,2-dichloroethane as a starting material for obtaining polycrystals: positive in the case of stilbene and negative in the case of *p*-terphenyl. The scintillation and optical characteristics of stilbene and *p*-terphenyl polycrystals obtained from grains as starting material show no significant differences. For stilbene polycrystals obtained from plates, it has been shown that the light yield values relative to the reference stilbene single crystal are over 60% when excited by alpha particles. For polycrystals made from stilbene and *p*-terphenyl grains, this value can reach 30%.

## CONCLUSIONS

1. Use of plates obtained by recrystallization from 1,2-dichloroethane as a starting material for obtaining polycrystals: positive in the case of stilbene and negative in the case of *p*-terphenyl.
2. The scintillation and optical characteristics of stilbene and *p*-terphenyl polycrystals obtained using grains as the starting material do not have significant differences.
3. For stilbene polycrystals obtained from plates, it has been shown that the light yield values relative to the reference stilbene single crystal are over 60% when excited by alpha particles. For polycrystals made from stilbene and *p*-terphenyl grains, this value can reach 30%.

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## ПОЛІКРИСТАЛІЧНІ ОРГАНІЧНІ СЦИНТИЛЯТОРИ З ПОКРАЩЕНИМИ ОПТИЧНИМИ ВЛАСТИВОСТЯМИ

*І.В. Лазарєв, Я.І. Полупан, А.В. Креч, І.Ф. Хромюк, Є.В. Мартиненко, С.В. Махота, С.С. Міненко*

Досліджено оптичні та сцинтиляційні характеристики полікристалічних органічних сцинтиляторів на основі *p*-терфенілу та транс-стильбену, отриманих пресуванням гранул або пластин. Основним недоліком полікристалічних органічних сцинтиляторів є низьке оптичне пропускання, що обмежує використання товстих детекторів. Встановлено кореляцію між оптичними та сцинтиляційними характеристиками. Сцинтиляційні та оптичні характеристики полікристалічних зразків, отриманих із зерен стильбену та *p*-терфенілу, практично однакові. Полікристалічні зразки, виготовлені з пластин транс-стильбену, продемонстрували найкращі характеристики. Використання пластин як матеріалу для створення полікристалічних зразків є вигідним для транс-стильбену та небажаним для *p*-терфенілу.