Properties of artificial bacteriorhodopsin analogs.
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From 1975 to 2019.

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Retinoids. Historical sketch.

The relationship between "night-blindness", or nyctalopia (severe decline of vision in dim light) and certain component in diets of both humans and animals was known back in ancient Egypt. In 1913 McCollum and Davis reported the discovery of a fat-soluble substance in some foods, which stimulated growth of rats and prevented development of "night-blindness" and xerophtalmia, and have called it "factor A", which was later renamed into "vitamin A". In 1930 Karrer has established its structure. Today three groups of chemical compounds are united under names vitamin A and retinoids: the derivatives of retinol (vitamin A alcohol, 2), of retinal (vitamin A aldehyde, 3) and of retinoic acid (RA, 4) (Fig. 1). β-Carotene (provitamin A, 1) as well as a number of other carotenoids were identified at the same time, however their transformation pathways into retinoids were found much later.

Today vitamin A (all-*E*-retinol, 2, Fig. 1) is considered the most multifunctional fat-soluble vitamin in the human body. It plays key roles in many physiological processes such as vision, reproduction, embryonic growth and development, immune competence, cell differentiation, cell proliferation and apoptosis, maintenance of epithelial tissue, and brain function. Severe vitamin A deficiency can lead to xerophthalmia and "night blindness".

Vitamin A comes into the body exclusively with food in the form of retinol esters or from carotenoids split by a number of enzyme systems located in intestines, and is stored as esters in the liver. The role of vitamin A as dietary component required for normal growth and vision was established, vitamin A deficiency (serum vitamin A levels of <0.7 μmol L^{-1}) is still prevalent in many developing countries, and considered responsible for child and maternal mortality. The administration of vitamin A alone has been shown to decrease preschool mortality in developing countries by 23−34%. Most of the biological processes linked to retinoids are in fact due to the interaction of several metabolites with retinal based proteins or their nuclear biological receptors. These metabolites are generated *in vivo* by redox changes affecting the functional group (retinal, 3, retinoic acid, 4), the C4-allylic position oxidation or C5-C6-double bond epoxidation, and the conjugated polyene chain and/or by isomerization of some selected double bonds.

Aside from vision, retinoids perform their function in the form of complexes with protein receptors: covalent complexes (retinal based proteins) and noncovalent complexes (nuclear retinoic acid receptors, RAR and RXR). Most of the cellular processes influenced by vitamin A and its analogues are mediated by their binding to (and activating) two families of nuclear receptors as well as to the retinoid metabolizing enzymes. The structural and functional studies of nuclear receptors, and the identification of retinoic acid receptor families, RARs [RARα (NR1B1), RARβ (NR1B2), and RARγ (NR1B3)], and retinoid X receptors, RXRs [RXRα (NR2B1), RXRβ (NR2B2), and RXRγ (NR2B3)], that are activated by all-*E*-retinoic acid (4) and/or its 9*Z*-isomer have significantly deepened our understanding of the molecular mechanisms by which retinoids as ligands of the nuclear receptor superfamily in general confer the ability onto these inducible transcription factors to regulate target gene transcription.

In medicine: all-*E*-retinoic acid/arsenic trioxide combination therapy (together with chemotherapy protocols primarily for post-remission consolidation and maintenance therapy) of acute promyelocytic leukemia (cures more than 90% of patients). As far as RXR ligands (also called rexinoids) are concerned, the U.S. Food and Drug Administration approved bexarotene in 1999 for the treatment of refractory cutaneous T-cell lymphoma, and efforts are ongoing to dissociate activities that induce hypothyroidism and elevated triglyceride levels, presumably by affecting RXR heterodimer pathways for other nuclear receptors. A limitation of all-*E*-retinoic acid-based therapies is their teratogenicity and hypervitaminosis, the excess intake of vitamin A, may be harmful to the elderly people due to adverse effects of vitamin A toxicity on bone loss [29, 30, 32].

Retinoid nomenclature and stereochemistry.

Retinoids are referred to as three groups of fat-soluble vitamin A derivatives that differ in the nature of the terminal group. Their molecules consist of the trimethylcyclohexene ring conjugated via four double bonds with the polar terminal group. The numbering of carbon atoms according to IUPAC-IUB recommendations is presented on Fig. 1.

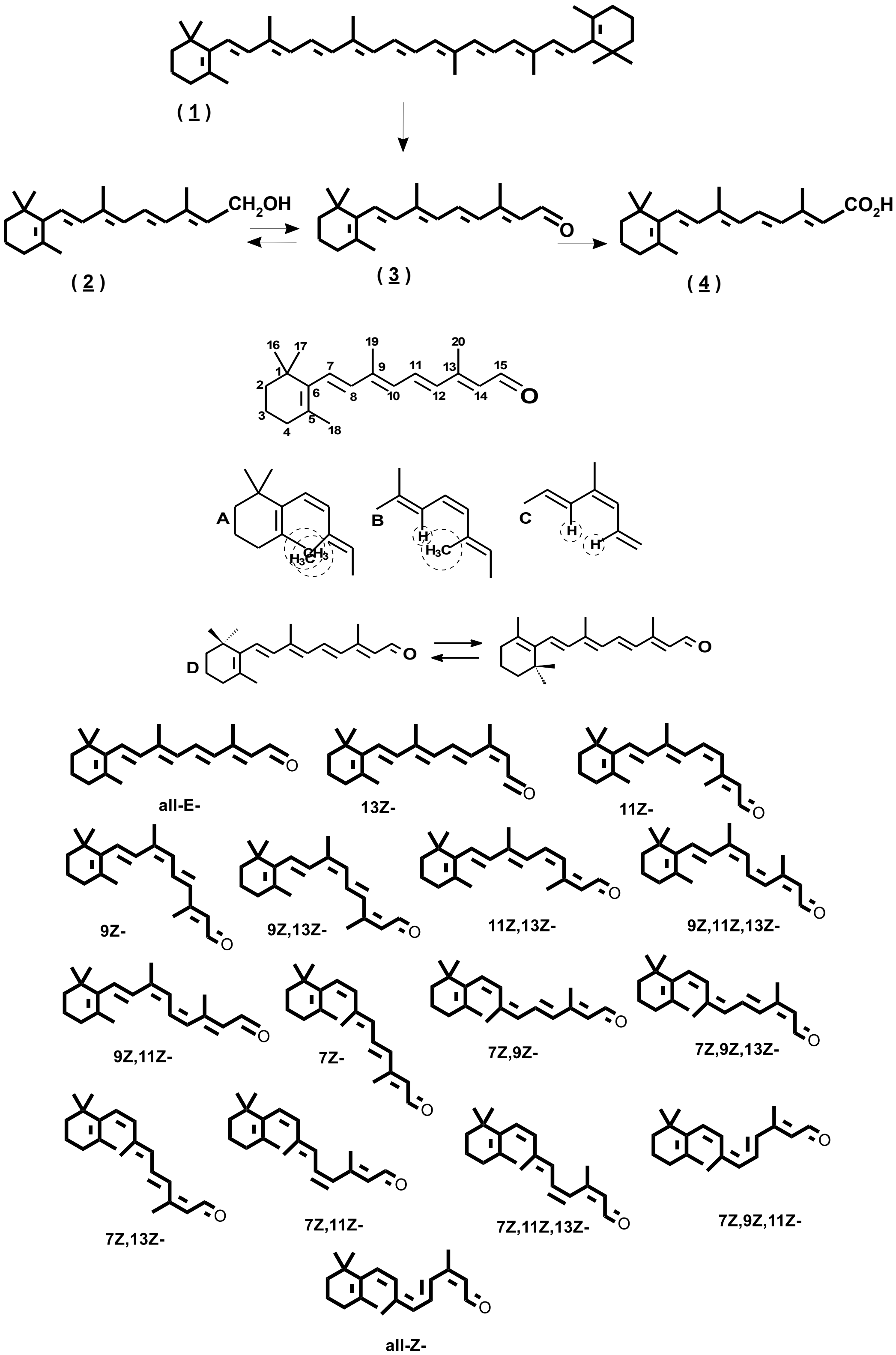

Fig. 1. Retinoid derivatives structures diversity.

The retinal molecule by its chemical nature contains lipophilic isoprenoid fragment of size C_{20} with a system of five conjugated double bonds, one of which is contained inside the trimethylcyclohexene ring, and the remaining four in the side chain ending with a terminal aldehyde group.

Two types of isomery are characteristic for retinoids: *Z*- and *E*-; s-*trans*- and s-*cis*-. Sixteen geometric retinal isomers are possible in total; their structures are presented in Fig. 1. All isomers may be subdivided into sterically unhindered – all-*E*-; 9*Z*-; 9*Z*,13*Z*- and 13*Z*-, and sterically hindered – the remaining ones. Isomerization to *E*-series, both spontaneous and induced by various physical factors (irradiation, temperature) is characteristic of the latter ones. This phenomenon is due to presence of steric difficulties of overlapping van der Waals radii of interacting groups (H, CH_3).

Retinal based Proteins

The retinoid isomers play the key role in functioning processes in retinal based proteins — visual pigments; ion-pump bacteriorhodopsin (BRh), halorhodopsin (HRh), sensoric rhodopsins (SRhI, SRhII), tundra-rhodopsin (ESRh), and others, as well as in the retinoic acid nuclear receptors. Upon absorption of light quantum the isomerization of the definite double bond initiates a cascade of events needed for the generation of the physiological or chemical responses. During the evolution process this property of retinoid molecule became the basis for a number of light quantum energy transformation into chemical energy or some physiological response in biological systems, both in higher animals and microorganisms. Retinal based proteins contain a number of defined retinal isomers as part of their chromophoric groups bound via the protonated aldimine bond with the ε-amino group of the Lys residue.

Retinal proteins (Retinal based proteins) are chromoproteins that function either as sensors or as ion pumps in several species across all domains, Archaea, Eubacteria, and Eukarya. These light-sensitive proteins share a common fold of seven transmembrane (7TM) helices and bind a retinal chromophore through a protonated Schiff base (PSB) with a Lys residue located in helix seven. The absorption maxima of each retinal-based protein are modulated by the ionic environment of the PSB in the binding pocket. Several retinal based proteins with unexpected functions have been discovered and characterized recently.

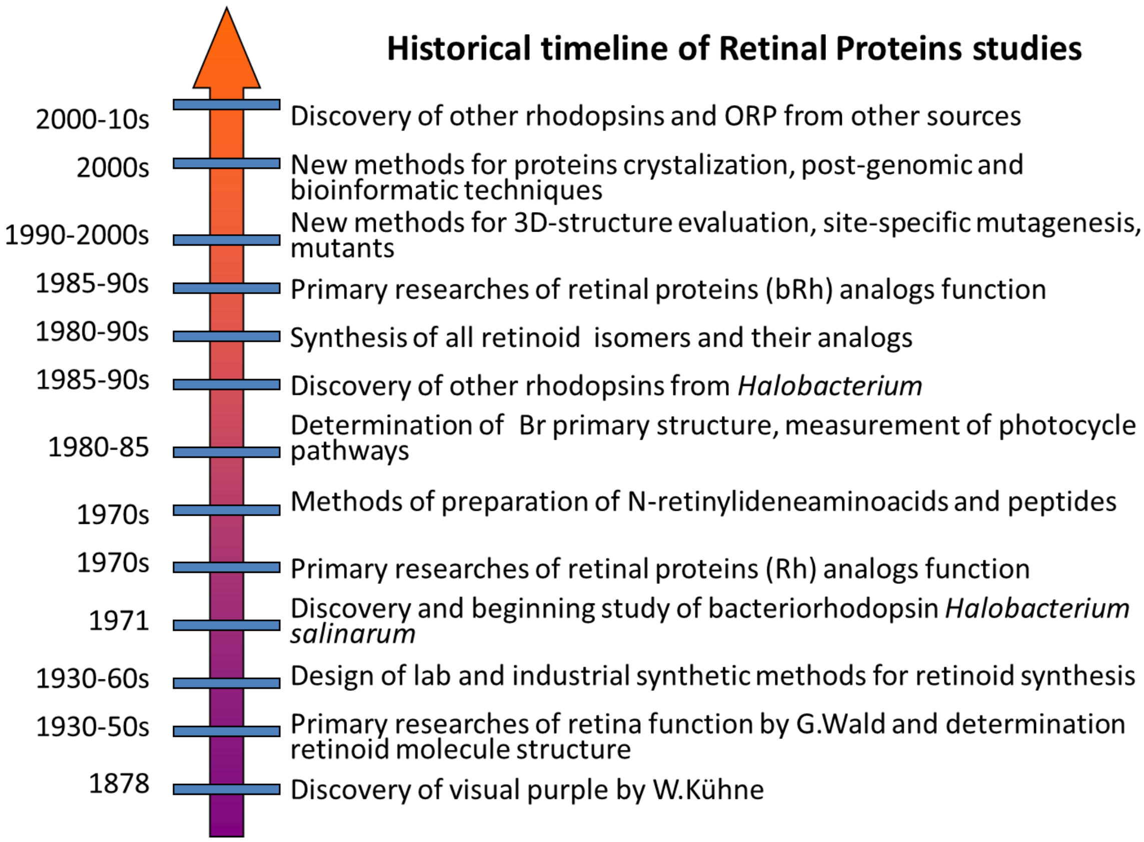

Fig. 2. Historical timeline of Retinal based proteins studies

General features of Retinal based proteins structure

Retinal based proteins have the following general features of their structures:

- Protein structure — 7 helical trans-membrane domain fold - (7TM) helices
- Chromophoric group is definite isomer retinal (all-*E*- for the microbial pigments and 11*Z*- for visual pigments) bounded to protein via protonated aldimine bond (Schiff base)
- Their function is closely connected with sun energy conversion into different chemical or physiological response
- Functional mode: light-driven Cl^- pump, light-driven H^+ pump, light-driven Na^+ pump, inward H^+ pump, light-gated cation channel, light-gated anion channel, light sensor with transmembrane transducer and soluble transducer, and light-activated enzyme.

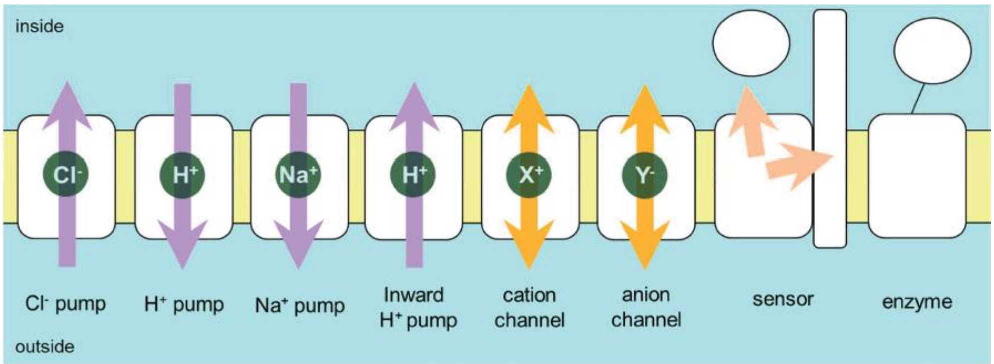

Fig. 3. Functions of microbial retinal based proteins - rhodopsins (RHs): light-driven Cl^- pump, light-driven H^+ pump, light-driven Na^+ pump, light-driven inward H^+ pump, light-gated cation channel, light-gated anion channel, light sensor with transmembrane transducer and soluble transducer, and light-activated enzyme. Purple or orange arrows indicate uni-directional or bi-directional transport of ions in pumps or channels, respectively [293-294].

The oldest representatives from known retinal based proteins are two visual pigment families – rhodopsins and cone opsins, which responsible for processes dark and color vision. George Wald determined in 1934 that 11*Z*-retinal (Fig. 1) is the chromophore of the visual pigments. Our understanding of the biochemistry and molecular biology of the visual cycle and the retinoid cycle (the conversion of *all-E*-retinal via 11*Z*-retinol to 11*Z*-retinal) has increased enormously in the last years. Other retinal based proteins (microbial rhodopsins) used by microorganisms to control membrane ion homeostasis and phototaxis are based on light-induced photocycles driven by isomerization of the chromophore *all-E*-retinal (3) bound to membrane proteins that are similar to the proteins of the visual cycle.

Retinal based proteins of micrioorganisms are currently considered to be universal and the most abundant biological light energy transducers. Before the 2000s, only microbial rhodopsins from halophilic archaea have been known (bacteriorhodopsin (BRh) and halorhodopsin (HRh)). A 2000 metagenomic study resulted in the discovery of a rhodopsin gene in marine Proteobacteria that was, accordingly, named proteorhodopsin (PRh). Since 2000, thousands of microbial rhodopsins have been identified, in all three domains of life (bacteria, archaea and eukaryota) as well as in large viruses. The renaissance of rhodopsins as a research field has culminated in the development of optogenetics, the revolutionary method for controlling cell behavior in vivo in which microbial rhodopsins play the key role. Several rhodopsins with unexpected functions have been discovered and characterized recently. Among the members of this family are light-driven proton, anion and cation pumps, light-gated anion and cation channels, and photoreceptors. Also, rhodopsins that function as inward proton pumps have been discovered (see, Fig. 2,3) [29, 30, 291-295].

The opsin genes are classified into two groups: Type I opsin genes are found in archaea, eubacteria, fungi, and algae, and Type II opsins are found in animals. Microbial type I opsins, which comprise more than 1000 members, control proton gradients and maintain membrane potential and ionic homeostasis. This group includes the light-driven ion pumps bacteriorhodopsin (BRh) and halorhodopsin (HRh) and light-gated ion channels called channel rhodopsins (ChRhs). Other microorganisms use opsin-based photoreceptors, such as sensory rhodopsin (SRh), to modulate flagelar movements in phototaxis. In marine photic ocean zone, the light-activated ion pumps from proteobacteria called proteorhodopsins, PRhs, have been linked to the survival of bacterioplancton. Type II or animal opsins couple to G-protein coupled receptors (GPCR)-dependent signal transduction pathways that affect transmembrane ion currents.

All unicellular organisms use all-*E*-retinal (3) bound to opsin in rhodopsin-like photoreceptors to capture energy and/or information from light sources and transform it into light-activated ion channels and pumps. Light absorption induces isomerization of the chromophore from all-*E*-retinal (3) to 13*Z*-retinal. In contrast to type II rhodopsin, the activated 13*Z*-retinal chromophore in type I (microbial rhodopsins) remains covalently bound to its opsin protein partner and thermally reverts rapidly to the all-*E*-retinal state without detaching from the protein. The efficiency of light absorption depends on the extinction coefficient of the complexes (ε_{max}, typically between 50 000 and 70 000 $M^{-1}cm^{-1}$) and the quantum efficiency (Φ, typically between 0.3 and 0.7). The turnover time of the photocycle for most light-driven pumps (HRh and BRh) is 10−20 ms [29, 30, 291-295].

