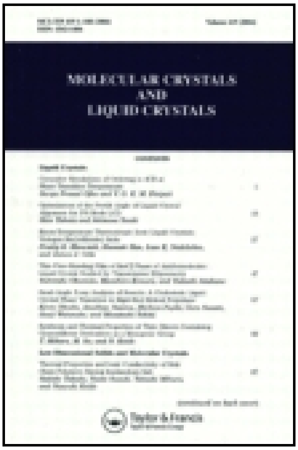


Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

# Combined Detectors Based on Crystalline p-Terphenyl for Detection of UV-Radiation

L. Andrushenko [a], J. Baker [b], S. Budakovsky [a], N. Galunov [a], V. Titar [c] & I. Yermolenko [a]

[a] Institute for Single Crystals, NASU, Lenin av. 60, 61001, Kharkiv, Ukraine

[b] SELOR eeig, Amsterdam, the Netherlands

[c] Institute of Holography Kharkiv, Ukraine

Version of record first published: 24 Sep 2006

*Mol. Cryst. and Liq. Cryst.*, 2001, Vol. 361, pp. 293-298
Reprints available directly from the publisher
Photocopying permitted by license only





# Combined Detectors Based on Crystalline p-Terphenyl for Detection of UV-Radiation

L. ANDRUSHENKO[a], J. BAKER[b], S. BUDAKOVSKY[a], N. GALUNOV[a], V. TITAR[c] and I. YERMOLENKO[a]

[a]*Institute for Single Crystals, NASU, Lenin av. 60, 61001, Kharkiv, Ukraine,* [b]*SELOR eeig, Amsterdam the Netherlands and* [c]*Institute of Holography Kharkiv, Ukraine*

Efficiency and availability of instruments for detection of UV-radiation is determined by low cost of photocells, stability of the materials used for conversion of UV radiation to light, and the degree of matching between spectral sensitivity of the photocells and the luminescence spectrum of the converter. To obtain this, we used crystalline p-terphenyl as converting material, which is stable to radiation and has high spectrum-shifting ability. However, the luminescence maximum of p-terphenyl is in the range of 380...390-nm. Standard photocells for this spectral region are rather expensive. Photocells with spectral sensitivity above 500 nm are available. The required shifting of the luminescence maximum of the converter was obtained by its p-terphenyl doping. Possibilities of conversion to longer wavelength range were also studied, when luminophor molecules were doping into compositions, and thereby optical matching between the p-terphenyl crystal and the photocell was created. Spectral characteristics for converters, as well as current-voltage characteristics of the combined detectors are presented. Prospects are shown of the use of p-terphenyl as a converter of UV radiation.

*Keywords:* luminescence; optical matching; molecular solids; UV-detectors

## INTRODUCTION

UV radiation covers the wavelength range from 220 to 420 nanometers, and enters the earth's atmosphere from space. Usually it subdivided into three ranges: UV-A (420 to 320 nm), UV-B (280 to 320 nm) and UV-C (220 to 280 nm). It is realistic to make such a division, because the different bandwidth ranges are responsible for different effects on humans. For example, the shorter wavelength band UV-C is potentially the most hazardous for human life. The ozone layer in the upper atmosphere absorbs a large amount of the UV radiation. For wavelength bands shorter than 250 nm, the absorption is practically total. A correlation between the UV intensities in two other bands is important for the normal bodily functions, such as the production of D vitamins. There are three main aspects to be considered in the cases when it comes to verify the validity of these three radiation bands, to devising means for their accurate determination, as well as quantification of their effects on humans. Firstly, the "ozone holes" have appeared in the upper atmosphere. Theretofore in recent decades the lower limit of this range has been extended down to 220...230 nm, bringing it into a range injurious to human health. It is known that the UV-radiation absorption maximum for nucleic acids, which are the building blocks of our genetic apparatus, is in the region of 260 nm. This is the clear reason why UV-radiation in this range results in genome damage because of photochemical damage to DNA. Furthermore, this is the fundamental cause of increase of skin cancer (melanoma, melanoblastoma), dermatological diseases, and reduction of organism adaptiveness and compensation properties. UV-radiation in other ranges of the solar radiation spectrum is also injurious for organisms. Secondly, The influence of high doses of UV-radiation on humans has been studied in depth, in order to develop protection for the eyesight of military personnel against laser UV-radiation attack. When dealing with the wider problem of evaluating the effects of solar UV on the population, it becomes necessary to detect relatively weak intensities of UV solar radiation. This requires new measuring devices and techniques. The same problem applies to measuring the intensity of UV-radiation in physiotherapy (where different devices are UV emitters), and in welding industries, where high UV levels are emitted during the welding process. The last third aspect is connected with the determination of those levels of UV radiation, which can be injurious to man, must be carried out on the basis of scientific results of medical and biological research.

