Circular Polarization Observed in Bioluminescence

Wynberg, H.; Meijer, E.W.; Hummelen, J.C.; Dekkers, H.P.J.M.; Schippers, P.H.; Carlson, A.D.

Published in:
EPRINTS-BOOK-TITLE

Publication date:
1981

CIRCULAR POLARIZATION OBSERVED IN BIOLUMINESCENCE

H. Wynberg
E.W. Meijer
J.C. Hummelen

Department of Organic Chemistry
University of Groningen
The Netherlands

H.P.J.M. Dekkers
P.H. Schippers

Department of Theoretical Organic Chemistry
University of Leiden
The Netherlands

A.D. Carlson

Department of Neurobiology and Behaviour
University of New York
Stony Brook, New York

The chemistry and biology of firefly luminescence has been studied intensively (1). However, to date no detailed analysis of the polarization of bioluminescence *in vivo* has been performed (2). The present study describes some observations concerning the intensity of circularly polarized bioluminescence. It was found that left and right lanterns of live larvae of the fireflies *Photuris Lucicrescens* and *Photuris Versicolor* emit respectively left and right circularly polarized light. Measurements of the total light emission from both lanterns of the larvae (Fig. 1) gave puzzling and disappointing results. Constant results were obtained when the left and right lanterns were measured

ISBN 0-12-208820-4

separately. The circular polarization of luminescence was measured as the anisotropy factor or g-lum factor $(I_L-I_R)/\frac{1}{2}(I_L+I_R)$. *In vivo* measurements of circular polarization of bioluminescence (CPBL) of 16 firefly larvae lanterns are shown in Fig. 2.

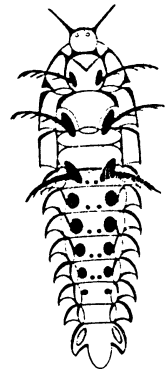

FIGURE 1. Sketch of the firefly larva (ventral view), The shaded spots at *the bottom represent the lanterns.*

It is concluded that the CPBL of opposite sense must, at least in part, be based on a macroscopic phenomenon rather than on any differences in molecular chirality. The following hypothesis is proposed: The light from a bioluminescent emitter may be (partially) plane polarized due to anisotropy of an absorbing medium or by inhomogeneous formation of excited states due to local molecular organization within a photocyte. This plane polarized light will become elliptically polarized when it passes through a linearly birefringent medium. Oriented biopolymers can serve as such a medium. On a macroscopic scale the larvae, like many other living organisms, have a symmetry plane dividing the lanterns. In this sense the lanterns are enantiomeric, even though their constituent molecules are of the same chirality. It is reasonable to assume that this macroscopic mirror image relationship holds on the level of the membrane structure and orientation of the emitters. This will result in circularly polarized light of opposite sense.

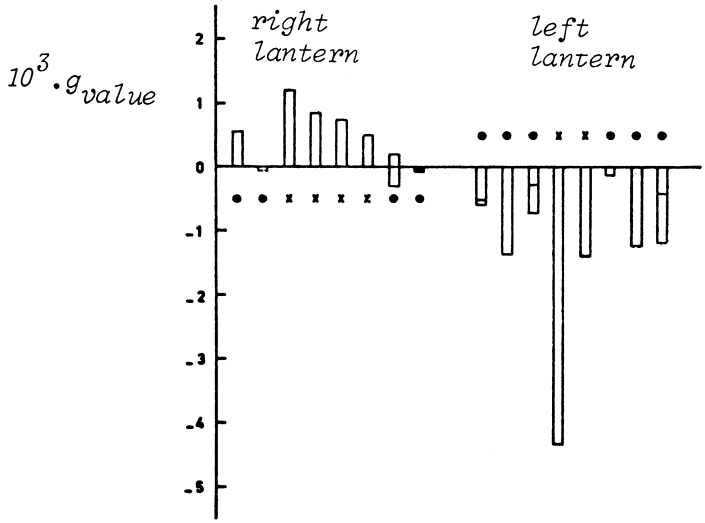

FIGURE 2. Results of measurements of circular polarization of bioluminescence of firefly larvae lanterns with sufficiently high emission intensity. The height of each bar represents the g- value for individual lanterns of Photuris Lucicrescens (x) or *Photuris Versicolor (•). Superimposed bars refer to the effect of orientational changes. The circular polarization is measured at the peak of emission band at a wavelength of 540nm using a spectral bandwidth of 40nm. The rms noise level corresponds with* $g \leq 5 \times 10^{-4}$.

REFERENCES

(1) "Bioluminescence in Action" (ed. P. Herring). Academic Press, Inc.: London (1978).
(2) Wampler, J.E. in "Bioluminescence in Action" (ed. P Herring). Academic Press, Inc.: London (1978), p. 9-48.