Bacteriorhodopsin

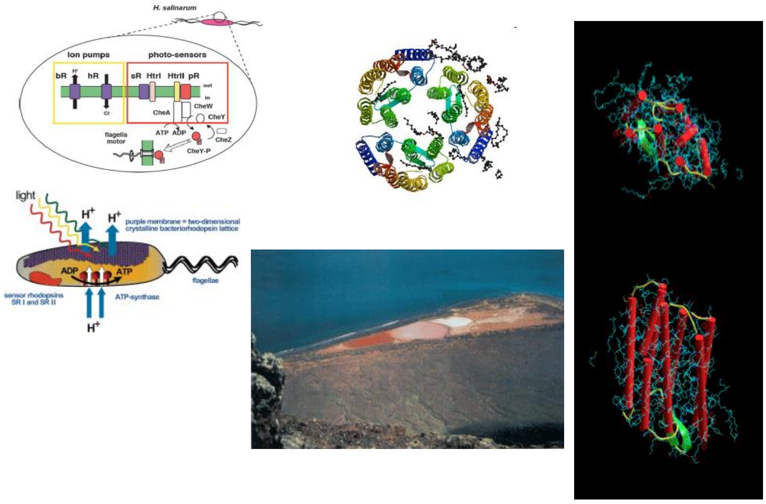

Fig. 4. ***Halobacterium salinarum*** **cell structure (purple membranes and Bacteriorhodopsin)**

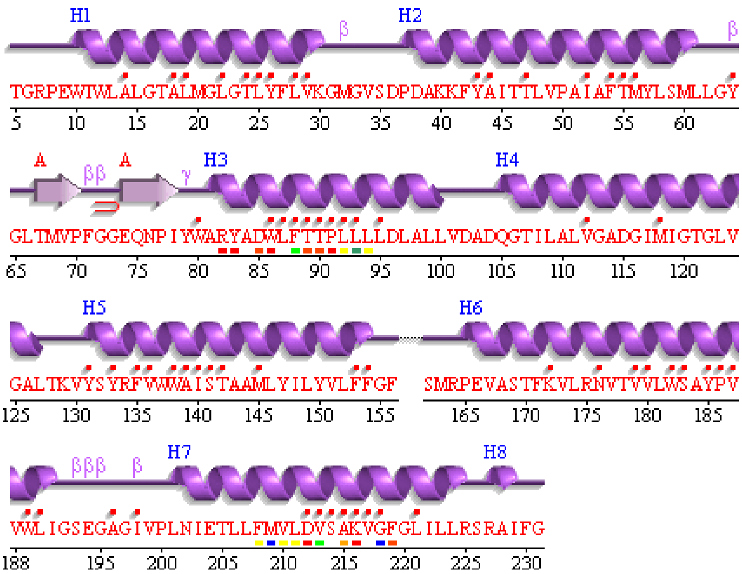

Fig. 5. Bacteriorhodopsin primary amino acid sequence (fragment) and secondary structure (PDB 1m0l).

Bacteriorhodopsin (BRh) from *Halobacterium salinarum*, the first discovered microbial rhodopsin in 1971, [1] is the first membrane protein whose structure was found to be composed of seven helices by electron microscopy, and was also the first membrane protein to have its amino acid sequence determined [2-6]. As the best studied microbial rhodopsin, it serves as a paradigm of a light-driven retinal-binding ion pump and aids in studies of novel rhodopsins.

BRh is the focus of our investigation. This compound is a unique natural photochrome acting as a light-driven proton pump. It is located in special areas of the cells, purple membranes (PM), consisting of BRh trimers embedded in the lipid bilayer. The chromophoric group of this protein is the protonated aldimine of all-*E*- and 13*Z*-isomers of vitamin A aldehyde (retinal). The purple membrane (PM) of *Halobacterium salinarum* is a natural 2D crystal honeycomb lattice of BRh trimers. The BRh protein contains a single polypeptide chain (248 aa) and converts light energy absorbed by the retinal chromophore covalently linked via a PSB to ε-amino group of Lys216 in helix 7 into a proton electrochemical gradient across the membrane (Fig. 4-8).

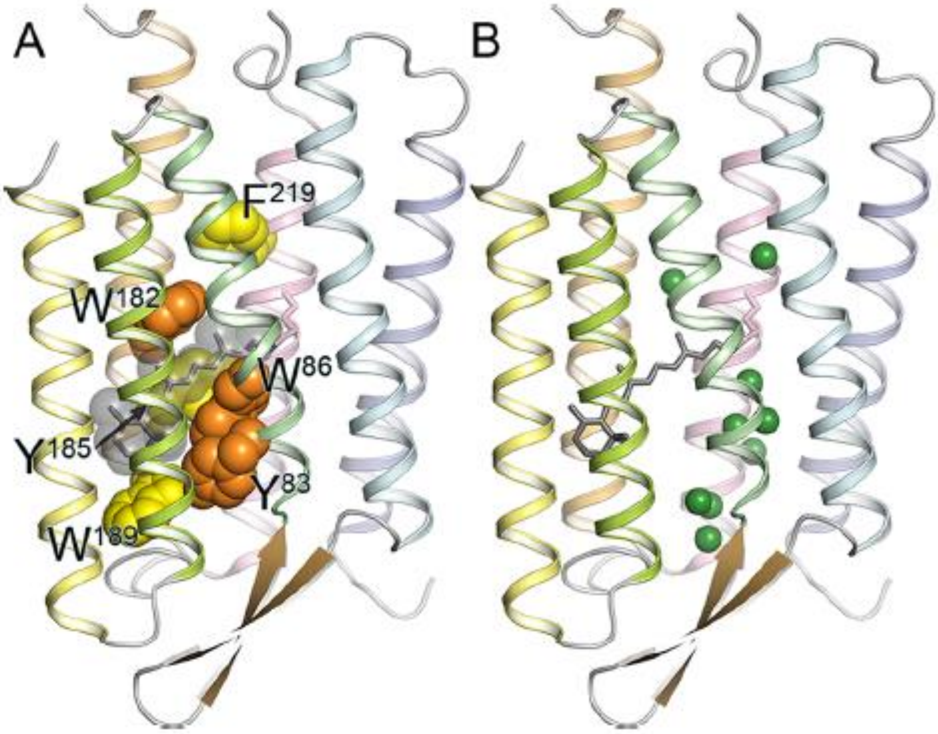

Fig. 6. (A) Structure of bacteriorhodopsin (BRh), with conserved aromatic residues highlighted (PDB ID: 1QM8). (B) Crystallographically observed internal water molecules of BR (shown as green spheres)[291, 292]. Tyr83, Trp86, and Trp182 are strongly conserved among microbial rhodopsins (orange). Aromatic amino acids are strongly conserved at the position of Tyr185, Trp189, and Phe219 (yellow). In BRh, Trp86, Trp182, Tyr185, and Trp189 constitute the chromophore binding pocket for all-*E*-retinal (gray).

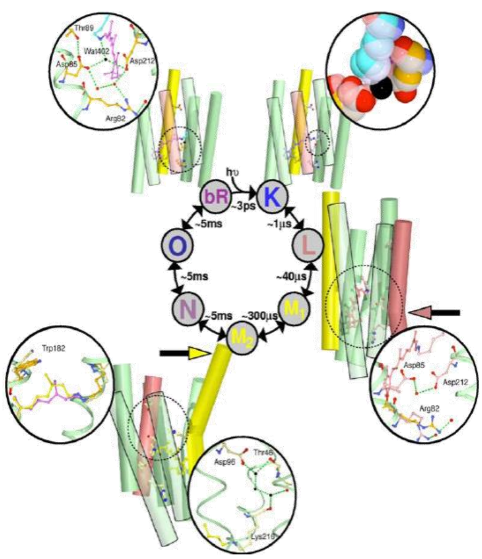

Fig. 7. Bacteriorhodopsin photocycle [291-294].

BRh undergoes cyclic photochemical reactions accompanied by the isomerization of the chromophore polyene chain and the deprotonation and reprotonation of the retinal aldimine moiety (Fig. 7, 8). The ground - B-state (λ_{max} 570 nm, ε 63,000 M^{-1} cm^{-1}) and the $M_{1,2}$-states (λ_{max} 412 nm, ε 45,000 M^{-1} cm^{-1}, Φ 0.64) are the key states. Fig. 7 depicts the photocycle of BRh with the species spectroscopically characterized, the wavelength at which each intermediate maximally absorbs light and their lifetimes. Six discrete steps are recognized to account for the isomerizations (from BRh568 to K610 and from N530 to O646), proton transport (from L550 to M_1 412 and from M_2 412 to N530), and accessibility changes (from M_1 412 to M_2 412 and from O646 to BRh568) of the photocycle. A net transfer of one proton from the cytoplasm to the extracellular side of the membrane is produced under physiological conditions (pH > 7) as a result, and the ground-state configuration containing all-*E*-retinal PSB is recovered. The proton transport sequence comprises transfer of a proton to Asp85, release of a proton from the proton release complex, reprotonation of the SB by Asp96, uptake of a proton from the cytoplasm to reprotonate Asp96, and the reprotonation of the proton release complex from Asp85, followed by a final proton transfer from Asp85 to Arg82.

The dark-adapted BRh chromophore consists of a mixture of all-*E*-15-*anti*-PSB and 13*Z*-15-*syn*-PSB 1:1. The crystal structure of BRh in the dark-adapted state with 13*Z*-15-*syn*-retinal-PSB revealed that the configuration changes due to retinal isomerization affect residues in the vicinity of the PSB, but most of the aromatic amino acids that surround the chromophore, and the polypeptide backbone of Lys216, undergo small displacements. The photochemistry and photophysics of BRh have been the subject of intense investigations [291-294].

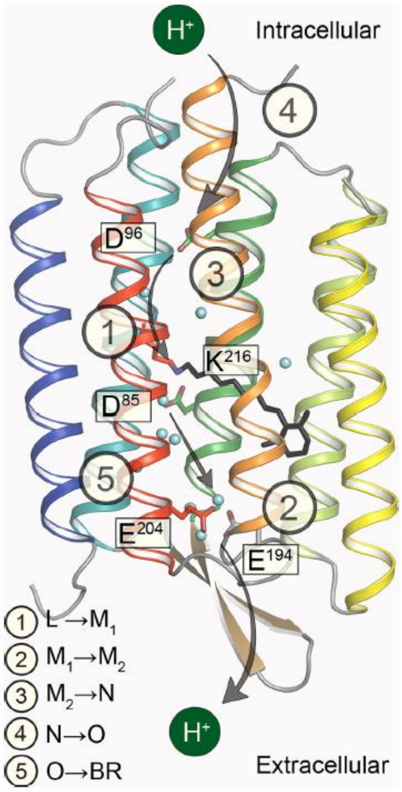

Fig. 8. Main proton transfer steps in the bacteriorhodopsin photocycle [291-294].

The proton pathway across the membrane from the cytoplasmic to the extracellular side in BRh is shown in Fig. 8, together with protonatable groups and the order of respective proton transfers. Protonatable groups and bound water molecules important for transport activity are shown as stick representation and blue spheres, respectively (PDB ID: 1C3W). Numbers with arrows represent the sequence of proton transfer reactions, the corresponding transitions between the photointermediates are indicated in the inset. The TM helices are shown in the following colors: A, blue; B, teal; C, green; D, lime green; E, yellow; F, orange; G, red; and the chromophore is depicted as black sticks. ① Proton transfer from the $RSBH^+$ to the primary proton acceptor Asp85; ② proton release to the extracellular medium from the proton-releasing complex; ③ reprotonation of the RSB from the primary proton donor Asp96; ④ reprotonation of Asp96 from the cytoplasmic medium; ⑤ proton transfer from Asp85 to the proton-releasing complex.

The absorption of light by the light-adapted BRh form (which contains the all-*E*-15-anti-PSB chromophore) induces an ultrafast photocycle (complete in less than 30 ms), which starts with the isomerization of all-*E*-retinal PSB to the 13*Z*-isomer (with the 15-anti-configuration) on the "vibrationally hot" I state followed by a thermal relaxation process involving conformational changes of the retinal and the protein. Light absorption initiates functions of both microbial and animal rhodopsins, and the wavelength dependence of the absorption efficiency determines the colors of the proteins. The structural features of the protonated Schiff base chromophore and the proton/ion conduction pathway regulate the absorption maxima of the pigments: ChRh, $\lambda_{max} \approx 470$ nm; SRhII, $\lambda_{max} \approx 487$ nm; BRh, $\lambda_{max} \approx 568$ nm; HRhs, $\lambda_{max} \approx 580$ nm; SRhI, $\lambda_{max} \approx 587$ nm.

The length of the π-conjugated polyene chain in the retinal chromophore as well as the protonation of the retinal SB linkage determine the energy gap of the π−π* transition, so that the absorption of most rhodopsins is within the visible region (400−700 nm). While the chromophore molecule is usually the same in all pigments (retinal bound via a (protonated) Schiff base), the absorption maxima differ significantly, implying an active protein control of the energy gap between the ground and excited states of the retinal chromophore.

The mechanism of color tuning has fascinated researchers for a long time, and several factors have been determined to be responsible for it. The protonation state of the chromophore plays a crucial role in color tuning; the unprotonated retinal SB absorbs in the UV region (λ_{max} ~360−380 nm), and this absorption is quite insensitive to the environment in contrast to the $RSBH^+$ (PSB), which exhibits a large variation in absorption covering the entire visible light spectrum. Other factors defining the spectral tuning of individual rhodopsins are given by chromophore−protein interactions such as electrostatic interactions with charged and polar amino acids, termed electrostatic tuning and extensively studied, first using retinal analogues, and, later, sitedirected mutagenesis [29, 30, 291-295].

Interactions of retinal with charged, polar, and aromatic amino acids play a role in changing the electronic energy levels, as do hydrogen-bonding interactions and steric contact effects. Strong hydrogen bonds can lead to charge transfer, and steric contacts can lead to a twist of retinal. All these tuning processes in concert shape the absorbance maxima of retinal in microbial and animal rhodopsins. One of the most prominent factors in color tuning is the interaction of retinal with the counterion(s). For microbial rhodopsins, however, the C6−C7 bond is 6-s-*trans*, although the C6−C7 6-s-*cis*-conformer is more stable in solution. As a consequence, an extended conjugation of π-electrons becomes possible from the polyene chain to the β-ionone ring, which presumably contributes to the considerable spectral red-shift observed in microbial rhodopsins. In fact, while absorbance spectra of protonated Schiff bases of all-*E*- and 11*Z*-retinal in MeOH solution are similar (λ_{max} ~450 nm), most microbial and animal rhodopsins typically possess λ_{max} in 520−580 nm and 480−525 nm ranges, respectively, which can in part be explained by the differences in the C6−C7 bond conformation.

The energy difference between ground (S_0) and excited (S_1) states of the rhodopsin-like proteins was initially considered to depend upon the planarity of the chromophore (a 6-s-*trans*-conformation and an elongated, almost planar polyene chain for BRh), the distance between the PSB and the counterion, and the interactions of the chromophore with amino acid residues in the binding pocket (the "two-point" charge model, which suggested the presence of a negative charge close to the hydrophobic ring). The term "opsin shift", defined as the difference between the protein absorption maximum and that of model retinal N-butylamine-PSB hydrochloride in MeOH, was coined to quantify the effect of the apoprotein on the absorption maximum of the retinal chromophore.

Thus, the chromophore molecule modification is a promising approach to the structure-function relationship study in BRh. Analogues of the native chromophore have yielded valuable structural, spectroscopic, and functional insights into the ground-state structure of the chromophore in the complex before X-ray structures became available, and continue to provide information on the nature of the photocycle intermediates. Produced by chemical synthesis, retinal analogues have been obtained with alterations on the polyene side-chain by substitution (demethylations, change of methyl positions), saturation of double bonds, incorporation of substituents (halogens, alkyl groups) and additional rings to lock conformations and/or configurations, and modifications on the trimethylcyclohexenyl ring.

The uniqueness of BRh – a natural photocontrollable photosynthetic system – for nanobiophotonics is defined by its following properties:

1) BRh is the most simple and surprisingly stable proton pump;
2) availability in high quantities, simplicity of isolation with relatively low cost;
3) stability in intensive light, oxygen, wide range of temperatures (–196 – 70°C), pH values (0–11), concentrations of salts, water-glycerol media;
4) the "primary act" after photon absorption (B→J) is an extremely fast process (0.5 ps);
5) high quantum yield (Φ 0.64);

6) possibility of making "dry" films as well as integrating BRh into polymer matrices of various compositions;
7) application possibilities both in optical and electronic devices, using either varying optical or electrical component of the response.

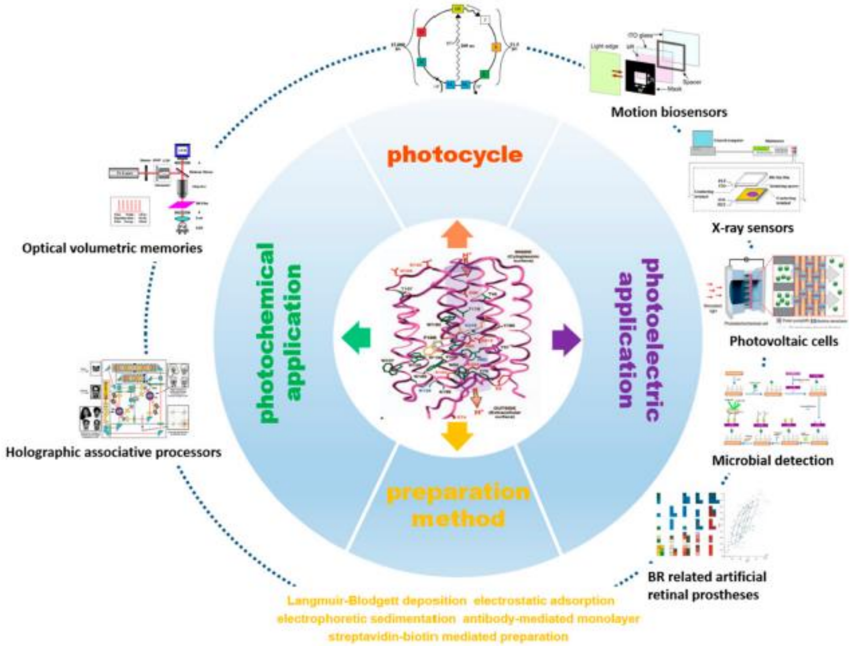

Fig. 9. An overview of BRh-based bioelectronic devices showing the photocycle, preparation method, and photochemical and photoelectric applications

Fig. 9 shows the roadmap of BRh-based bioelectronics applications since the discovery of BRh protein which reveals the development of BRh application [296].

Basic directions in the retinal molecule modification strategy

This chromoprotein is one of the first successful examples of biological photochromic material designed by the nature. One promising area of research on the retinal protein structure function relationship involves the replacement of the natural chromophore by analogs and the comprehensive study of the hybrid products. The photochemical properties of analogs BRh (ABR) can be controlled using the following approaches: 1) the substitution of one or more amino acid residues in certain positions of the BRh molecule by genetic engineering methods (using BRh mutant strainswith slower photocycles); 2) the use of natural BRh incorporated into a polymer matrix, oriented Langmuir-Blodgett films, or oriented layers immobilized on a solid support; 3) the use of environmental conditions (low temperature, electric fields, humidity, pH level); 4) a combination of the above-mentioned approaches. General directions of the BRh chromophore structure modification are depicted in Figs. 10, 11. The comparative analysis of our and other researchers' data has shown, that by diversification of the chromophore structure, it is possible directly to change λ_{max} in the spectra of the BRh analogs in the rather wide interval (from 412 to 830 nm), though not all of these pigments are capable for cyclic photochemical reactions.

We have previously developed a common procedure for structure function studies of retinal proteins. The preparation of BRh analogs (ABR) and the testing scheme are shown in the Fig. 9. Several approaches to the preparation of ABR have been developed earlier based on the addition of polyenals to:
1) growing cells of retinal-deficient *H. salinarum* strains (for example, JW5);
2) to "white" membranes or membrane vesicles obtained from the retinal-deficient strains;
3) to so-called apomembranes containing bacterioopsin (BO) generated from purple membranes by hydroxylaminolysis at pH 7.0 and 0-5^{0}C under intense illumination. We used the third approach in our investigations with an additional procedure for the removal of retinal oxime based on the treatment of BO with a saturated solution of β-cyclodextrin. Then a comprehensive study of the artificial pigments: the kinetic peculiarities of the formation of BRh analogs, the spectral properties

(λ_{max}, the presence and type of the photochemical cycle, quantum yield, the adaptation to the light and darkness) and the efficiency of the proton transport were undertaken.

The synthesized retinal analogs were tested in recombination with bacterioopsin (BO), from apomembranes *H. salinarum* (strain ET1001). Apomembranes obtained from purple membranes by hydroxylaminolysis at pH 7.0 and 0 - 5°C and intensive illumination. Resynthesis of pigments conducted by addition of a methanol solution of analog to a suspension apomembranes in a buffer (protein concentration - 2 mg/ml, 21^{0}C, pH 6.0, 5 mM MES). It was found, that the formation of pigments takes place from several min till 1 month period. It should be noted that position of the ABR λ_{max} located from 412 to 830 nm.

