

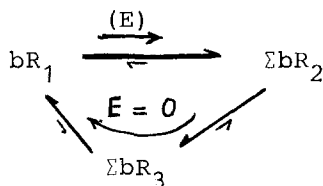
Structural changes induced by electric fields in membrane-bound bacteriorhodopsin

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Electric fields ($E = 1\text{--}30\text{ kV/cm}$, $\Delta t = 1\text{--}100\text{ }\mu\text{s}$) induce structural changes in bacteriorhodopsin (bR) of purple membrane fragments, involving:

- (1) a change in the chromophore orientation by $\geq 20^\circ$ toward the membrane normal,
- (2) an extremely large polarizability anisotropy ($\alpha_1 - \alpha_2 = 2 \times 10^{-30}\text{ Fm}^2$ ($2 \times 10^{-14}\text{ cm}^3$), at $E = 5\text{ kV/cm}$ the induced dipole moment is 10^{-24} Cm ($3 \times 10^5\text{ Debye}$), and a permanent dipole moment $p = 4.7 \times 10^{-28}\text{ Cm}$ (140 Debye) per orienting unit,
- (3) alterations of the pK-values of at least two types of proton binding sites, and
- (4) a cyclic reaction scheme for conformations characterized by at least two different extinction coefficients, ϵ_1 , for bR_1 at $E=0$ and ϵ_2 for the bR_2 states at E .



The induced dipole moment may result from cooperative increases in the distances l_i between charged groups, NH^+ and COO^- , such that the dipole moment $p = \sum_i e_i \cdot l_i$ increases in the electric field to $p_E = p + \sum_i e_i \cdot \Delta l_i$; or from a shift of $\text{OH} \cdots \text{N} \rightleftharpoons \text{O}^- + \text{NH}^+$ equilibria. The field induced pK-shifts are opposite in direction to the light-induced pK-shifts, suggesting a possible negative feedback of the increased electric membrane field on the proton transporting conformations.

The data on bacteriorhodopsin are suggestive of a possibly general mechanism for the interaction of membrane electric fields with transport and gating proteins, in particular those of excitable biomembranes.

- 1) Tsuji, K. and Neumann, E. (1981), Intern. J. Biol. Macromolecules, 3, in press; FEBS Lett. (1981), in press.
- 2) Neumann, E. and Tsuji, K. (1981), in: Molecular Electro-Optics (ed. S. Krause), Plenum Press, p. 241-268.