Light Induced Contraction of the Disk-Membrane - A Comprehensive Description of Time Course and Intensity Dependence

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Light causes a fast (msec) shrinkage of bovine rod outer segments (ROS) which is observed as a light-scattering change (1,2). It has been shown, that a lateral contraction of the disk-membrane takes part in these events (3).
The contraction saturates as a function of flash intensity (4). If the flash is measured as the relative rhodopsin turnover ρ, the best description of the saturation is given by:

$$S(\rho) = 1 - \exp(-\beta\rho)$$ (The value of β depends on preparation ($\beta = 27 \pm 3$, pH = 6, T = 20^{o} C))

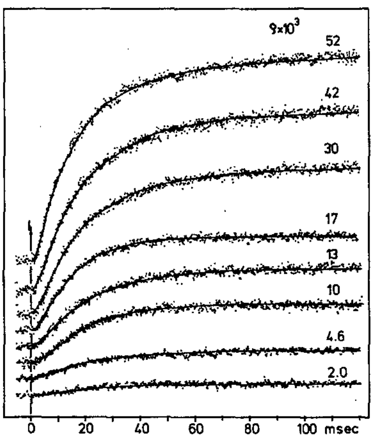
The signals show - as is seen in the figure below - a sigmoidal time course whose detailed form is dependent on intensity. We attempt a comprehensive description of the saturation behaviour and the time course:
Light induces a transition of the rhodopsin molecule in a conformation M with a time constant k_1. We assume:

$$M(t) = 1 - \exp(-k_1 t)$$

This state M has a contracting influence on the membrane. The development of the contraction in time is approximated by a time constant k_2 which is introduced into a time-dependent saturation function:

$$S(\rho,t) = 1 - \exp(-\beta\rho(1 - \exp(-k_2 t)))$$

The relation between the inducing time course M(t) and the observable time course of the contraction $P(\rho,t)$ can then be expressed by a convolution operation:



$$P(\rho,t) = \dot{M}(t) * S(\rho,t)$$

We have fitted a number of measured signals. ($0.002 \leqq \rho \leqq 0.052$, pH=6, T=20^{o}C). Two free parameters are sufficient to describe the whole family of curves. We obtain:

$$\ln(2)/k_1 = 2.0 \pm 0.3 \text{ msec}$$
$$\ln(2)/k_2 = 15.2 \pm 1.3 \text{ msec}$$

These time constants do not agree with the transitions of rhodopsin as determined by chromophore spectroscopy or the alkalisation effect (5). The activation energies derived for k_1 and k_2 are discussed elsewhere (5).

1) Hofmann, K.P.,et al.(1976) Biophys.Struct.Mechanism 2,61-77
2) Uhl, R.,et al.(1977) Biochim.Biophys.Acta 469, 113-122
3) Hofmann, K.P., Emeis, D. in: Annual Meeting of the Deutsche Gesellschaft für Biophysik, Springer-Verlag Berlin Heidelberg 1979
4) Hofmann, K.P., Reichert, J.: Presented at Sixth International Biophysics Congress, September 1979, Kyoto, Japan
5) Emeis, D., Hofmann, K.P., this issue