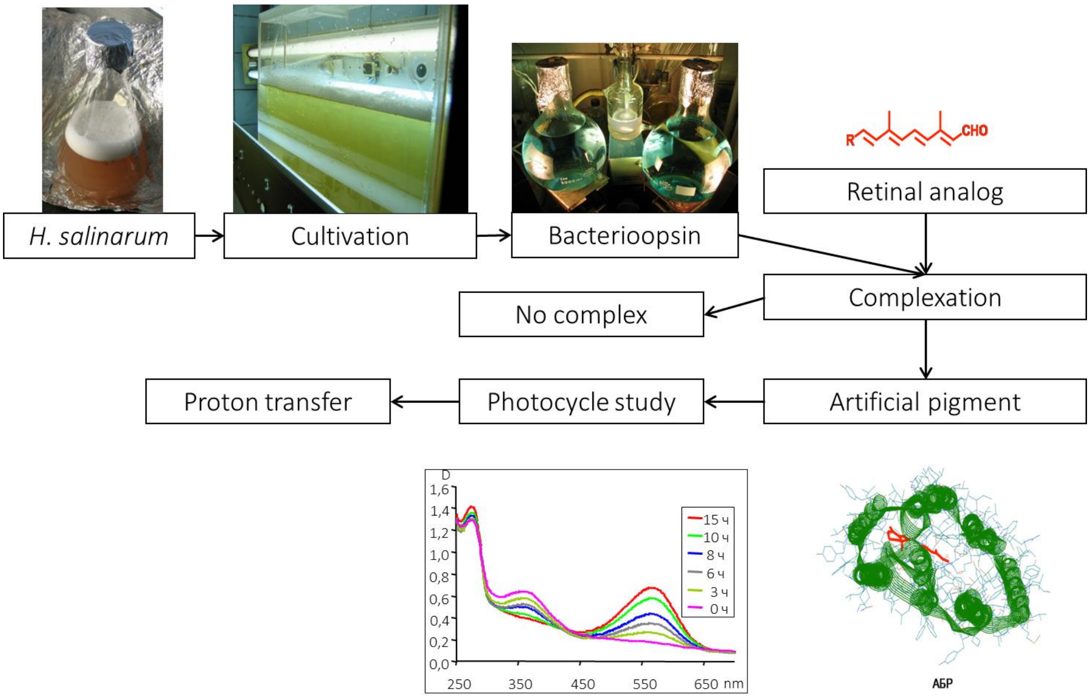

Fig. 10. Technology of the Bacteriorhodopsin analogs production.

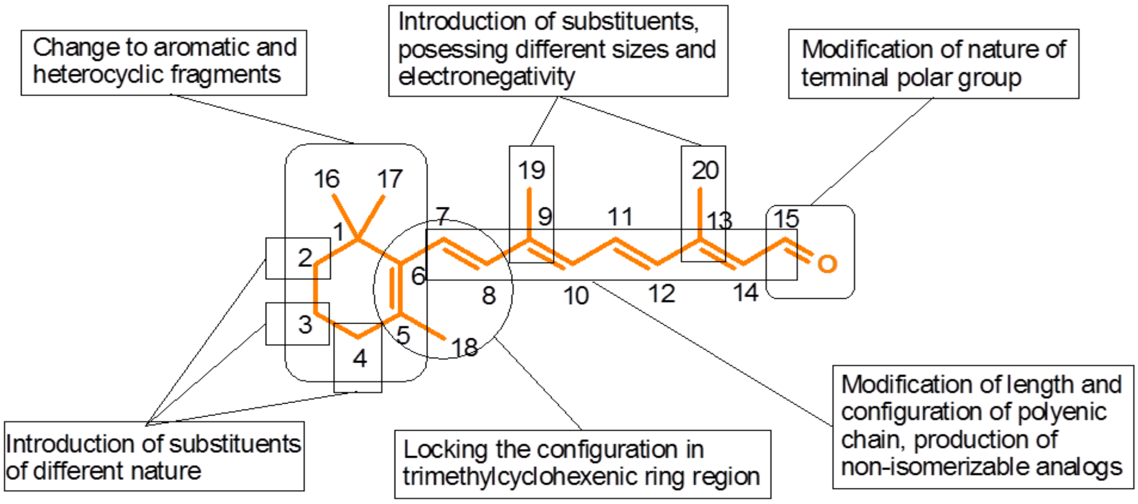

Fig. 11. Basic directions in the retinal molecule modification strategy

All retinal molecule modification variants were divided in next charts:

A. Natural chromophore — retinal and its isomers
B. Terminal polar group modification
C. Polyenic chain modification
D. Alteration of the bond types and its disposition in the chromophore polyenic chain
E. Alteration of the polyenic chain length and bond disposition and terminal group types
F. Alteration or locking of the bond configuration. Non-isomerizable analogs
G. Alteration of the trimethylcyclohexenic ring. Ring modification

H. Alteration of the trimethylcyclohexenic ring. Replacement ring to aromatic or heterocyclic fragments
I. Alteration of the trimethylcyclohexenic ring. Acyclic analogs
J. Miscellaneous modifications
K. Labelled BRh derivatives (radioactive, photo-affinic, fluorophoric, heavy-atom, paramagnetic (SL), ionophoric and photochromic probes)

The next year will be 50-year anniversary from discovery of the bacteriorhodopsin by D. Oesterhelt and W. Stoekenius [1].

Below we are presenting the database "Properties of artificial bacteriorhodopsin analogs. Version 2, 2020. From 1975 to 2019", which combined information from our and literature data sources with duration period 1975 - 2020. The comparative analysis of our database, including the information on spectral characteristics and proton transport efficiency of the interaction products about 440 polyenic compounds with BO has shown, that by diversifying the chromophore nature, it is possible to directly change λ_{max} in ABR spectra in a rather wide interval (from 412 to 830 nm), though not all these pigments are capable to cyclic photochemical reactions.

In the frames of defined type modification relationship between λ_{max} position in dependence of chromophore nature could be described by linear regression equations in axes (Y) - λ_{max}SB or (SBH^+, P^{LA}) / (X) - λ_{max}(CHO). These relationships could be used for the prognosis of the spectral properties of ABR from new retinal derivatives and BO.

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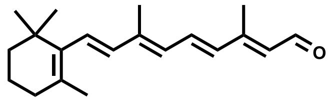
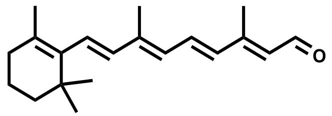
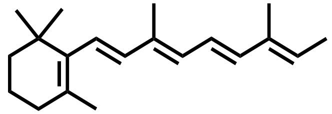
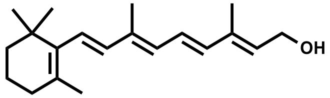
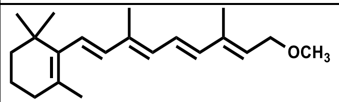
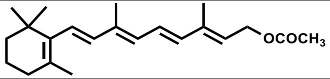
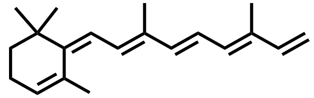
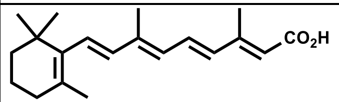
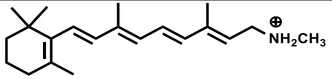
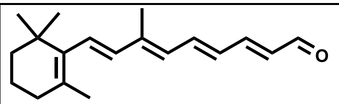
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
A. Natural chromophore — retinal and its isomers																			
		all-E-	381	360	440		558			+			50/50	4810					1-32
									568	+	412	100	100/0	5120					
		all-E-	380	360	437				570	+	412	100		5350				pK_a 13.3-+0.3	17
		all-E-	380			400, 430/ 460													
		all-E-			440				568				<2 13Z-						Biochem 1978, 17(25), 5353-5359 Eur. J. Biochem 1977, 76, 499-511
								555					34/66						
		13Z-	375				548		568			0	0/100						
		11Z-	254, 290sh 377			400													
		9Z-				388 390/ 470													JACS. 1996, 118(45), 11299-11300
		9Z,13Z-			465														
		all-E-					570 605 565											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
	 6-*s*-trans conformer	all-E-	381				568							3900					JACS. 1986. 108(11) 3104 - 3105
B. Terminal polar group modification																			
2.		all-E-				332	NO											str. R_1M_1	Biochem 1978, 17(25), 5353-5359

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
		all-E-					NO											str. R_1M_1 cells suspensions with 1 mM nicotine	Biochem Soc.Trans. 1976. 4(4), 556 - 559
3.		all-E-	325			344sh 357, 376	NO											str. R_1M_1	Biochem 1978, 17(25), 5353-5359
		13Z-				345, 360, 376sh													
		11Z-				345, 360, 376sh													
		9Z-				330													
		all-E-					NO											str. R_1M_1 cells suspensions with 1 mM nicotine	Biochem Soc.Trans. 1976. 4(4), 556 - 559
4.		all-E-				336, 357sh 376sh	NO											str. R_1M_1	Biochem 1978, 17(25), 5353-5359
5.		all-E-					NO											str. R_1M_1	2
6.		all-E-					NO											str. R_1M_1	Biochem 1978, 17(25), 5353-5359
7.		all-E-					NO											str. R_1M_1	2
							NO											str. R_1M_1 cells suspensions with 1 mM nicotine	Biochem Soc.Tran s. 1976.

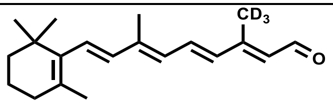
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			4(4), 556 - 559
8.		all-E-				NO	NO											str. R_1M_1	Biochem 1978, 17(25), 5353-5359
								C. Polyenic chain modification											
9.		all-E-	377	362	439		565		565	+		+		5080				str.353P, pH 6.5, 20^{o}C τ_{rec} 13Z 0.5h τ_{rec} all-E- 2 days τ_{Mdecay} decelerated There 2 long-waved intermediates 13Z-(BRA) $\tau_{form(1)}$ <200 ns; $\tau_{form(2)}$ ~ms; Photoelectrical responses are smaler in amplitudes and drastically differ in form and kinetics from natural BR cycle. No L-D adaptation	Bioorgan Khim. 1988, 14(3), 434-436 Biophysics (Rus), 1989, 34(4), 623-626 Bioorgan Khim.1989, 15(11), 1484-1497 Archiv. Biochem .Biophys 1990. 279(2), 225-231 Biolog Membrany 1998, 12(1), 121-123.
		all-E- 13Z- 11Z-	380[b]				565 565 565	565	565 ε 60000	+	420	1-3	21/69 15/85 15/85 8/92 10/80/10 all-E /13Z/					White membranes, str. JW5, 21^{o}C. "M"-like intermediate has two species in 1.5 : 1 ratio. In cycle all-E "M"[420] BRA $\tau_{1/2Mform}$ 25/400 μs, $\tau_{1/2Mdecay}$ 20/1700 ms, In cycle 13Z-(BRA	Tetrahedron L. 1980, 21(4), 347-350. Biochem 1988, 27(9), 3497 -

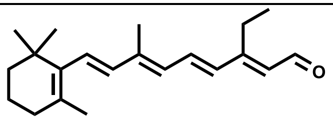
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-11Z	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			“CHO”	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
													11Z					85%) I^{610} τ_{form} <4μs, τ_{decay} 250ms Photophosphorilation rate 1.1% from control BR	3502 Biochem 1983. 22(11), 2637–2644
		9Z-					NO												
		7Z-					495												
		all-E-	366[c]						565 ε 60000	+	+	16						White membranes, str. JW5, (BRA)-<5ns->K -0.4 s->(BRA)	Biochem 1987. 26(3), 751-758
		all-E-	365[c]			430	560	560	560			0						str. R_1S_9, 22°C. all-E-430 nm species BRA stable in dark	Recl. 1983. 102(1), 42- 46 Recl. 198r3. 102(1), 46 -51
		13Z-				430	560		560			0	0/100						
		11Z-				430	560												
		9Z-				NO	NO												
		7Z-				NO	NO												
		all-E-					554 595 595											in water. pH 7.0 pH 2.5 pH 0.5	Biophys. J., 1989, 56, 1259-1265
		all-E-							565	+								Photochemistry of 13-desmethyl BRA Resonance Raman spectra of BRA	J. Phys. Chem. B 2005, 109(33), 16142-16152. J. Phys. Chem. 1990, 94(12), 4920-4926
		all-E-						569		+	410	<20 WT	15/85		stable			native WT	The Biology ChemInterface
								567										transform WT	

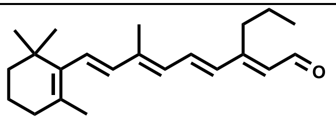
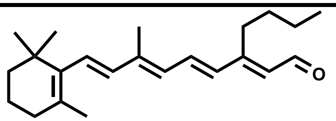
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
								566				0 R82A						R82A str. IV-8 pK_a R82A 8.1 τ_{Mdecay} 3 s "O" 600nm, arises from the 13-cis cycle and is long lived.	1999 ch 15 431-444
																		Raman spectra Schiff base (-C=NH-) stretching frequency. 1642 cm^{-1}	PhotochemPhotobiol 1985 41(5) 563-567
																		BRA quantum-chem calculations	BiophysJ 1985 47(3) 349-355
								560										str. S9 BRA cycle was tested by picosecond transient spectroscopy (PTA). "J" "K"	Chem. Phys. Lett. 1992, 190(3-4), 298-304.
		all-E-						565			410							Holographic properties of BRA film in gelatin matrix were investigated.	Optical Rev. 2001, 8(5), 368-372.
10.		all-E-	381	360	440		565		565	+		+++		5030 5030				str.353P, pH 6.5 τ_{rec} 0.5 h, 20°C	Bioorgan Khim. 1988, 14(3), 434-436 Bioorgan Khim. 1989, 15(11), 1484-1497. Archiv. Biochem

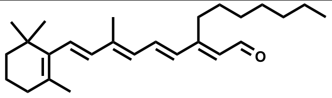
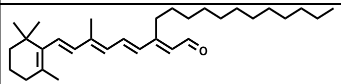
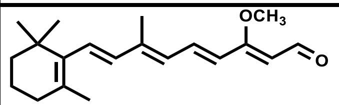
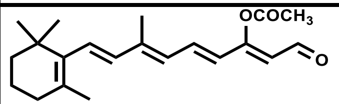
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			“CHO”	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																			.Biophys 1990. 279(2), 225–231
																		10 mM Hepes buffer, pH 7.3. PM washing with BSA. Kinetic isotope effects for dark adaptation for BRA.	Bioorgan Chem 1991 19(1) 18-28
11.		all-E-	383	365	446		567			+	+	++		4790				str.353P, pH 6.5 τ_{rec} 0.5 h 20°C BRA cycle similar to BR (M, O). L-D adaptation decelerated	Bioorgan Khim. 1988, 14(3), 434-436 Bioorgan Khim. 1989, 15(11), 1484-1497. Archiv. Biochem .Biophys 1990. 279(2), 225–231
		all-E-	379[b]				559 ε 60000		556	+	420	70	67/33 67/33					White membranes, str. JW5, 21°C. BRA cycle similar to BR (M, O). $(BRA)^{559}$-->K-->L-->M-->(BRA) τ_{Kform}< 5ns, τ_{Kdecay} 0.55μs; $\tau_{1/2\,Mform}$ 20 μs, $\tau_{1/2\,Mdecay}$ 1.2 ms, BRA formation rate 0.9% from BR	Biochem 1987. 26(3), 751–758 Biochem 1988. 27(9), 3497-3502 Eur. J. Biochem 1988. 176. 641–648
		all-E-					558			+	+	26			$\tau_{1/2destr}$			$\tau_{1/2rec}$ 8 min pK_a Asp85 4.7	

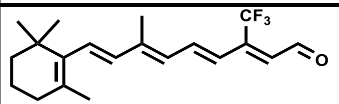
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
							WT 550 T90A			+	+	<10			4.1 h $\tau_{1/2destr}$ 3.7 h		CD BRA 567 (+)/ 625 (-) WT CD BRA 559 (+)/ 605 (-) T90A	$\tau_{1/2rec}$ 12 min pK$_a$ Asp85 6.7 str. WT and T90A No light-dark adaptation T90A and T90A-13E-RET showed similar M intermediate formation kinetics, faster than WT. M decay showed at least two components for T90A-13E-RET BRA quantum-chem calculations	PLoS One 2012 7(8) e42447 BiophysJ 1985 47(3) 349-355
12.		all-E-	380[b]				545		537	+	+	40						White membranes, str. JW5, 21°C. BRA cycle similar to BR. (BRA)^{559}-->K-->L-->M-->(BRA) $\tau_{1/2\ Mdecay}$ 5 ms	Biochem 1988. 27(9), 3497-3502
13.		all-E-	382	358	439		540			+		+		4260				str.353P, pH 6.5 τ_{rec} 3h 20°C	Bioorgan Khim. 1988, 14(3), 434-436 Bioorgan Khim. 1989, 15(11), 1484-1497. Archiv. Biochem .Biophys 1990. 279(2), 225–231

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
14.		all-E- 13Z-	380 376	357 363	439 444		531 527			+		+		3950 3550				str. 353P, 20°C pH 6.5, τ_{rec} 3 days	29
15.		all-E- 13Z-	381 375	361 364	443 442		543 547			+		+		4160 4340				str. 353P, 20°C pH 6.5, τ_{rec} 6 days	29
16.		13Z-	360[b]	346[b]	360[b]		460, 515 ε 40000		460, 515	+		2	30/70 9Z,13Z-/13Z-	6040 8360				White membranes, str. JW5, 21°C. τ_{rec} 20h, BRA cycle K^{570}-decayed in biphasic mode. (BRA): τ_{1decay} 0.5 μs (67%-13Z-) and τ_{2decay} 5 μs (33%-9Z,13Z)). τ_{rec} BRA 40 h is slower by a factor of 40 compared to 13-ethyl BR. BRA 515nm photoreversion of its blue-shifted form - 460 nm.	Biochem 1987. 26(3), 751–758 Tetrahedron Lett. 1982. 23(36), 3673 - 3676. Liebigs Ann. Chem. 1988. (7), 705 - 715. Eur. J. Biochem 1988. 176, 641–648
							520 552 544											in water. pH 7.0 pH 2.5 pH 0.5 changed to 450 nm after 60 s.	Biophys. J., 1989, 56, 1259-1265.
																		BRA quantum-chem calculations	BiophysJ 1985 47(3) 349-355
17.		all-E- 13Z-	 274,				NO 573											str. R_1. 13Z-τ_{rec} 1h BRA undergoes very slower Irreversible	J. Org. Chem. 1995. 60(5),

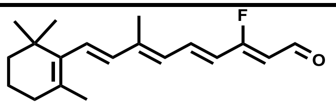
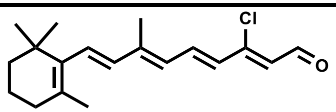
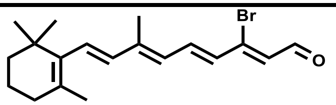
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH[+]	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
			383[a]													slowly replaces $\tau_{1/2repl}$ 12h		selfdestruction in BRA[406]. $\tau_{1/2destr}$ 8 days Cross-link OAc and Asp[212]. BRA[573]--> BRA[406]. Chromophore extraction shown that 13-AcO-retinal not isolated and remained binding to protein.	1189 - 1194. JACS 1994 116(20) 9383-9384
		14-[3]H-																[[3]H]- 119.6 mCi/mmol BRA nonhydrolysed enamine intermediate or cross-link	Photochem Photobiol 1999 70(4) 680-685
18.		all-E-	390[a] 400		460		624			+				5710				$\tau_{1/2rec}$ 5 min, 15°C H^+pump in JW5 cells vesicles	JACS., 1981, 103(25), 7642-7643
		all-E-		367	467 pK$_a$ 1.8		625 pK$_a$ 8.0			+	430			5400					15,17 Retinal Proteins 1987. 205–216 JACS. 1982. 104(18). 4979 – 4981
		all-E-		367	467		625			+				5400					Photochem Photobiol. 1993. 58(5). 701-705
		all-E-					630											pKa values of the above two residues are substantially modified: 13-CF_3 BRA, pKa (SB BRA) 8.2. Data of BRA titrations.	Biochem 1995 34(37) 12066-12074