Therefore, it is necessary to design a device in which the spectral bands of UV-ranges may be easily changed, without any change in the construction or the calibration testing technique. In such a case, the idea of block diagram will be the following. Light of needed band of wavelengths is choosing by optical filter. Shifter shifts UV- light to the range of photodiode sensitivity. The signal from the photodiode is analysed and memorised. In other words, one of the most important parts of such a device is light - resistant (for UV - range) effective light shifter, which is sensitive for the light in the range 220 - 400 nm and has the luminescence spectrum with maximum about 500 nm.

## MATERIALS FOR LIGHT SHIFTER

It is well known that one of the most light - resistant and luminescent effective an organic material, which is sensitive for UV- radiation, is a p- terphenyl single crystal [1]. Doping the melt of p- terphenyl allows growing the binary single crystals, which have the maximum of luminescence spectra about 420-nm [2]. Some time ago, we have design the technology, which allows obtaining organic luminescent polycrystals by pressure from grinding single crystals [3]. Absorption and luminescent spectra for single crystals and polycrystals of one the same composition were similar. For shifting the luminescent spectrum of doped p-terphenyl, the additional shifter was used. It based on 1,8-naphthoilene - 1', 2' benzimidazole, which allowed getting the best results in comparison of other derivatives of naphthalic acid we used. Fig.1 shows absorption and Fig.2 luminescent spectrum of additional light shifter.

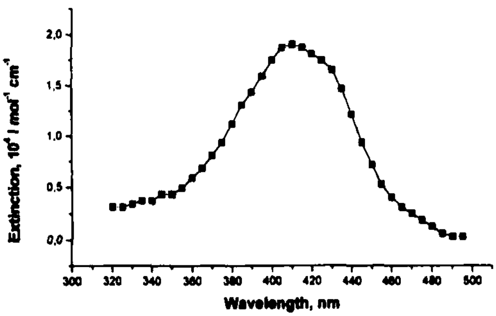


FIGURE 1 Absorption spectrum of addition shifter.

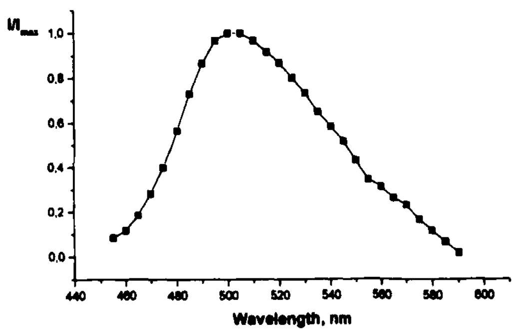


FIGURE 2 Normalised luminescence spectrum of addition shifter.

It was a protective - nonreflecting covering on the additional shifter. Such a covering was obtained on the base of polymethylphenylsiloxane or polymethylphenylsiloxane resins. The special purification technology was used to obtain the samples of high quality. The best results were obtained for such a resin, which contain light shifter molecules as an addition agent.



## RESULTS

Monolithic photodiode (with amplifier) OPT210 of Burr-Brown production was used.

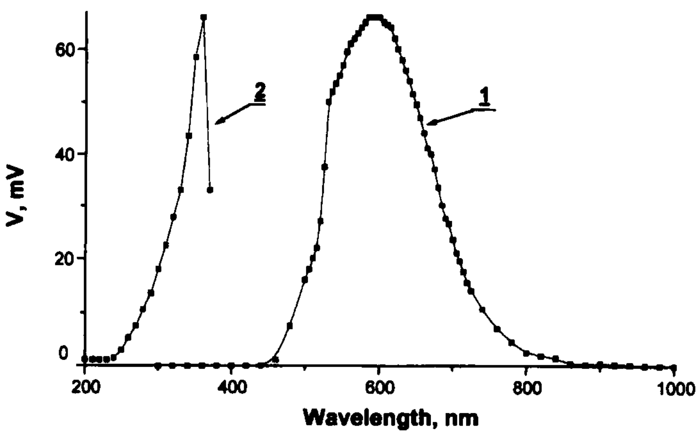


FIGURE 3 Signal from photodiode excited by the light. No light sifter was used (curve 1); the p-terphenyl polycrystal shifter and additional light shifter were used (curve 2).

Figure 3 shows the photodiode signal as a function of wavelength for photodiode OPT210 with and without light shifter. The light shifter consists of p- terphenyl polycrystal and additional shifter optically matches with it. Protective - nonreflecting covering additionally protected shifter and additional shifter. It gives a possibility not only to protect the system from age, but also to increase it light transmission on 30%.

## CONCLUSIONS

The above demonstrates that using discussed light shifter and cheap photodiode one can obtain light - resistant and luminescent effective system for registration UV- radiation.

### *References*

[1] N.Z. Galunov, V.P. Seminozhenko. *The Theory, and Practice of Radioluminescence of Organic Condensed Media* (Kyiv, Naukova Dumka, 1997) (In Russian).

[2] B.M. Krasovitskii, B.M. Bolotin, *Organic Luminescent Materials* (Weinheim: VCH, 1988).

[3] S.V. Budakovsky, N.Z. Galunov, V.P. Seminozhenko. *In the Book of Lectures Notes of First International School on Crystal Growth Technology*. (Beatenberg, Switzerland, September 5–16, 1998).