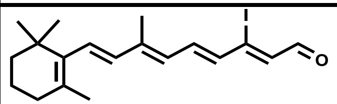
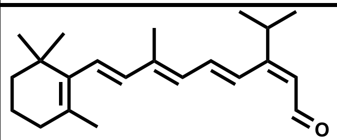
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
		all-E-		367	467		625			+	430			5400				10 mM Hepes buffer, pH 6.5 at 25°C for 1 h. pKa (SBH^+) 1.8, pKa (SB BRA) 8.2	PNAS 1986, 83, 3262-3266.
		all-E					625 JW5 625 L-07											$13-CF_3$-retinal BRA to growing JW5 and D96N (chromophore deficient strain L-07) cells,has low pK shifts to 9.1/8.1 Flash photolysis data.	Biochem 1998 37(22) 8227-8232
																		BRA quantum-chem calculations	BiophysJ 1985 47(3) 349-355
																		Spin-labeled Pigments (BRA mutants A103C, M163C, or E74C). Reduction reaction with NH_2OH is light-catalyzed in the A103C-labeled pigment, but not in E74C or M163C. ESR data. BRA reduced by $NABH_4$	JBiolChem 2000 275(28) 21010-21016
		13Z-					618											str. R_1M_1 pH 7.0, 25°C 10 mM HEPES buffer X-ray photoelectron spectroscopy.	JPhysSoc Japan 1984 53(10) 3321-3323
		all-E					625											pKa (SB BRA) 7.3 At high pH, the major absorption band shifts to 440 nm.	FEBSL 1989 250(2) 179-182

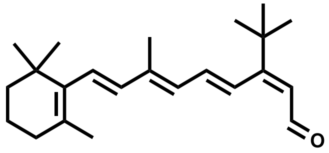
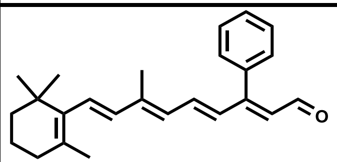
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
		all-E					624							5390					Mol. Cryst. Liq. Cryst 2000, 345, 317-322
		all-E					625			+	420							10 mM PIPES buffer, pH 7, pK ~ 8.4, dehydration of the sample leads to appearance of a fraction of an M-like ABR form with deprotonated SB.	Biophysics. 2006. 51(3). 391–398
19.		all-E-	382	362	446		548							4170				str. S9	J.Org. Chem. 1997, 62(2), 310-319
		all-E-					566												Seibutsu Butsuri 2001.41(suppl), S62
20.		all-E-					597						90/10					τ_{decay} 10.3 ms	Seibutsu Butsuri 2001.41(suppl), S62
21.		all-E-	388 ε 23800		465		595		595	+				4700 4700		stable τ_{repl}>24h dark, 25ºC, pH 7.0	CD BRA 560 (+)/ 632 (-)	τ_{rec} 20 h, 25ºC, pH 7.0. 30min D <====> L 30 h	JACS. 1980. 102(27), 7947 – 7949 MIE, V. 88 Part I,

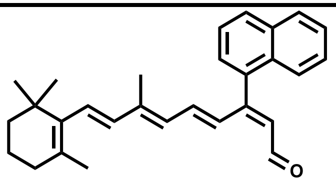
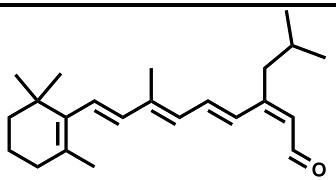
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			1982. 178-180.
		all-E-							596	+		+++ JW 2N				stable		str. ET1001, JW 2N pH 7.0, 22°C, BO washed by BSA BRA cycle compared to BR, but various rate constants are altered. X-ray data.	PhotochemPhotobiol 91 54(6) 873-879
		all-E-					598				+		97/3					τ_{decay} 6.1 ms	Seibutsu Butsuri 2001.41(suppl), S62
22.		all-E-			470[e]	440/ 500		598 ε 58000	598	+	426	100 pH 6.8 60 pH 6.5	97/3 97/3	4600			CD BRA 555 (+)/ 635 (-)	BRA photointermediates τ_{form} τ_{decay} slightly faster than the native bR "O" 690nm X-ray data	Biophys. J. 2002, 83(6), 3460-3469
		9Z-					NO												
		all-E-					598						97/3					τ_{decay} 2.7 ms	Seibutsu Butsuri 2001.41(suppl), S62
23.		13Z-	373	347	427		545		550	+	+			5070 5240				str. 353P, pH 6.5 τ_{rec} 6h, 20°C BRA cycle compared to BR. L-D adaptation decelerated.	Bioorgan Khim. 1988, 14(3), 434-436 Bioorgan Khim. 1989, 15(11), 1484-1497.

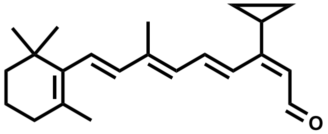
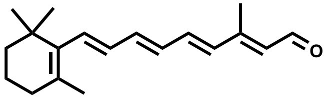
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	Pigments DA	Pigments LA	Photocycle	Photocycle M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
																			Archiv. Biochem .Biophys 1990. 279(2), 225–231
24.		13Z-	325, 360				500			+								str. 353P, pH 6.5 τ_{rec} 48h 40°C At 20°C BRA doesn't formed during 10 days. BO washed by cyclodextrine solution. BRA cycle efficiency drastically degraded.	Bioorgan Khim. 1988, 14(3), 434-436 Bioorgan Khim. 1989, 15(11), 1484-1497. Archiv. Biochem .Biophys 1990. 279(2), 225–231
25.		all-E-	382	370	455		572		564	+	+			4500 4250				str. 353P, pH 6.5 τ_{rec} 3h 20°C No long-wave intermediates were determined in the time scales τ_{form}> 10μs τ_{Mdecay} ~ s.	Bioorgan Khim. 1988, 14(3), 434-436 Bioorgan Khim. 1989, 15(11), 1484-1497. Archiv. Biochem .Biophys 1990. 279(2), 225–231
		all-E-					572			+	415			4500				In 100 mM NaCl, 5 mM MES, 3 mM potassium citrate, pH 6.0	Sensors Actuators, B. 1997.

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																			39(1-3), 218-221. Mol. Cryst. Liq. Cryst 2000, 345, 317-322
26.		13Z-	392	372	461		587		581	+				4660 4480				str. 353P, pH 6.5 τ_{rec} 5 days 20°C BO washed by cyclodextrine solution. BRA cycle efficiency drastically degraded	Bioorgan Khim. 1988, 14(3), 434-436 Bioorgan Khim. 1989, 15(11), 1484-1497. Archiv. Biochem .Biophys 1990, 279(2), 225–231
27.		13Z-	379	355	435		500							2990				str. 353P, pH 6.5 τ_{rec} 3h 20°C	Bioorgan Khim. 1988, 14(3), 434-436 Bioorgan Khim. 1989, 15(11), 1484-1497. Archiv. Biochem .Biophys 1990, 279(2), 225–231

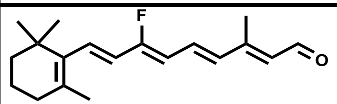
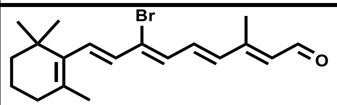
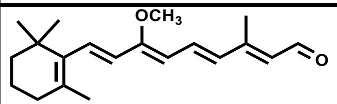
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
28.		13Z-	382	346	426		555			+				5460				str. 353P, pH 6.5 τ_{rec} 3 h 20°C	Bioorgan Khim. 1988, 14(3), 434-436 Bioorgan Khim. 1989, 15(11), 1484-1497. Archiv. Biochem .Biophys 1990. 279(2), 225–231
29.		all-E- 13Z- 11Z- 9Z- 7Z-	360[c] 357[c]			430 430 430 NO NO	530 530 NO NO NO		540	+		37	+/+ +/+					str. R1S9, 22°C in distilled water.	Recl. 1983. 102(1), 42- 46 Recl. 1983. 102(1), 46 -51
		all-E- 13Z-					540 532		548 548	+			44/56 70/30					70 mM potassium phosphate, pH 6.5.	Biochem 1983. 22(11), 2637 – 2644 15
		all-E-					530		540	+		68						str. S9	Biochem Biophys. Res.Commun. 1977. 78(2), 669-675.
																		str. L33 W182F W189F mutants FTIR data	Biochem 1995,

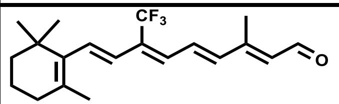
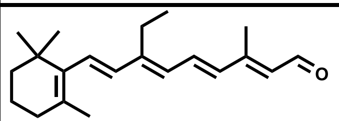
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																		BRA cycle exhibits great delay in the L→M conversion Trp182 interacts with the Ret side chain through the 9-methyl group Ret	34(2), 577-582
		all-E-					540			+	410	<20 WT			stable			native WT	
							540											transform WT	The Biology Chemistry Interface 1999 ch 15 431-444
							537											R82A str. IV-8 "O" 600 nm	
																		BRA cycle at 80, 170, and 213 K. BRA cycle is slowed down about 250-fold. Low-temperature FT-IR difference spectra.	Biochem 1995 34(41) 13502-13510
																		BRA cycle "M" at 410 nm and "O" 660 nm. Time-resolved UV-Vis and FT-IR difference spectra of WTBRA and mutant W182F. The steric interaction between W182 and the 9-methyl group of the retinal.	Biochem 1996 35(33) 10807-10814
																		compared the proton uptake and release of WT and two mutant BR D96N, D85N in BRA films or L-B layers on ATO.	Bioelectrochem 2000 51(1) 27-33 BioelectrochemBi

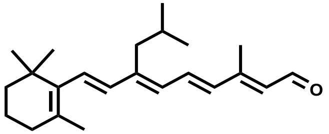
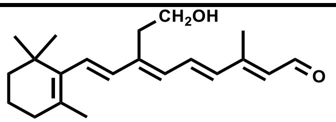
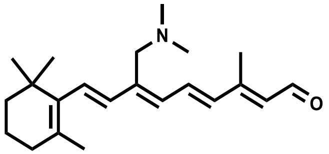
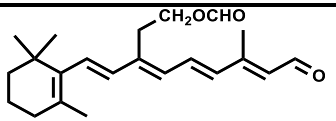
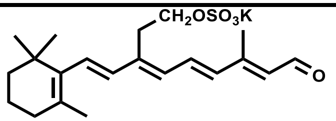
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			oenergetics 1997 44(1)-37-43
30.		all-E-	369[a]	357[a]	426[a]				530					4610					Synlett. 1995. (12), 1247 – 1248
		all-E	368	355	428		518							4060				str. S9	J. Org. Chem. 1997, 62(2), 310-319
31.		all-E-	372 ε 39300		430			535	545	+				4570 4910		stable	CD-L-BRA 512 (+) / 590 (-) CD D-BRA 505 (+) / 585 (-)	τ_{rec} 6 h, 25°C pH 7.0 , H_2O 15min D <====> L 50 h	JACS. 1980. 102(27), 7947 – 7949 MIE, V. 88 Part I, 1982. 178-180. PhotochemPhotobiol 1981 33(4) 483-488
		all-E-					543	543		+	+	+++ JW2N in 4M NaCl				stable		str. ET1001 JW2N BO washed by BSA BRA cycle compared to BR, but rate constants are altered. X-ray data	Photochem.Photobiol, 1991, 54(6), 873-879.
32.		9Z-	380[b]				410/ 560		410/ 560									τ_{rec} 50 h 20°C BRA 415 nm after 300 min of hν →BRA 560 nm. 560 nm reconvert thermally in 415 nm after 15h in dark	Liebigs Ann. Chem. 1988. (7), 705 - 715.

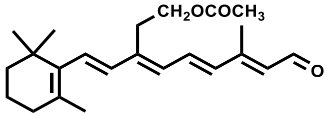
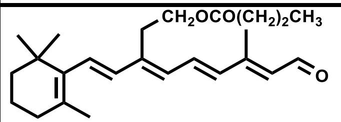
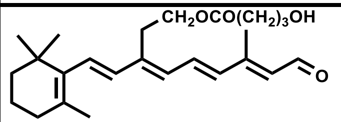
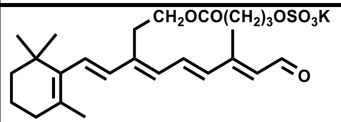
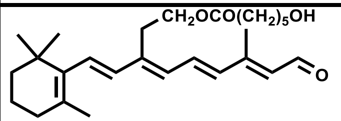
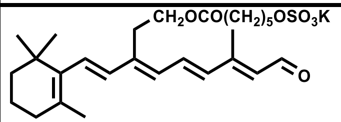
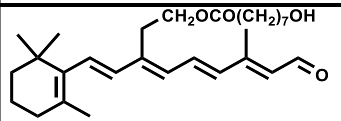
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			“CHO”	SB	SBH^+	NC	Pigments				M				NH_2OH	all-E-RET	CD	others	
							(P)	DA	LA										
																			Eur. J. Biochem 1988. 176, 641–648
33.		all-E- all-E-		347	399		520 520							5900				Second harmonic generation signal BRA	PhotochemPhotobiol. 1993. 58(5), 701-705 JACS, 1982, 104(18), 4979-4981 Tetrahedron Lett, 1985, 26(24), 2881-2884 JACS 2002, 124(40), 11844-11845
34.		all-E-		364	440		573			+				5300				Kinetics were measured at 22^{0}C in 10 mM sodium phosphate buffer at pH 7.0 Addition of bulk at the C9 position of Retinal does not accelerate the cycle of BRA Leu93 →Ala mutant.	Retinal Proteins 1987. 205–216 PNAS 1997 94(10) 5028–5033

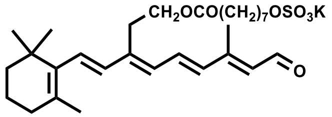
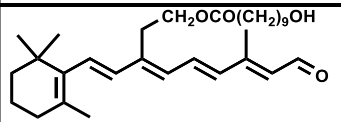
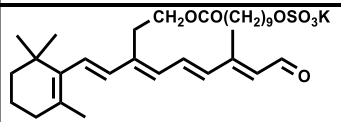
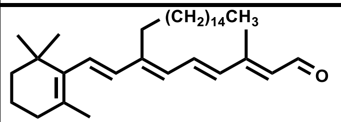
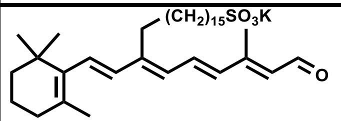
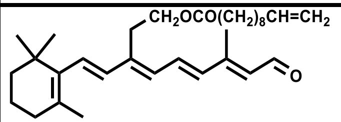
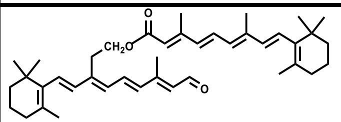
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M				NH$_2$OH	all-E-RET	CD	others	
							(P)	DA	LA										
35.		all-E-		355	435		450			+				750				Kinetics were measured at 22^{0}C in 10 mM sodium phosphate buffer at pH 7.0 Addition of bulk at the C9 position of Retinal does not accelerate the cycle of BRA Leu93 →Ala mutant.	Retinal Proteins 1987. 205–216 PNAS 1997 94(10) 5028–5033
36.		all-E-					560			+		40 JW2N						pH 7.0, 25^{o}C 10 mM HEPES buffer, smooth formation	JACS, 1989, 111(13), 4997-4998.
		all-E-		351	430		571							5700					Retinal Proteins 1987. 205–216
37.		all-E-		360	447		449							0					Retinal Proteins 1987. 205–216
38.		all-E-					452											HEPES buffer, pH 7.0, 25^{o}C in dark	JACS, 1989, 111(13), 4997-4998.
39.		all-E-					NO											HEPES buffer, pH 7.0, 25^{o}C in dark no BRA after 16-24 h	JACS, 1989, 111(13), 4997-4998.

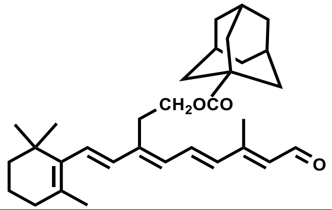
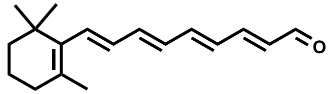
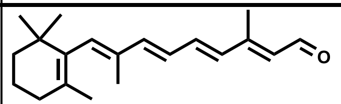
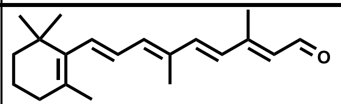
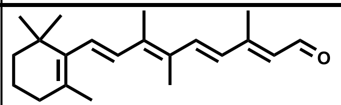
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
40.		all-E-					452											HEPES buffer, pH 7.0, 25°C in dark	JACS, 1989, 111(13), 4997-4998.
41.		all-E-					452			+		12 JW2N						HEPES buffer, pH 7.0, 25°C in dark	JACS, 1989, 111(13), 4997-4998.
42.		all-E-					452								0.1 M light 450nm $\tau_{1/2destr}$ 5-10 min	stable τ_{repl}>24h dark, 25°C pH 7.0		HEPES buffer, pH 7.0, 25°C in dark smooth formation	JACS, 1989, 111(13), 4997-4998.
43.		all-E-					NO											HEPES buffer, in dark no BRA after 16-24 h.	JACS, 1989, 111(13), 4997-4998.
44.		all-E-					452								0.1 M light 450nm $\tau_{1/2destr}$ 5-10 min	stable τ_{repl}>24h dark, 25°C pH 7.0		HEPES buffer, pH 7.0, 25°C in dark smooth formation	JACS, 1989, 111(13), 4997-4998.
45.		all-E-					NO											in dark no BRA after 16-24 h	JACS, 1989, 111(13), 4997-4998.
46.		all-E-					452								0.1 M light 450nm $\tau_{1/2destr}$ 5-10 min	stable τ_{repl}>24h dark, 25°C pH 7.0		HEPES buffer, pH 7.0, 25°C in dark smooth formation	JACS, 1989, 111(13), 4997-4998. .

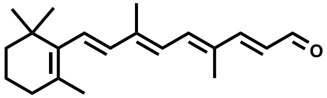
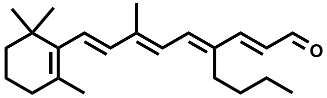
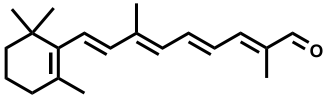
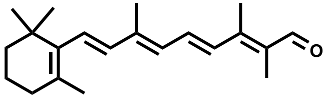
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
47.		all-E-					475											HEPES buffer, pH 7.0, 25°C in dark τ_{form}≥6h.	JACS, 1989, 111(13), 4997-4998.
48.		all-E-					452					7 JW2N			0.1 M light 450nm $\tau_{1/2destr}$ 5-10 min	stable τ_{repl}>24h dark, 25°C pH 7.0		HEPES buffer, pH 7.0, 25°C in dark smooth formation	JACS, 1989, 111(13), 4997-4998.
49.		all-E-					475					12 JW2N			0.1 M light 450nm $\tau_{1/2destr}$ 5-10 min	stable τ_{repl}>24h dark, 25°C pH 7.0		HEPES buffer, pH 7.0, 25°C in dark immediately formation	JACS, 1989, 111(13), 4997-4998.
50.		all-E-					450	452							0.1 M light 450nm $\tau_{1/2destr}$ 5-10 min			HEPES buffer, pH 7.0, 25°C in dark	JACS, 1989, 111(13), 4997-4998.
51.		all-E-					475								0.1 M light 450nm $\tau_{1/2destr}$ 5-10 min	stable τ_{repl}>24h dark, 25°C pH 7.0		HEPES buffer, pH 7.0, 25°C in dark immediately formation	JACS, 1989, 111(13), 4997-4998.
52.		all-E-					452					10 JW2N						HEPES buffer, pH 7.0, 25°C in dark	JACS, 1989, 111(13), 4997-4998.
53.		all-E-					450											HEPES buffer, pH 7.0, 25°C in dark	JACS, 1989, 111(13), 4997-4998.

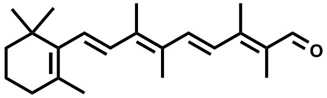
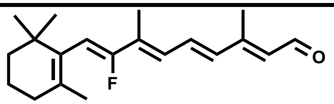
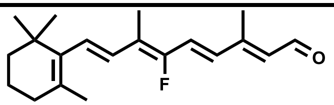
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε ($M^{-1}cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
54.		all-E-					452					7 JW2N						HEPES buffer, pH 7.0, 25^{o}C in dark	JACS, 1989, 111(13), 4997-4998.
55.		all-E-	356[c]			430	530		530			37						str. R1S9, 22^{o}C	Recl. 1983, 102(1), 42- 46 Recl. 1983, 102(1), 46 -51
		13Z-				430	530		530										
		11Z-	356[c]			430	530		530										
		9Z-				430	530		530										
		all-E-						539		+		<20 WT			<25% in 2h pH 7.5 moderate degradation			native WT	The Biology Chemistry Interface 1999 ch 15 431-444
								538										transform WT	
								539				0 R82A						R82A str. IV-8, pH 8.8 "M" WT quite small Only long-lived 600-nm species was found	
56.		all-E-	360	346	424	440	?									immediately replaced		str. S9 τ_{rec} 6 days 20^{o}C	JACS 1995 117(31) 8220-8231
57.		all-E-	380	354	432		540							4630		immediately replaced		str. S9 τ_{rec} 6 days 20^{o}C	JACS 1995 117(31) 8220-8231
58.		all-E-					+			NO		NO						BRA pigment shows no light-induced absorbance changes over the time scale of 0.1 ms to 1.0 s. Raman spectra Schiff	Photochem Photobiol 1985 41(5) 563-567

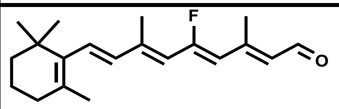
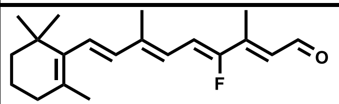
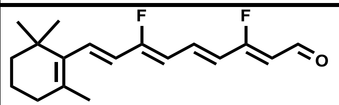
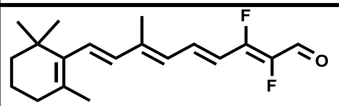
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																		base (-C=NH-) stretching frequency. 1643 cm^{-1}	
59.		all-E-	382	368	444	420	?									immediately replaced		str. S9	JACS, 1995 117(31) 8220-8231
60.		all-E-				420	NO												PhotochemPhotobiol 1986 43(3) 297-303 JACS 1995 117(31) 8220-8231 18
61.		all-E- all-E-	378	366	438	420 / 440	? NO											str. S9 str. R_1M_1 cells suspensions with 1 mM nicotine	JACS 1995 117(31) 8220-8231 Biochem Soc.Trans. 1976. 4(4), 556 - 559.
62.		all-E- 13Z- all-E-		~360		410, 428, 450 370, 390, 410	NO? NO? 425			NO								Likely can form pigment with unprotonated aldimine bond str. R1 form unprotonated SB Raman spectra Schiff base (-C=N-) stretching frequency. 1624 cm^{-1}	JACS., 1983, 105(15), 5162-5164 PhotochemPhotobiol 1985 41(5) 563-567

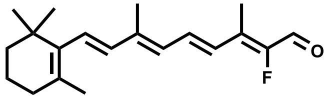
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
		all-E-					425			NO								str. R1	Biochem 1990, 29(25), 5948-5953
		13Z-					423			NO									
63.		all-E-		~ 360			433			NO								str. R1 form unprotonated SB. Raman spectra Schiff base (-C=N-) stretching frequency 1623 cm^{-1}	PhotochemPhotobiol 1985 41(5) 563-567
64.		all-E-		351	418		530		530					5000 5000					Photochem.Photobiol., 1993, 58(5), 701-705
		all-E-			427		530		530					4550 4550				str. R1	Biochem 1990, 29(25), 5948-5953
		all-E-																8-F mutant D96N and str. S9 Effects of fluorinatition of the retinal polyenic chain on the influence protein-lipid interaction	Eur. Biophys. J., 2001, 29(8) 628–640
65.		all-E		364	438		562							5000					Photochem.Photobiol., 1993, 58(5), 701-705
		all-E-			442		431, 565			+	410	+		4930 4670				str. R1. "O" -650 nm	Biochem 1990, 29(25), 5948-5953
		13Z-					557												

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																		10-F mutant D96N and str. S9 Effects of fluorinatition of the retinal polyenic chain on the influence protein-lipid interaction	Eur. Biophys. J., 2001, 29(8) 628–640
66.		all-E-	370	354	434		540							4520				str. S9	J. Org. Chem. 1997, 62(2), 310-319
67.		all-E-		365	450		591							5300					Photochem.Photobiol., 1993, 58(5), 701-705
		all-E-			447			566, 591						4700 5450				str. R1	Biochem 1990, 29(25), 5948-5953
																		12-F mutant D96N and str. S9 Effects of fluorinatition of the retinal polyenic chain on the influence protein-lipid interaction	Eur. Biophys. J., 2001, 29(8) 628–640
68.		all-E-	372	355	429		520							4080				str. S9	J. Org. Chem. 1997, 62(2), 310-319
69.		all-E- 13Z-			466	450	600 600			+	420	+		4790				str. R1	Biochem 1990, 29(25), 5948-5953

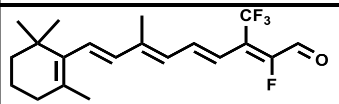
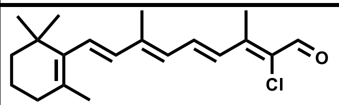
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH⁺	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
70.		all-E-		368	459		587 680sh					+		4900 7300					Photochem.Photobiol., 1993, 58(5), 701-705
		all-E-			455	440	587, 680sh				410- 415		55/45	4940 7270				str. JW2N pH 6.0, 25^{0}C For 13Z- τ_{rec} BRA587 <1 min After 1h in dark slight decrease BRA587 formed 680sh For all-E- 440-nm NC τ_{rec} <1 min τ_{rec} BRA587 1h, hν λ>560 nm BRA587 →680sh nm grows. Cycle "O"-690-700 nm $\tau_{dec1/2}$ 100ms "M" 410-415 nm $\tau_{decM1/2}$ 30 ms	Biochem 1990, 29(25), 5948-5953
								587, 680sh	587, 680				95/5	4940 7270					
		13Z-					587						trace/99						
								587, 680sh					55/45						
									587, 680				93/7						
																		Spin-labeled Pigments (BRA mutants A103C, M163C, or E74C). Reduction reaction with NH_2OH is light-catalyzed in the A103C-labeled pigment, but not in E74C or M163C. ESR data. BRA reduced by $NABH_4$	JBiolChem 2000 275(28) 21010-21016
																		Dynamic holography recording using 14-FBRA in gelatin films.	PhotochemPhotobiol 2005 81(4) 920-923
		all-E-					588											str. WT ET-1000 and D96N pH 6, 25^{0}C,	BBA 1998

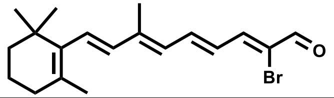
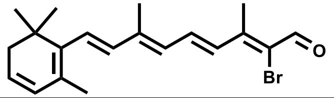
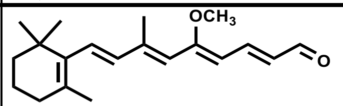
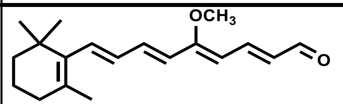
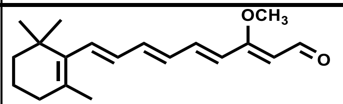
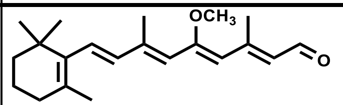
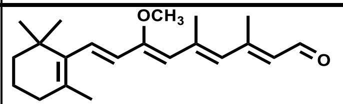
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
		13Z-					587											BRA from all-*trans*- and 13-*cis*-14-F-retinal analogs. τ_{rec} 1h from WT ET-1000 or D96N BR and no red tail band was formed! After 560 nm light in 5 min illumination, pH 7, 10^0C, BRA640-650 nm band appear for both the 14-F WT and D96N BRA. The photocurrent transients generated by yellow light in 14-F-WT and 14-F-D96N unoriented films on tin-oxide electrodes were measured.	1371(2) 371-381
																		Spectral and kinetic transformations were studied in gelatin films made with 14-F WT 14-F D96N BRA	Bio Systems 2001, 59(1), 53-60
																		Photoinduced transformation in gelatin films made with 14-F BRA, both WT and D96N mutant, were studied. Spectral and kinetic peculiarities for these two types of samples were compared over a wide range of relative humidity (9–92%).	Appl.Biochem.Biotechnol. 2005, 120(2), 121-132
																		Spectral and kinetic characteristics were measured for gelatin films based on14-F BRA, both wild-type	JBiomaterSciPolymer 2008 19(12)

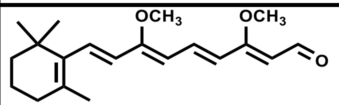
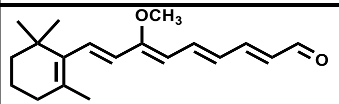
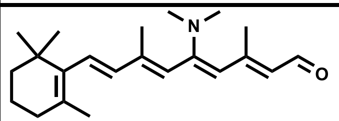
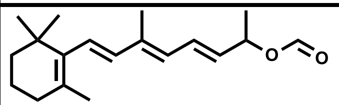
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																		(WT) and D96N mutant, to study the peculiarities of photo-induced transformation of the samples.	1585-1595
		all-E-	394[a]		455		587 680sh							4800 7100					PhotochemPhotobiol 2001 74(6) 837–845
																		14-F mutant D96N and str. S9 Effects of fluorinatition of the retinal polyenic chain on the influence protein-lipid interaction	Eur. Biophys. J., 2001, 29(8) 628–640
																		effect of high pressure on ABR, BR mutant D96N and fluoroABR	EurBiophysJ. 2002 31(7) 539-548
71.		all-E-		371	426		NO												PhotochemPhotobiol., 1993, 58(5), 701-705
72.		all-E-					440-475, 691						after 5 days 61/39					str. JW2N pH 6.0 25^{0}C τ_{rec} BRA440-475 1 h τ_{rec} BRA691 5 days ~ 5% BRA691 after 5 days	Biochem 1990, 29(25), 5948-5953
		13Z-					430 691	691					after 5 days 55/45						
		all-E-	396[a]		461		472/ 691							500 7200					PhotochemPhotobiol 2001

Properties of artificial bacteriorhodopsin analogs

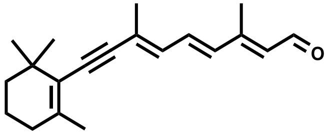
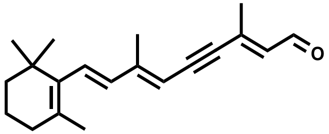
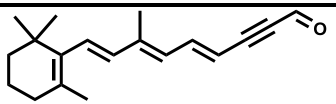
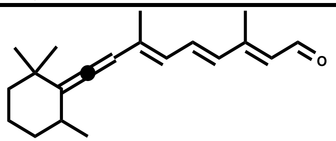
No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			74(6) 837–845
73.		all-E-					NO												10
74.		all-E-				+	NO												29
75.		11Z-	364				532												Eur. J. Biochem 1988. 176, 641–648
76.		11Z-	366				534												Eur. J. Biochem 1988. 176, 641–648
77.		13Z-	347				490												Eur. J. Biochem 1988. 176, 641–648
78.		all-E-																Spin-labeled Pigments (BRA mutants A103C, M163C, or E74C). Reduction reaction with NH_2OH is light-catalyzed in the A103C-labeled pigment, but not in E74C or M163C. ESR data. BRA reduced by $NABH_4$	JBiolChem 2000 275(28) 21010-21016
79.		all-E-																Spin-labeled Pigments (BRA mutants A103C, M163C, or E74C).	JBiolChem 2000 275(28)

Properties of artificial bacteriorhodopsin analogs

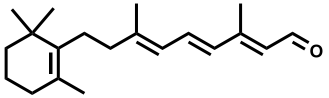
No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			“CHO”	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																		Reduction reaction with NH_2OH is light-catalyzed in the A103C-labeled pigment, but not in E74C or M163C. ESR data. BRA reduced by $NABH_4$	21010-21016
80.		9Z,13Z-	352				500												Eur. J. Biochem 1988. 176, 641–648
81.		9Z-	376				490 in H_2O 510 in cells					10						str. JW2N	Eur. J. Biochem 1988. 176, 641–648
82.		all-E-																Spin-labeled Pigments (BRA mutants A103C, M163C, or E74C). Reduction reaction with NH_2OH is light-catalyzed in the A103C-labeled pigment, but not in E74C or M163C. ESR data. BRA reduced by $NABH_4$	JBiolChem 2000 275(28) 21010-21016
83.		all-E-	291[c] ε 34100 293[a]			331 ε 29000	NO											No covalent binding. Possible iinteraction between C18 fragment and some groups in protein microenviroment. τ_{rec} 6 min. Iminoester formation? If PM instead BO λ_{max} 302 nm	Photochem.Photobiol. 1992. 55(5), 745-752.

D. Alteration of the bond types and its disposition in the chromophore polyenic chain

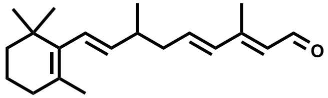
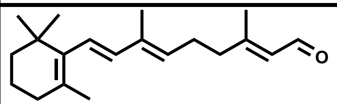
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
84.		all-E- 13Z-				440	532 515			+ +		45	70-90%E					H^+ pumping in str. JW-5 cells	JACS., 1984, 106(19), 5654-5659
85.		all-E- 13Z- 9Z- 9Z,13Z- 7Z- 7Z,9Z- 7Z,13Z-	290sh 364 ε 26100 288sh 358 ε 20300	343 347	418 417	 + NO NO NO	539 519 495			+ + +	~410			5370 4710					Bioorgan Khim. (Rus), 1989, 15(3), 307-312 Biolog. Memranes (Rus), 1994, 11(5), 575-576 Molecular Biol. (Rus), 1995, 29(6), 1398-1407 Mol. Cryst. Liq. Cryst 2000, 345, 317-322
86.		all-E-					NO												10
87.		all-E-					+					+ 10-15							Pure Appl. Chem., 1986, 58(6), 719-724

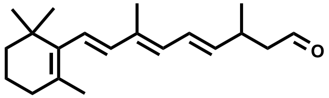
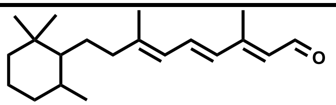
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	Pigments DA	Pigments LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
88.		all-E-	342		392		440							2780					Biophys. J. 1986. 49, 479-483
		all-E-			390		442	442	440				77/23 51/49	3000 2900				50 mM Hepes, pH 7.0	PhotochemPhotobiol 1991 54(6) 969-976
		all-E-					400												10
		all-E-	338		385		400							1000					JACS. 1980. 102(27), 7945 - 7947
		all-E-			385			400						1000					PhotochemPhotobiol 1981 33(4) 483-488
		all-E-	340		385		445							3500				H_2O, pH 7.0	JACS 1986 108(11) 3104-3105
		all-E-					448												BiophysJ 1984 45 272a
		all-E-			392		440					NO		2780					Pure Appl. Chem., 1986, 58(6), 719-724
		all-E-					440											in water. pH 7.0	BiophysJ 1989

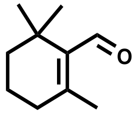
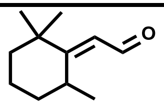
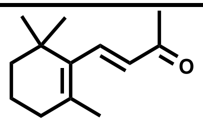
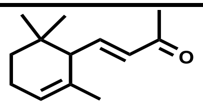
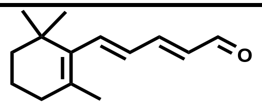
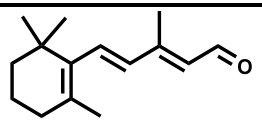
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
							455 455											pH 2.5 pH 0.5	56(6) 1259-1265
		all-E-	342[a]				440											Protein-*b*-Ionone Ring Interactions. Second harmonic generation (SHG) to probe the light-induced dipolar changes.	JPhysChem B 2003 107(25) 6221-6225
89.		all-E-	284		322			343	 325					1910 300					Biophys. J. 1986. 49, 479-483
		all-E-			322		325							300					PhotochemPhotobiol 1981 33(4) 483-488
		all-E-	278		322		325											phosphate buffer, pH 7.0.	JACS. 1980. 102(27), 7945 - 7947
		all-E-					+	343				NO		1910					Pure Appl. Chem., 1986, 58(6), 719-724
		all-E-					335												BiophysJ 1984 45 272a
90.		all-E-	236		270		+											λ_{max} BRA overlap with the absorption of the protein.	PhotochemPhotobiol 1981 33(4) 483-488

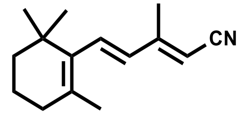
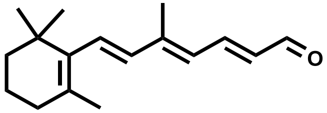
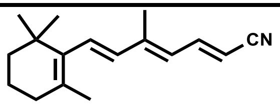
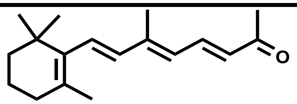
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																			JACS. 1980. 102(27), 7945 - 7947
91.		all-E-	289[a]				328							4110				in 20 mM Tris/HCl and 4 M NaCl at pH 7.0. BRA^{328} with distinct vibrational fine structure. τ_{rec} 45 min Mutagenesis studies and two photon spectroscopy studies argue against a discrete charge in the binding site but not against the local electrostatic fields, which would fulfill the conditions of the original point charge model. 270-fold inhibition of the native retinal Incorporation in BRA.	JBiolChem. 1995, 270(50), 29668-29670
92.		all-E-	339		392		435							2520					Biophys. J. 1986. 49, 479-483 Pure Appl. Chem., 1986, 58(6), 719-724
		all-E-			382		438	438	436				61/39 40/60	3350 3200				50 mM Hepes, pH 7.0.	PhotochemPhotobiol 1991 54(6) 969-976
E. **Alteration of the polyenic chain length and bond disposition and terminal group types**																			

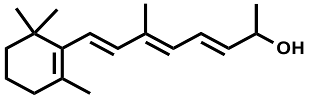
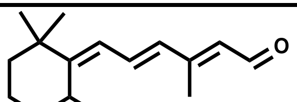
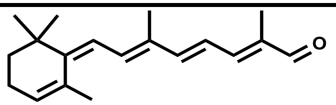
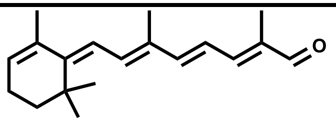
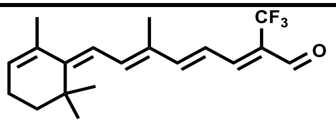
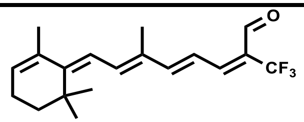
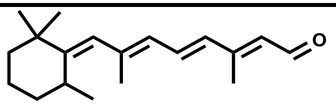
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
93.						NO	NO											str. R_1M_1 5°C	Eur. J. Biochem 1981, 117(2), 353-369
94.		E-	225[c]			NO	NO		NO									In 50 mM sodium phosphate buffer pH 7.2. 24 h	Biochem 1986, 25(8), 2022-2027. 18
95.		E-	222, 292[b]			NO	NO		NO									str. R_1M_1 5°C	Eur. J. Biochem 1981, 117(2), 353-369
96.		E-	232[b]			NO	NO		NO									str. R_1M_1 5°C	Eur. J. Biochem 1981, 117(2), 353-369
97.		all-E- 9Z-	264, 330[b] 266, 320[b]			346 344	NO NO											str. R_1M_1 5°C	Eur. J. Biochem 1981, 117(2), 353-369
98.		all-E- 9Z-	264, 330[b] 266, 326[b]			350 352	NO		NO						unstable, destroyed very rapidly			str. R_1M_1 5°C	Eur. J. Biochem 1981, 117(2), 353-369
		all-E- 9Z-	326[a] 323[a]			364 362											364+ 362+		Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
		all-E- 9Z-	280 278			360 359													Photochem.Photobiol., 1981,

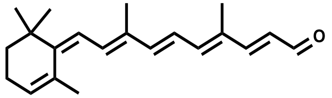
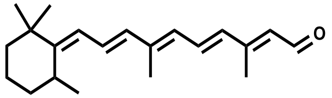
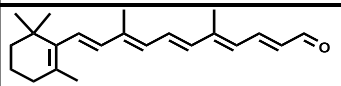
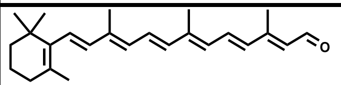
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			33(4), 495-499
99.		all-E-	252, 306[b]			324	NO											str. R_1M_1 5°C	Eur. J. Biochem 1981, 117(2), 353-369
100.		all-E- 9Z-	350[b] 322[b]			420 380									unstable			str. R_1M_1 5°C	Eur. J. Biochem 1981, 117(2), 353-369
		all-E- 11Z- 9Z-	340[a] ε 33200 323[a] 336[a] ε 29000			413 ε 40000 400 402 ε 30000									unstable unstable			str. R_1	Photochem.Photobiol., 1981, 33(4), 495-499
		all-E-	340[a]					413	415	NO	NO								18
101.		all-E-	328[b]			366	NO											str. R_1M_1 5°C	Eur. J. Biochem 1981, 117(2), 353-369
102.		all-E- 9Z-	352[b] 302, 344			414 344	NO											str. R_1M_1 5°C	Eur. J. Biochem 1981, 117(2), 353-369
		all-E-				+													FEBS Lett., 1979, 97(1), 15-19.

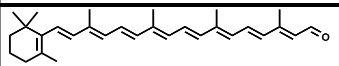
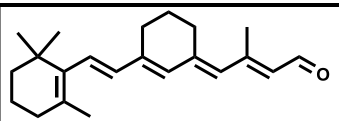
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
103.		all-E-	284[c] ε 33000, 284[a]			328	NO									328 nm peak moves to 300 nm, when all-E-Ret added			Photochem.Photobiol., 1992, 55(5), 745-752.
104.		E- 2Z-	320[c] 318[c]				416 414		420 420	NO NO		NO			stable stable	stable stable		In 50 mM sodium phosphate buffer pH 7.2. 24 h	Biochem 1986, 25(8), 2022-2027. 18
105.		6Z-	378[c]			409	514sh								stable hν			stable under illumination. Isomerisation to E-isomer τ_{rec} 14 days	Tetrahedron Lett., 1991, 32(17), 1933-1936
106.		all-E-	378[c]			449	542								stable hν			stable under illumination. τ_{rec} 11 days	Tetrahedron Lett., 1991, 32(17), 1933-1936
107.		Z-	400[c]				579								unstable hν			destroyed under illumination. τ_{rec} 1 day	Tetrahedron Lett., 1991, 32(17), 1933-1936
108.		E-	400[c]				NO												Tetrahedron Lett., 1991, 32(17), 1933-1936
109.		E- 2Z-	334[c] 332[c]				458 455		463 463	+	355-360	+			stable $\tau_{1/2destr}$ 70 min	easy replaced		In 50 mM sodium phosphate buffer pH 7.2. 24 h $\tau_{1/2rec}$ 25 min low yield. $\tau_{1/2Mdecay}$ 11ms.	Biochem 1986, 25(8), 2022-2027.

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
		all-E-	334[a]					458	463	+	357	+							18
110.		all-E-					528		535										29
111.		E-	382[c]				518		524	+	395	+++			stable $\tau_{1/2destr}$ several hours	stable		In 50 mM sodium phosphate buffer pH 7.2. 24 h $\tau_{1/2rec}$ 2 min high yield. $\tau_{1/2Mdecay}$ 11ms	Biochem 1986, 25(8), 2022-2027.
		2Z-	380[c]				517		524										
		6Z-	375[c]				485		524										
		all-E-	382[a]					518	524	+	392	+++							18
112.		all-E-	398 ε 45000	376	458	430-460	555			+				3810				str. 353P	29
		all-E-	392[a]				~520 broad sh.			-		-			unstable, stepwise destruction	stable		H^+-pump in egg lecithin vesicles. The same Lys residue bound in BRA. τ_{rec} 2 h	Biophys. J., 1977, 19, 191-198
		13Z-	396[a]							-									
		all-E-	384[c]					500, 540sh	500, 540	+	400	++			unstable 5 mM in dark	unstable		30 mM sodium phosphate buffer, pH 7.0. Two distinct BRA appear to be formed which can interconvert with each other upon illumination or change of pH of the medium. Long irradiation with strong light destroys of BRA. Reversible L-D conversion 540-->500 nm or at raised pH →500 nm.	Photochem Photobiol 1986 43(3) 297-303 18
113.		all-E-					NO											str. R_1M_1 cells suspensions with 1 mM nicotine	Biochem Soc.Trans. 1976. 4(4), 556 - 559.

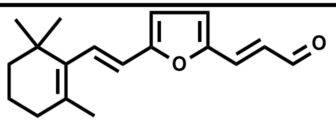
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
		all-E-	400				460sh 523		460sh 527									str 353P	29
114.		all-E-					NO											str. R_1M_1 cells suspensions with 1 mM nicotine	Biochem Soc.Trans. 1976. 4(4), 556 - 559.
	F. Alteration or locking of the bond configuration. Non-isomerizable analogs																		
115.		all-E-	384	360	448		570		570	+	410	+++	50/50 90/10	4800 4800				Hepes buffer, pH 6.5 τ_{rec} 30 min. BRA cycle compared to BR. Short-lived "K", long-lived "M". No observed light-dark adaptation. H^+-pump in in vesicles.	Retinal Proteins 1987. 205–216 17 JACS 1986 108(15) 4614-4618
		all-E-					567 538 540 564			+ + + +	+ + + +		100/0 100/0 100/0 100/0					Leu93X mutants. Leu93 τ_{Mdecay} 1.1ms τ_{Odecay} 5ms Leu93→Ala τ_{Mdecay} 0.9ms τ_{Odecay} 3.4 ms. Leu93→Thr τ_{Mdecay} 90ms Leu93→Val +τ_{Mdecay} 2.2ms τ_{Odecay} 6.2 ms in 10mM sodium phosphate buffer at pH 7.0 22^{0}C. Laser-induced transient spectra. Leu93→Ala dramatic acceleration 550-fold in the decay of the "O". Leu93→Thr 150-fold increase lifetime of "O". Leu93 →Val	PNAS 1997 94(10) 5028–5033

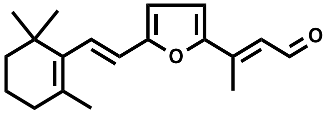
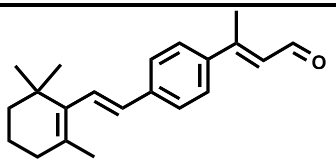
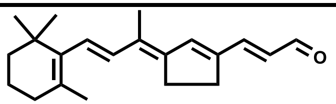
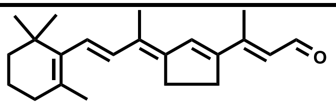
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			“CHO”	SB	SBH^+	NC	Pigments				M						CD	others	
							(P)	DA	LA						NH_2OH	all-E-RET			
																		mutant has little effect on the lifetime of the “O”.	
																		BRA 200 ps cycle is tested by both ps absorption and vibrational spectroscopy. Time constant J--> K 5 ps	J. Phys. Chem. 1995, (19), 7801-7805.
																		BRA picosecond resonance coherent anti-Stokes Raman scattering (PR/CARS) and PTA data. Picosecond transient absorption (PTA) data show that the initial 200-ps interval of the BRA photocycle contains two intermediates: “J6.9” formed with <3-ps time constant and decaying to “K6.9” with a 5-ps time constant (“K6.9” has a >5-ns lifetime). Data show that no C13=C14 isomerization is needed to form “K6.9”, even though BRA exhibits biochemical activity and the structure of BRA permits C13=C14 isomerization, it is evident that the biochemical mechanism in BRA, unlike native BR, proceeds with a “K-	JPhysChem A 2002 106(14) 3325-3336

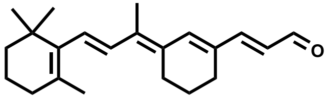
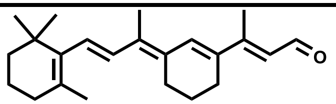
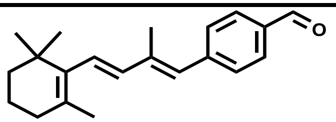
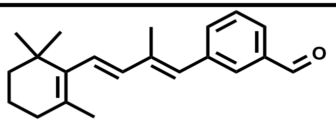
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			“CHO”	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																		intermediate” that can undergo C13=C14 isomerization, but does not. It is possible, of course, that C=C isomerization (either at the C13=C14 bond or at another C=C bond occurs later in the BRA photocycle, New model of the primary events of the BR photocycle. Picosecond intermediates appearing in the respective photo-reactions BRA are measured by coherent anti-Stokes Raman spectroscopy (CARS).	Chem Physics 2005, 313(1-3), 51-62.
		all-E-					572											PR/CARS and PTR/CARS data measured from the sample BRA.	JPhysChem A 2003 107(49) 10787-10797
116.		all-E-	379[a]	365[a]	435[a]		540sh 565			+				4470 5290				20mM HEPES, pH 7.0. BRA cycle compared to BR. Short-lived “K”, “L”.	Biochem 1985, 24(5), 1260 - 1265
		all-E-		364	435		570							5450					Retinal Proteins 1987, 205 – 216 17

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
		all-E-			435		570							5400				pKa (SBH^+) = 6.7, pKa (BRA SB) = 9.1. Titrations of BRA data	Biochem 1995, 34(37), 12059-12065
117.		all-E-	386[a]	364[a]	442[a]		540sh 576			NO				5260				20mM HEPES, pH 7.0.	Biochem 1985, 24(5), 1260 - 1265
118.		all-E-	330[b] ε 20000		380[b] ε 26320		490 ε 20410		490			0		5910 5910					Angew. Chem. 1984, 96(1), 76 –78
		13Z-	305[b]		365[b]	+	NO												
		7Z-	323[b]		372[b]	+	NO												
		all-E-					490 ε 31000					NO	100/0					str. R_1M_1. BRA does not isomerize. λ_{max}flu 605 nm. Φ $1.2\text{-}10^{-3}$. "K" is not formed and no rotation in the region of C-12-C-14 of BRA.	BBA 1984, 767(3), 635-639
119.		all-E-	411[a]		475[a]		608					0		4610		stable		str. R1S9 τ_{rec} 14 days No L-D-adaptation.	Recl. 1994, 113(1), 45-52.
		all-E-	410	472	460	443	608							5290				str. 353P	Kirillova Yu.G. Ph.D. thesis, 1994
120.		all-E-	411[a]		480[a]		624 ε 63000					45		4810		stable		str. R1S9 τ_{rec} 30 min	Recl. 1994, 113(1), 45-52.
		all-E-	410	385	485	487	624	608	624	+	+	+		4590 4170 4590				str. 353P	Kirillova Yu.G. Ph.D.

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																			thesis, 1994
121.		all-E-	395[a]		466[a]		NO											str. R1S9	Recl. 1994, 113(1), 45-52.
		all-E-	393	371	460	420	NO			NO								str. 353P	Kirillova Yu.G. Ph.D. thesis, 1994
122.		all-E-	395[a]		466[a]		NO											str. R1S9	Recl. 1994, 113(1), 45-52.
		all-E-	393	355	485	428	NO			NO								str. 353P	Kirillova Yu.G. Ph.D. thesis, 1994
123.		E-	336	324	390	325, 425	NO			NO								str. R1, 50mM MES, pH 6.5. 24 h. NC easy destroyed by Ag^+ / Triton X-100. C18-keton easy replaced NC	Bioorgan Khim. (Rus), 1984, 10(2), 256-259. Bioorgan Khim. (Rus), 1987, 13(8), 1116-1124
		E-	337			428	NO											str. R1S9	Recl. 1984 103(4) 105-109
		9Z-	332			NO	NO												
124.		E-	265, 295			343, 360	NO			NO								str. R1, 50mM MES, pH 6.5. 24h. NC easy destroyed by Ag^+ / Triton X-100. C18-	Bioorgan Khim. (Rus), 1987, 13(8),

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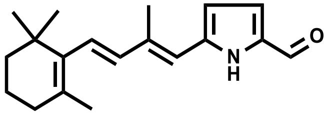
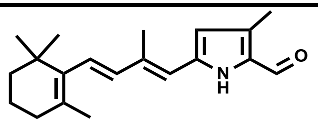
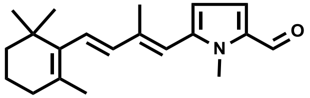
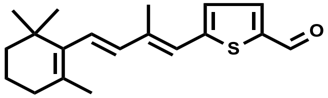
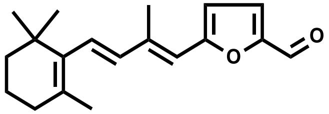
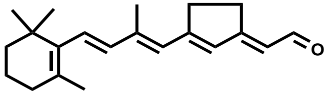
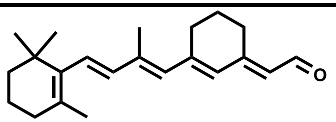
No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																		keton easy replaced NC	1116-1124
125.		E-	356			407, 427	NO			NO								str. R1S9	Recl. 1984 103(4) 105-109
126.		E-	362			400, 423	NO			NO								str. R1S9	Recl. 1984 103(4) 105-109
127.		E-	351			399, 424	NO			NO								str. R1S9	Recl. 1984 103(4) 105-109
128.		E-	377			430	NO											str. R1S9	Recl. 1984 103(4) 105-109
129.		all-E-	233, 355[c]			435	565		565			11		5290				str. R1S9	Recl. 1983 102(1) 42-46
		9Z-	242, 290, 355[c]			NO													Recl. 1983 102(1) 46-51
		all-E-	375[a]	367[a]	436[a]		565			NO				5240				20mM HEPES, pH 7.0.	Retinal Proteins 1987, 205–216 17 Biochem 1985, 24(5), 1260 - 1265
		all-E-			436		568							5300				pKa (SBH^+) 6.0, pKa (BRA SB) 8.2.	Biochem 1995,

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
																		Titrations of BRA data	34(37), 12059-12065
		all-E-																pKa (BRA SB) 8.2. Titrations of BRA data	Biochem 1995 34(37) 12066-12074
															$\tau_{1/2destr}$ 330 s in the dark $\tau_{1/2destr}$ 778 s under light			Light-Induced NH_2OH reactions occur with SB C13= C14 locked BRA	Biophys J 1998 75(1) 413-417
																		step-scan FT-IR data	LaserChem 1999 19(1-4) 169-172
																		str. WT Electric-Field Effects in BRA films	PhotochemPhotobiol 1999 70(1) 103-110
																		Atomic force sensing (AFS) for dynamically probe BRA protein conformational changes with microsecond time resolution	PNAS 1997, 94(15), 7937-7941
																		Spin-labeled Pigments (BRA mutants A103C, M163C, or E74C). Reduction reaction with NH_2OH is light-catalyzed in the A103C-labeled pigment, but not in	JBiolChem 2000 275(28) 21010-21016

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																		E74C or M163C. ESR data.	
130.		all-E-				440	525			NO		NO	0/100					Hepes buffer, pH 6.5. NC 440nm τ_{rec} 20 min BRA τ_{rec} 48 h in dark.	Retinal Proteins 1987. 205 – 216
		13Z-	384	366	438		525						0/100	3780				13Z form BRA 525 in τ_{rec} 20 min. BRA525 photocycle lacks the "M", long-lived red-shifted species, "L_{610}" as in BR13-cis. In NC 440 nm no photocycling was observed.	JACS 1986 108(15) 4614-4618 17
		all-E-			438		524 560 560							3780				in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
		all-E-					522											pKa (SBH^+) = 7.3, pKa (BRA SB) = 12.0. Titrations of BRA data	Biochem 1995, 34(37), 12059-12065
131.		all-E-	378	358	436		556		556	+	410	+++	50/50 90/10	5000 5000				Hepes buffer, pH 6.5 τ_{rec} 30 min. BRA cycle compared to BR. Short-lived "K", long-lived "M". No observed light-dark adaptation. H^+-pump in in vesicles.	Retinal Proteins 1987. 205–216 JACS 1986 108(15) 4614-4618 17
																		573-nm excitation of BRA. BRA laser-induced transient	BiophysJ 1993 65(2)

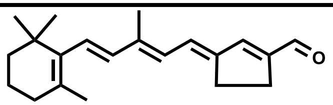
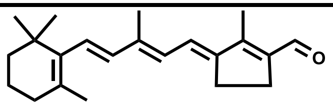
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M						CD	others	
							(P)	DA	LA						NH_2OH	all-E-RET			
																		picosecond absorption and picosecond time-resolved fluorescence spectra. Differences including slower formation rates for"J" $_{610\ nm}$ and "K1"$_{590nm}$ as well as the presence of a second "K2" $_{650\ nm}$ Restricted motion in the C11=C12-C13 region of retinal found in BRA does not greatly change the overall photoreaction mechanism, but does alter the rates at which processes occur. Resonance Raman spectrum.	964-972
		all-E-					556 530 532 552			+τ + + +			100/0 100/0 100/0 100/0					Leu93X mutants. Leu93 τ_{Mdecay} 0.6ms τ_{Odecay} 4 ms Leu93→Alaτ_{Mdecay} 0.7ms τ_{Odecay} 15ms Leu93→Thrτ_{Mdecay} 60ms Leu93→Val τ_{Mdecay} 1.0ms τ_{Odecay} 5.3ms. In 10 mM sodium phosphate buffer at pH 7.0 22^{0}C. Laser-induced transient spectra. Leu93→Val, Leu93→Ala mutants, BRA accelerates decay of the "O" by 2-fold and 120-fold, respectively.	PNAS 1997 94(10) 5028–5033
		all-E-					556											str. S9. In water	JPhysCh

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																		without buffer pH 6.5. Resonance Raman spectrum	em 1993 97(47) 12416-12422
		all-E-			436		556							5000				pKa (SBH^+) = 7.2, pKa (BRA SB) = 12.1. Titrations of BRA data	Biochem 1995, 34(37), 12059-12065
																		New model of the primary events of the BR photocycle. Picosecond intermediates appearing in the respective photo-reactions BRA are measured by coherent anti-Stokes Raman spectroscopy (CARS).	Chem Physics 2005, 313(1-3), 51-62.
		all-E-					556											PR/CARS and PTR/CARS data measured from the sample BRA. The significantly slower rate (τ 12-16 ps) for the "J" to "K" transformation in BRA relative to that in BR-570 (3.5 ps) directly reflects the time required for trans to cis isomerization of the C13=C14 bond. The decreased isomerization rate in BRA arises from the proximity of the ring to the C13=C14 bond, which increases inertia near the C13=C14 bond and	JPhysChem A 2003 107(49) 10787-10797

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																		introduces new steric interactions between the ring and amino acid residues. As a consequence, the rate at which torsional motion is converted into isomerization of the C13=C14 bond slows.	
132.		all-E-	381[a]		464[a]		NO											str. R1S9	Recl. 1994, 113(1), 45-52.
		all-E-	391	363	440	430	562			NO		NO		4930				str. 353P	Kirillova Yu.G. Ph.D. thesis, 1994
133.		all-E-				420sh 443, 470sh	576	576				NO		4140		displaced		τ_{rec} 15 days, 10mM HEPES, pH 7.0.	JACS 1983 105(15) 5162-5164 19
		all-E-					576												Biochem 1990 29(25) 5948-5953
		all-E-				439	555	555	555	NO		NO			light-induced reaction $\tau_{1/2destr}$ 65 min; in the dark $\tau_{1/2destr}$ 81 min			τ_{rec} 12 days. BO expressed in E. coli (ebO). Reaction with NH_2OH in the dark and in the light were similar.	J.Biol. Chem., 1992, 267(10), 6757-6762
																		C13=C14 locked BRA tested an early photophysical events	Biochem M 2001 66(11)

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			“CHO”	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																		with subpicosecond time resolution. BRA cycle lack the characteristics of native bR cycle, “I” BRA exhibit long lived decays of 18 ps, regenerating their original ground state.	1210-1219
															$\tau_{1/2destr}$ 846 s in the dark $\tau_{1/2destr}$ 375 s under light			Light-Induced NH_2OH reactions occur with SB C13= C14 locked BRA	Biophys J 1998 75(1) 413-417
		all-E-				464	574							4250				pKa (SBH^+) 7.3, pKa (BRA SB) 11.5. Titrations of BRA data	Biochem 1995, 34(37), 12059-12065
																		step-scan FT-IR data	LaserChem 1999 19(1-4) 169-172
																		Primary Light-Induced Events in BRA $BRA \xrightarrow{h\nu} H^I(FC) \xrightarrow{\leq 30\ fs} [I^I_{460} \longleftrightarrow T^I_{660}] \xrightarrow{18\ ps} BRA$	JACS. 1996, 118(50) 12828-12829.
		all-E-					578											str. JW5. In aqueous solutions containing 100 m*M* NaCl. BRA $T_{5.12}$ transient species τ_{decay} 18 ps. Laser-induced optoacoustic	Photochem.Photobiol. 2000, 72(5), 590-597

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																		spectroscopy (LIOAS) was employed to inspect the ns-ms time region. Photothermal beam deflection data with the BRA suspensions. BRA no optical transients have been observed at times longer than several picoseconds.	
																		str. S9. Potassium phosphate buffer pH 7.0. Femtosecond pump–probe spectroscopy BRA.	Chem. Phys. Letters 2003, 381(5-6), 549-555
		all-E-					576			NO		NO			slight sensitivity to in the dark			In egg phosphatidylcholine vesicles. Flash photolysis at room and liquid nitrogen temperatures and Fourier-transform infrared difference spectroscopy data.	Biophys. J. 1985 47(4), 509-512
																		Atomic force sensing (AFS) for dynamically probe BRA protein conformational changes with microsecond time resolution	PNAS 1997, 94(15), 7937-7941
																		Spin-labeled Pigments (BRA mutants A103C, M163C, or E74C). Reduction reaction	JBiolChem 2000 275(28) 21010-21016

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																		with NH_2OH is light-catalyzed in the A103C-labeled pigment, but not in E74C or M163C. ESR data.	
																		Primary dynamics of BRA in fs range.	Chem. Phys.Lett. 1999. 314 429-434
																		Photoreduction process by $NaBH_4$ probing the photoreactivity of the SB of C13=C14 locked BRA	PhotochemPhotobiol 2002 75(6) 668-674
																		Vibrational Spectrum of a BRA Picosecond Intermediate T5.12 (660 nm, <3 ps formation and decay in 17ps) is measured by picosecond time-resolved coherent anti-Stokes Raman spectroscopy (PTR/CARS).	JACS 2000 122(1) 96-106
																		New model of the primary events of the BR photocycle. Picosecond intermediates appearing in the respective photo-reactions BRA are measured by coherent anti-Stokes Raman spectroscopy (CARS).	Chem Physics 2005, 313(1-3), 51-62.

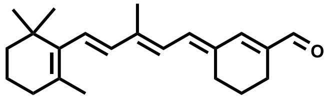
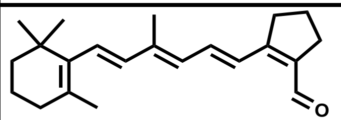
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M				NH_2OH	all-E-RET	CD	others	
							(P)	DA	LA										
		all-E-					578											Comparisons between the PTR/CARS spectra of "J-625" and "T5.12", in BRA with blocking C13=C14 isomerization, support the conclusion that the "J-625" structure reflects the reaction coordinates in the BR photocycle that precede C13=C14 isomerization. Since these PTR/CARS data show "J-625" to have an all-*trans* retinal, C13=C14 isomerization cannot be the primary reaction coordinate described in numerous models for the BR photocycle. 100 mM NaCl, 50 mM phosphate buffer, pH 7.0. τ_{rec} 15 days. Femtosecond time-resolved mid IR and UV-vis spectroscopy. Excited state of BRA τ_{decay} 18 ps. The fluorescence spectrum of BRA closely resembles that of BR-570 although the relative fluorescence yield is higher (10-fold). Kinetic fits show that the red-absorbing intermediate "T5.12", appears within <3 ps and decays with a	JPhysChem A 2000 104(18) 4130-4139 J.Phys. Chem. B 2009, 113(22), 7851-7860 PNAS 1995 92(6) 2101-2105

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																		time constant of 17 ± 1 ps to form only BRA RR spectra of BRA.	
																		In bRA analogous BR dramatic changes associated with "I5.12" are arrested beyond the first 100 fs, reverting uniformly to the initial ground state with exponential time constants of 19 ps respectively. Evolution of "J625" BR, are not, as previously thought, reliable measures of all-trans →13-cis isomerization dynamics.	JPhysChemB 1999 103(24) 5122-5130
																		Reaction Path Analysis of the Photoisomerization SB in BRA	JACS 2002 124(15) 4124-4134
		all-E-					578											PR/CARS and PTR/CARS data measured from the sample BRA	JPhysChem A 2003 107(49) 10787-10797
		all-E-				460	+											τ_{rec} 4-5 days, spectrally and temporally resolved fluorescence properties of locked ABR	Biopolymers 2002, 67, 306–309

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
134.		all-E-	374[a]		460[a]		NO			NO								str. R1S9	Recl. 1994, 113(1), 45-52.
		all-E-	384	362	440	393	NO			NO								str. 353P 5mM MES, 1mM EDTA pH 6.0.	Kirillova Yu.G. Ph.D. thesis, 1994
135.		13Z-	376	360	442	420	548			NO		NO		4380		stable in dark		str. 353P, 5mM MES, 1mM EDTA pH 6.0. τ_{rec} 72 h, reversible hydrolysis under light action. pKa (SB) 6.56.	Kirillova Yu.G. Ph.D. thesis, 1994 Bioorgan Khim. (Rus), 1993, 19(8), 825-835
		13Z-	366[c]		440	370sh 395sh 422, 440sh	547			NO destroyed under light action		NO		4480			330-/ 370+ / 510+ / 580-	10mM HEPES, pH 7.0. τ_{rec} 150 min Hydrolysis under light action.	JACS 1983 105(15) 5162-5164 19
		13Z-						547 600											Biochem 1990 29(25) 5948-5953
																		C13=C14 locked BRA tested an early photophysical events with subpicosecond time resolution. "I" BRA exhibit long lived decays 11 ps, regenerating their	Biochem M 2001 66(11) 1210-1219

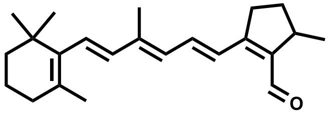
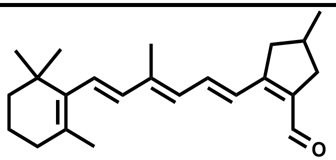
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																		original ground state.	
		13Z-													$\tau_{1/2destr}$ 6300 s in the dark $\tau_{1/2destr}$ 100 s under light			Light-Induced NH_2OH reactions occur with SB C13=C14 locked BRA	Biophys J 1998 75(1) 413-417
																		Atomic force sensing (AFS) for dynamically probe BRA protein conformational changes with microsecond time resolution	PNAS 1997, 94(15), 7937-7941
																		Spin-labeled Pigments (BRA mutants A103C, M163C, or E74C). Reduction reaction with NH_2OH is light-catalyzed in the A103C-labeled pigment, but not in E74C or M163C. ESR data.	JBiolChem 2000 275(28) 21010-21016
		13Z-					550											BRA was prepared from BR, D85N, Y185F, and A103C mutants pH 7, 25°C τ_{rec} 16 h. Light-induced protonated Schiff base hydrolysis reaction was studied. Two intermediates are formed during the hydrolysis reaction, H450 (λmax 450 nm) and H430 (λmax 430 nm). Upon blue light irradiation after the hydrolysis reaction,	BiophysJ 2002 82(5) 2617-2626

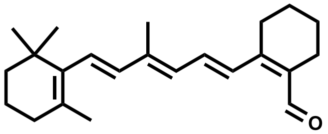
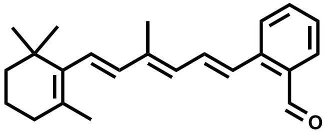
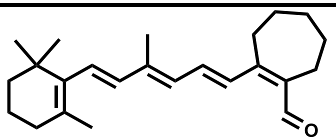
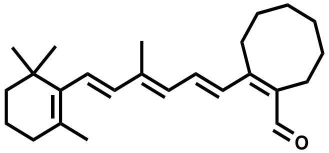
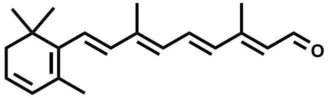
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M								
							(P)	DA	LA						NH_2OH	all-E-RET	CD	others	
																		these intermediates rebind to the AM to reform BRA. Irradiation of the H450 intermediate forms the original pigment BRA, whereas irradiation of H430 at neutral pH results in a red shifted species (P580), which thermally decays back to BRA. EPR measurements.	
																		step-scan FT-IR data	LaserChem 1999 19(1-4) 169-172
																		Photoreduction process by $NaBH_4$ probing the photoreactivity of the SB of C13=C14 locked BRA	PhotochemPhotobiol 2002 75(6) 668-674
																		str. S9. Potassium phosphate buffer pH 7.0. Femtosecond pump–probe spectroscopy BRA.	Chem. Phys. Letters 2003, 381(5-6), 549-555
																		Reaction Path Analysis of the Photoisomerization SB in BRA	JACS 2002 124(15) 4124-4134
																		In bRA analogous BR dramatic changes associated with "I5.13" are arrested	JPhysChemB 1999 103(24)

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			“CHO”	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																		beyond the first 100 fs, reverting uniformly to the initial ground state with exponential time constants of 11 ps respectively. Evolution of “J625” BR, are not, as previously thought, reliable measures of all-trans →13-cis isomerization dynamics.	5122-5130
136.		13Z-	370	365	445	420	548			NO		NO		4220				str. 353P, 5mM MES, 1mM EDTA pH 6.0. τ_{rec} 14 days	Kirillova Yu.G. Ph.D. thesis, 1994 Biolog. membranes (Rus), 1993, 10(4), 447-448
137.		13Z-	370	365	445	415	NO			NO				-				str. 353P, 5mM MES, 1mM EDTA pH 6.0. pKa (SB) 6.52.	Kirillova Yu.G. Ph.D. thesis, 1994 Biolog. membranes (Rus), 1993, 10(4), 447-448

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	Pigments DA	Pigments LA		M				NH_2OH	all-E-RET	CD	others	
138.		13Z-	370	356	439	415	NO			NO				-				str. 353P, 5mM MES, 1mM EDTA pH 6.0.	Kirillova Yu.G. Ph.D. thesis, 1994 Bioorgan Khim. (Rus), 1993, 19(8), 825-835
139.		13Z-	327, 369	338	420	343	NO			NO								str. R1, 50mM MES, pH 6.5. 24 h NC easy destroyed by Ag^+ / Triton X-100. C18-keton easy replaced NC	Bioorgan Khim. (Rus), 1987, 13(8), 1116-1124
140.		13Z-	364	352	435	NO	NO											str. 353P, 5mM MES, 1mM EDTA pH 6.0.	Kirillova Yu.G. Ph.D. thesis, 1994
141.		13Z-	358	348	431	NO	NO											str. 353P, 5mM MES, 1mM EDTA pH 6.0.	Kirillova Yu.G. Ph.D. thesis, 1994
G. **Alteration of the trimethylcyclohexenic ring. Ring modification**																			
142.		all-E-	396		471				600					4560				in water.	BiophysJ 1986 49(2) 479-483
		all-E-						585	593	+		71		4140 4370				str. S9	Biochem Biophys. Res. Com 1977, 78(2), 669-675.

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M				NH_2OH	all-E-RET	CD	others	
							(P)	DA	LA										
		all-E-						590	602			+++			stable in the dark			str. R1	Biophys. J. 1977 19. 191-198
		all-E-						+				+++						str. R_1M_1 cells suspensions with 1 mM nicotine	Biochem Soc.Trans. 1976. 4(4), 556 - 559.
		all-E-						593 ε 47500	603 ε 52200 606 77K		434 -60^{0}C						DA-543+/625- LA-555+/577+/636-	in water 2h or in 75% glycerol for low – temperature experiments. Spectrum of BRA is unchanged when pH 3.5 to 10.	Biochem 1978. 17(10), 1915-1922
		all-E-							603	+	434 77K	+++	95/5					str. R1. BRA tested by low temperature spectrophotometry at 77K. In 10mM phosphate buffer (pH 6.5). Glycerol was added to the sample to give a final concentration of 75%. Upon cooling from 272K (0°C) to 77K, the absorption maximum of BRA moved from 603 to 624 nm.	Photochem Photobiol. 1981. 33(4), 547-557
		all-E-	400		470		593		603			70		4690				str. 353-P, pH 6.0, 20-23^{0}C. Cycle and ATP synthesis by BRA cells similar to BR.	Archiv. Biochem Biophys. 1989. 270(1), 184 -197 Biolog. membra

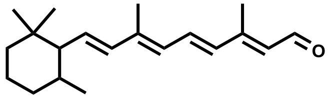
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																			nes (Rus), 1984, 1(11), 1125-1142.
		all-E-						593	603	+	+							Kinetics of the photo-induced processes in BRA	J.Photochem.Photobiol., B: Biology 2001, 62(3), 128-132
		all-E-	401 387[c]	381	463			592	603 ε 52000	430	+	+++		4710 5010				str. 353-P, pH 6.0, 20-23^{0}C	29
		all-E-					594										542+	in 20 mM sodium phosphate buffer, pH 7.0. CD spectra.	Chirality 2006 18(2) 72-83
		all-E-						592 589 580 593	603 596 582 600									str. 353-P, ET1001, D96N, 100 mM NaCl, 5 mM MES, pH 6.0, 20-23^{0}C, τ_{rec} 1h. str. 353-P str. ET1001 str. D96N str. JW5 BRA cycle similar to BR (M, O). "M" time constants BRA (τ_{Mdec}) coincide with BR data.	Biolog. membranes (Rus), 2009 26(3) 40-46 Rus. J. Bioorg Chem., 2002, 28(6), 487–493 Mironova E.V. Ph.D. thesis, 2002

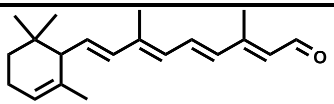
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
		all-E-					603			425				5010				In 100 mM NaCl, 5 mM MES, 3 mM potassium citrate, pH 6.0.	Sensors and Actuators B: 1997. 39(1-3), 218-221 Mol. Cryst. Liq. Cryst 2000, 345, 317-322
																		str. S9 Model of the color sensitive artificial retina with wild type 3,4-didehydro and 4-oxoBRA	BioSystems 2000, 54(3) 131–140
																		WT BR 3,4-didehydroBRA and 4-oxo-BRA, were studied as potential materials for optoelectronic and molecular electronic applications. Thick-film elements based on the three types of BR and PVA were prepared to determine the photoelectric properties of the materials for the development of a color-sensitive optoelectronic sensor.	Optical Mater 2004 27(1) 57-62

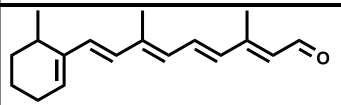
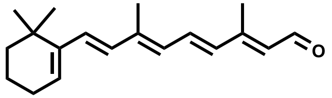
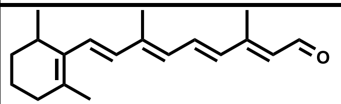
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M						CD	others	
							(P)	DA	LA						NH_2OH	all-E-RET			
143.		all-E-			431		466	466	464				65/35 31/69	1750 1650				pH 7.0, 50 mM Hepes	Photochem Photobiol 1991 54(6) 969-976
		all-E-5,6-trans	370		430				478					2340					BiophysJ 1986 49(2) 479-483
		all-E-5,6-cis	369		432				467					1740					
		all-E-	368[a]			395		475 ε 53600	475	+	370	+++	60/40		destroyed after 1h in the dark	$\tau_{1/2repl}$ 10h		in distilled water at 25^0C pH 6.8. τ_{rec} 30 min, L→D-adaptation faster, than in BR. At 77 K "K" formed then →"M" $\tau_{1/2Mdec}$ BRA 2min.	Biochem 1981, 20(2), 428-435
		all-E-	370		425		476							2500				67 mM phosphate buffer, pH 7.0. τ_{rec} 60 min,	JACS. 1980. 102(27), 7945 – 7947
		all-E-	368		428		476							2300				pH 7.0 in H_2O	JACS. 1986. 108(11), 3104 – 3105
		all-E-			425		475	475		+	350			2500				pH 7.0 in H_2O. L-D-adaptation faster. 'M""decay delayed.	Photochem Photobiol 1981 33(4) 483-488
		all-E-																Raman spectra Schiff base BRA (-C=NH-) stretching frequency. 1660 cm^{-1}	Photochem Photobiol 1985 41(5) 563-567

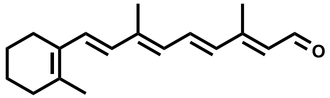
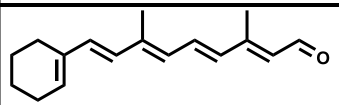
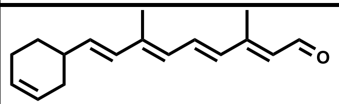
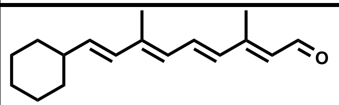
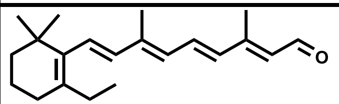
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
		all-E-					466 484 484											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
		all-E-5,6-trans			435		478			+		10-15		2340					Pure Appl. Chem., 1986, 58(6), 719-724
		all-E-5,6-cis	370		432		467			+		10-15		1740					
		all-E-	368[a]				470											Protein-β-Ionone Ring Interactions. Second harmonic generation (SHG) to probe the light-induced dipolar changes.	JPhysChem B 2003 107(25) 6221-6225
		all-E-5,6-cis					467										449+	in 20 mM sodium phosphate buffer, pH 7.0. CD spectra.	Chirality 2006 18(2) 72-83
144.		all-E-	370[b] ε 48800				492 ε 68000		484	+		+	85/15 60/40		unstable $\tau_{1/2destr}$ 40 min, 20°C			str. AO151, cells suspensions or BO at pH 5.5-7.5. τ_{rec} 150 min. Transient changes in flash photolysis BRA two species were found. One 520 nm τ_{form} 100ms, $\tau_{1/2decay}$ 400 ms and 370 nm τ_{form} 10ms. Neither of these species were comparable to the BR cycle.	FEBS Lett. 1980 117(1), 363-367.
		13Z-					480												
		all-E-			430		476	476	472	+			70/30 45/55	2250 2050				pH 7.0, 50 mM Hepes	Photochem Photobiol 1991 54(6)

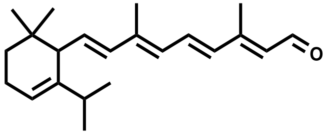
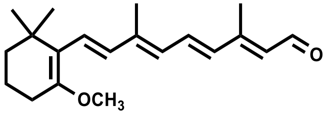
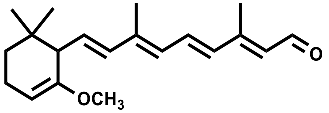
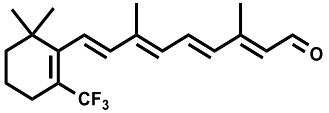
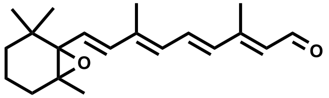
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																			969-976
		all-E-					495											str. ET1001. In 4 *M* NaCl, 25 mM Tris-HCl buffer, pH 7.2 $\tau_{1/2rec}$ 5 min	Photochem Photobiol 1994 60(4) 388-393
		all-E-	368		431				484					2540				In water.	BiophysJ 1986 49(2) 479-483
145.		all-E-	392		465		537		549			40		3100 3300		stable		str. R1S9	Recl. 1987 106(4) 112-119
146.		all-E-	388		453	420/460	540		548			70	50/50 100/0	3600 3800		stable		str. R1S9 τ_{rec} in 3 faster then BR. in H_2O	Recl. 1987 106(4) 112-119
		all-E- 13Z-	388[a] 381[a]			420/460 420/460	550 533	546	551		410	+++ 114	62/38 92/8		$\tau_{1/2destr}$ 40 min, 20°C in the dark.			str. R_1M_1, in 70 mM potassium phosphate, pH 6.5. τ_{rec} 20 min. BRA cycle compared to BR. "M" τ_{form} 1.5 ms,"O"'640 nm τ_{form} 9 ms. str. W296.	Biochem 1983 22(11) 2637-2644
		all-E-	388[a]			420/460	548	540	548			70	50/50 100/0			stable		str. R1S9, τ_{rec} 15 min	FEBSL 1983 154(1) 180-184
		13Z-	381[a]			420/460	535	540	548				50/50 100/0						
		11Z- 9Z-	384[a] 380[a]			425 NO	NO NO												
147.		all-E-	396		470		558		566			99		3350 3600		stable		str. R1S9	Recl. 1987 106(4) 112-119

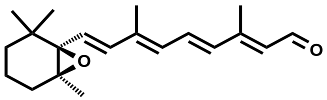
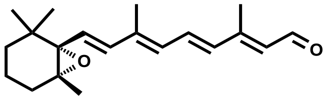
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
148.		all-E-	401		474		553		564			96		3000 3400		stable		str. R1S9	Recl. 1987 106(4) 112-119
		all-E-					552 592 560											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
149.		all-E-	387		458		539		544			57		3300 3500		stable		str. R1S9 τ_{rec} in 1.5 faster than BR. in H_2O.	Recl. 1987 106(4) 112-119
		all-E-		368	457		535		545		410			3190 3200				pH 6.5 Hepes buffer.	Retinal Proteins 1987. 205–216 17
		all-E-			457		535		545	+	410			3190 3200				pH 7.0, Hepes buffer. BRA cycle compared to BR. Short-lived "K", long-lived "M'.	FEBS Lett. 1984. 166(2), 245-247
150.		all-E-					495	495		+	+	+				stable		str. ET1001 BRA cycle compared to BR. str. JW 2N white membrane cells for H^+-pump.	Photochem Photobiol 1991 54(6) 873-879
151.		all-E-					485											str. ET1001. In 4 *M* NaCl, 25 mM Tris-HCl buffer, pH 7.2, $\tau_{1/2rec}$ 2 min.	Photochem Photobiol 1994 60(4) 388-393
152.		all-E-	378[b]			420	504 In H_2O ε 50000					++						str. JW 5 white membrane cells, τ_{rec} 4 min	AngewChem IE 1987 26(6) 580-583

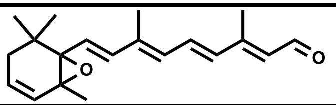
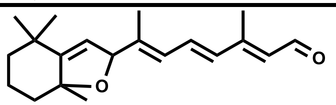
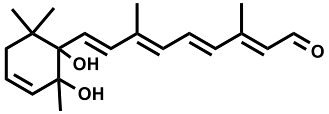
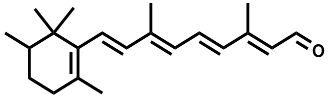
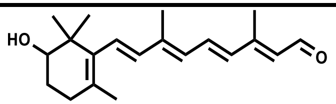
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M			cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
		13Z-					545 in 4M NaCl 504												
153.		all-E-					450											str. ET1001. In 4 *M* NaCl, 25 mM Tris-HCl buffer, pH 7.2, $\tau_{1/2rec}$ 15 min	Photochem Photobiol 1994 60(4) 388-393
154.		all-E- β–isomer	385				570					20 (α+β)						str. JW 5 white membrane cells	AngewChem IE 1987 26(6) 580-583
155.		all-E- α–isomer					460					20 (α+β)						str. JW 5 white membrane cells	AngewChem IE 1987 26(6) 580-583
156.		all-E- all-E-	 360	350 350	418 418		465 465	 465	 465		 NO	0 0	 70/30 30/70	2400 2400 2400					Photochem.Photobiol. 1993. 58(5), 701-705 JACS 1986. 108(19), 6077 – 6078 Tetrahedron L. 1989. 26(50), 6209-6212
157.		all-E-rac 13Z-rac	362		420		452		452	+		2.5-16		1690 1690		stable	415-/500-	str. 353-P, pH 6.0, 20-23^{0}C, τ_{rec} 30 min BRA cycle kinetics drastically slowed ϕ_{rel} 0.14±0.06.	Archiv. Biochem Biophys. 1989. 270(1), 184 -197

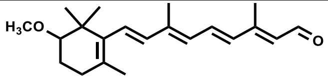
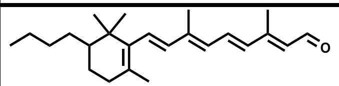
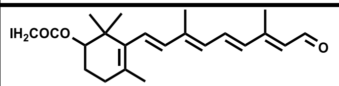
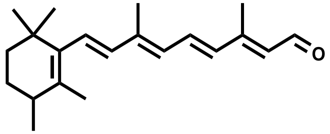
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M				NH$_2$OH	all-E-RET	CD	others	
							(P)	DA	LA										
		all-E-(5S,6R)	249, 365[a] ε 45300		421[e]		485 ε 41000		478			7	95/5 50/50	3100 2830		stable $\tau_{1/2\ repl}$ 8000 min	245+/355- CHO	str. R_1 CD-BRA-460(+), 520 (-) $\tau_{1/2rec}$ 400s, 10°C X-rays diffraction data	Biolog. membranes (Rus), 1984, 1(11), 1125-1142. Rus. J. Bioorg Chem., 2002, 28(6), 487–493 Biochim. Biophys. Acta. 1987. 891(2), 177 -193
		13Z-	253, 358[a]														250+/350- CHO		
		all-E-(5R,6S)	249, 365[a] ε 45300		421[e]		445 ε 40000		445			+	96/4 48/52	1300		stable $\tau_{1/2\ repl}$ 260 min	245-/355 + CHO	CD-BRA-435(+), 490 (-) sh $\tau_{1/2rec}$ 48s, 10°C X-rays diffraction data	
		13Z-	253, 358[a]														250-/350 + CHO		
		all-E-rac					+											str. R_1M_1 cells suspensions with 1 mM nicotine	Biochem Soc.Trans. 1976. 4(4), 556 -559.
		all-E-rac					452				375			1680				In 100 mM NaCl, 5 mM MES, 3 mM	Sensors and Actuators B:

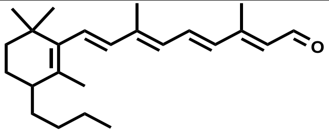
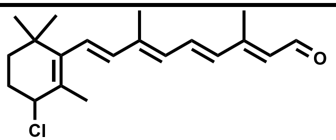
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																		potassium citrate pH 6.0.	1997. 39(1-3), 218-221. Mol. Cryst. Liq. Cryst 2000, 345, 317-322
158.		all-E-	363		422		460							1960					29
159.		all-E-	331		380		412		412					2040			430+ /370-		29
160.		all-E-	365				465												29
161.		all-E-					557 558 556											In water. pH 7.0 pH 2.5 pH 0.5 Molecular Dynamics Study BRA Molecular Dynamics Study BRA	BiophysJ 1989 56(6) 1259-1265 Biochem 1994 33(12) 3668-3678 BiophysJ 1995 68(4) 1270-1282
162.		all-E-	380[a]				520											Protein-*β*-Ionone Ring Interactions. Second harmonic generation (SHG) to probe the	JPhysChem B 2003 107(25)

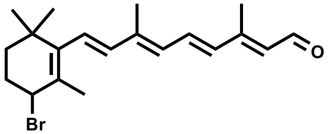
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																		light-induced dipolar changes.	6221-6225
163.		all-E-	380[a]				470											Protein-β-Ionone Ring Interactions. Second harmonic generation (SHG) to probe the light-induced dipolar changes.	JPhysChem B 2003 107(25) 6221-6225
164.		all-E-	380[a]				460											Protein-β-Ionone Ring Interactions. Second harmonic generation (SHG) to probe the light-induced dipolar changes.	JPhysChem B 2003 107(25) 6221-6225
165.		all-E-	222, 240, 362[a]				510		510										J. Sci Ind Res. 1982. 41(11), 665-673
166.		all-E-			438		470	470	470	+ +			62/38 62/38	1550 1550				50 mM Hepes, pH 7.0	Photochem Photobiol 1991 54(6) 969-976
		all-E-					462 494 505											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
		all-E-		360	440		465/ 550sh			+	390			1220 4500				Hepes buffer pH 7.0. BRA consists from 2 species with independent cycles.	Retinal Proteins 1987. 205–216 JACS 1984 106(8) 2435-2437

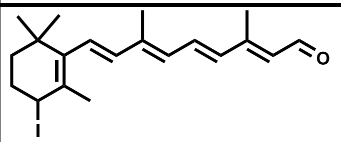
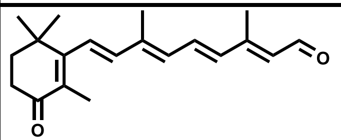
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH⁺	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																			17
																		Molecular Dynamics Study BRA.	Biochem 1994 33(12) 3668-3678
																		Molecular Dynamics Study BRA	BiophysJ 1995 68(4) 1270-1282
167.		all-E-					465		465	+	390							Hepes buffer pH 7.0. BRA consists from 2 species with independent cycles.	JACS 1984 106(8) 2435-2437
		all-E-		360	440		465/ 550sh			+				1220 4550					Retinal Proteins 1987. 205–216 17
		all-E-					469 503 510											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
168.		all-E-	348[c]					462		NO								30 mM sodium phosphate buffer, pH 7.2 unstable. On standing for several hours, or on exposure to light, the BRA absorption maximum shifts to 530 nm	Photochem.Photobiol. 1986. 43(3). 297 -303 18

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
169.		all-E-	352[c]					460		NO								30 mM sodium phosphate buffer, pH 7.2 unstable. On standing for several hours, or on exposure to light, the BRA absorption maximum shifts to 530 nm	Photochem.Photobiol. 1986. 43(3), 297 -303 18
		all-E-11,12-^{3}H						470 464 470 NO										str. IV-8, in 50 mM sodium phosphate buffer, pH 7.4. WT Met118Cys Thr121Cys Serl41Cys Incorporation of tritiated chromophore into the Met118Cys mutant BRA. Modified by N-ethylmaleimide BO formed a pigment with 4-bromoretinal but no cross-linking was observed, providing evidence that the cross-linking of the chromophore is to the Cys118 (BRA470nm)	Biochem 1994. 33(38), 11624 - 11630
																		MD analysis suggests the following ranking of binding site mutants in order of reactivity: R118C> S118C>> S121C> R141C>> S141C>>> R121C, R138C, S138C. Chiral center of 4-bromo-Ret produces variable impact on potential crosslinking.	BiochemMolBiolInter 1999 47(5) 773-780

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																		Chirality appears to have limited effect for the M118C mutants but shows more dramatic impact for the T121C and S141C mutants.	
170.		all-E-	340[c]					455		NO								30 mM sodium phosphate buffer, pH 7.2 unstable. On standing for several hours, or on exposure to light, the BRA absorption maximum shifts to 530 nm	Photochem.Photobiol. 1986. 43(3), 297 -303 18
171.		all-E-	294, 380 ε 43700		445		506		506	+				2710 2710			390+/462 +/540-	str. R1 in water τ_{rec} 24 h	Bioorgan.Khim (Rus), 1979, 5(7), 1053-1058
		13Z-	294, 373 ε 35300				506	506	506	+							470+/535-		
		all-E-	380 ε 43700				506			+								str. R1, in 50 mM phosphate buffer at pH 7.0	Bioorgan Khim (Rus), 1981, 7(11), 1731-1733
		all-E-	378[a]	369[a]	425[a]		524	506	502	+	410-412	+		4400 3770 3610	stable till 1h in 20 mM	stable		in distilled water, pH 7.0. $\tau_{rec1/2}$ ~5min "M"-intermediate decay kinetics and proton uptake are much slower than in BR.	Photochem.Photobiol. 1991. 54(6), 977-983. Biochem 1991 30(11),

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M				NH_2OH	all-E-RET	CD	others	
							(P)	DA	LA										
																			2976-2988
		all-E-					520											str. R1M1 cells grows in presence of 4-oxoRet when synthesis of natural Ret blocked.	FEBSL 1976, 71(2), 333-336.
		all-E-			425		527		511	+				4550 3960				str. 353-P, pH 6.0.	Biokhim (Rus), 1989, 54(1), 136-138
		13Z-					504		507	+									
		all-E-	380	369	425		506					25-70		3770				str. 353-P, pH 6.0, 20-23^{0}C. ϕ_{rel} 0.7±0.1.	29 Archiv. Biochem Biophys. 1989. 270(1), 184 -197 Biolog. membranes (Rus), 1984, 1(11), 1125-1142.
		all-E-					527				410							4-oxoRet formed with BO BRA. BRA cycle with drastically slowed intermediates and high value of $\phi_{rel.}$ *all-E-* 4-oxoBRA cycle has full period in a several min. "M" formation rate close to BR, but its decay is in biphasic mode. One component compared to control BR and tails contain slowed	Vestnik St-Peterburg Univer, Ser 3 2012, (4), 82-92 Biochem (M) 2012, 77(9),
		13Z-					504												

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M				NH_2OH	all-E-RET	CD	others	
							(P)	DA	LA										
																		components. It was compared the kinetics of spectral transformations of individual forms of E- and Z-4-oxoBRA and it was found that the E-cycle contains no long-wavelength intermediates, and all signals recorded in this region on uncontrolled samples are a summary of "K"like long-lived intermediates of the Z-isomer cycle.	1008-1010
																		str. 353-P, ET1001, D96N, 100 mM NaCl, 5 mM MES, pH 6.0, 20-23^{0}C, τ_{rec} 1h.	Biolog. membranes (Rus), 2009 26(3) 40-46
		all-E-						527	511									str. 353-P	
							526	526	508									str. ET1001	
							527	527	503									str. D96N	
								490	483									in str. JW5 cells.	
																		Both for ET1001 and for D96N strains the "M"-relaxation of the 4-oxoBRA was distinctly biphasic, with the slow phase comprising about 10–15% of the signal amplitude. For BRA the efficiency of the "M"-intermediate formation did not exhibit any reliable dependence on the point mutation. It was shown an additional decelaration of"M"-relaxation of the 4-	Rus. J. Bioorg Chem., 2002, 28(6), 487–493 Mironova E.V. Ph.D. thesis, 2002

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																		oxoBRA in D96N str.	
		all-E-					506			+	410							In 100 mM NaCl, 5 mM MES, 3 mM potassium citrate, pH 6 and in PVA dry films.	Sensors and Actuators B: 1997, 39(1-3), 218-221. Mol. Cryst. Liq. Cryst 2000, 345, 317-322
																		The effect of pH and sodium azide on the photochemical cycle of 4-oxo-BRA has been investigated	Biophys (Rus), 1992, 37, 79-84
																		The effect of applied constant electric field was investigated (10^7 V/m) on spectral properties of 4-oxo-BRA embedded in the gelatin-based matrix.	Biophys (Rus), 1992, 37, 86-90
																		BRA cycle was investigated in water suspension by pulse and low-temperature absorption spectroscopy. The scheme of BRA photochemical reactions was proposed.	Biologicheskie Membrany 1991, 8(5), 460-467
																		Incorporation of the 4-oxo-Ret into D85N AM was unexpectedly	Thin Solid Films.

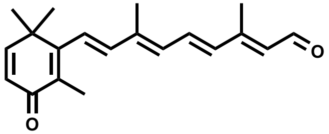
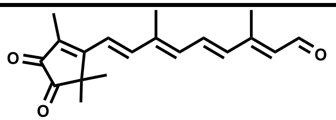
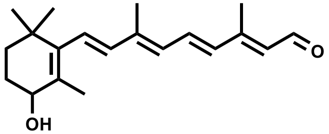
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																		slow: more than 10 days were required, and the yield was < 10%. It was demonstrated that electric field-induced SB deprotonation take place. SB pK = 6.15.	1997. 302(1–2), 231–234
																		Spectral and kinetic transformation studies of gelatin films based on 4-oxo WT BRA and D96N mutant BRA were carried out using absorbance spectroscopy. It was studed the influence of chemical additives and sodium azide on "M"-decay kinetics.	Thin Solid Films 1997 293(1-2) 281-284
																		str. 353P, R1M1 or ET-1000 Photochromic and electrochromic spectral properties of 4-oxo-BRA embedded in a polymer matrix were studied.	BioSystems 1995 35(1) 129-132
																		str. R1M1 or ET-1000 Photochemical reactions in a 4-oxo-BRA were studied by using low-temperature and pulsed laser absorption spectroscopy.	BioSystems 1995 35(1) 133-136
																		WT BR, 3,4-didehydroBRA and 4-oxo-BRA, were studied as potential	Optical Mater 2004 27(1)

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																		materials for optoelectronic and molecular electronic applications. Thick-film elements based on the three types of BR and PVA were prepared to determine the photoelectric properties of the materials for the development of a color-sensitive optoelectronic sensor	57-62
																		WT PM. theoretical model for the nonlinear transmittance properties of 4-oxo-BRA.	Optical Mater 1999 12(4) 473-480 ProcSPIE 1998 3347, 58-60
																		str. S9 Model of the color sensitive artificial retina with WT 3,4-didehydro and 4-oxoBRA	BioSystems 2000, 54(3) 131–140
																		compared the proton uptake and release of WT and two mutant BR D96N, D85N in BRA films or L-B layers on ATO	Bioelectrochem 2000 51(1) 27-33
																			BioelectrochemBioenergetics 1997 44(1)-

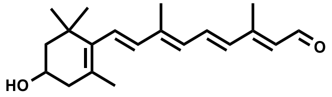
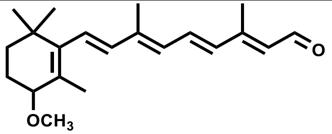
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
																			37-43
172.		all-E-	380[a]	370[a]	426[a]		522	508	500	+	400	+		4400 3700 3470	stable till 1h in 20 mM	stable		in distilled water pH 7.0. $\tau_{1/2rec}$~5 min "M"-intermediate decay kinetics and proton uptake are much slower than in BR.	Photochem.Photobiol. 1991. 54(6), 977-983. Biochem 1991 30(11), 2976-2988
173.		all-E-	435[a] ε 45000	442[a]	455[a]		515	500	500	+	360-370			2600 1980 1980	stable till 1h in 20 mM			in distilled water pH 7.0. τ_{rec}~BR $\tau_{1/2Mdec}$>>200ms cross-links with Arg residues doesn't formed.	Photochem.Photobiol. 1991. 54(6), 977-983. Biochem 1991 30(11), 2976-2988
174.		all-E-	254, 375 ε 40100		440		535		543	+				4040 4310			360+ /420- /520 +/ 577-	str. R1 in water τ_{rec} 24 h	Bioorgan.Khim 1979, 5(7), 1053-1058
		13Z-	254, 375 ε 30800		440		530		543					4040 4310			380+ /503 +/ 577-		
		all-E-			437		525	525	527	+			85/15 65/35	3800 3900				50 mM Hepes, pH 7.0	PhotochemPhotobiol 1991 54(6) 969-976
		all-E-					535												

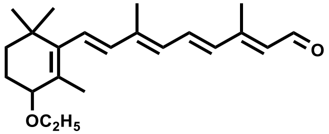
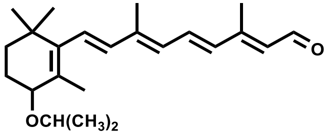
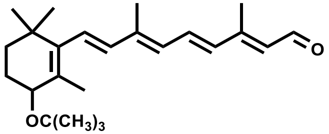
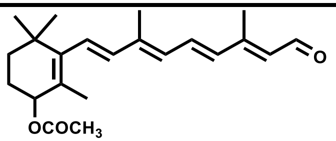
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
									540									in 50 mM sodium acetate buffer pH 5.5.	Photochem Photobiol 1981, 33(4), 489-494
		all-E-	370[c]				530		540	+	400	+++						30 mM sodium phosphate buffer, pH 7.2	Photochem.Photobiol. 1986. 43(3), 297 -303
		all-E-					540											in 67 mM phosphate buffer at pH 7.0	Photochem Photobiol 1981, 33(4), 483-488
		all-E-		360	440		550			+				4550				Hepes buffer pH 7.0.	Retinal Proteins 1987. 205–216
		all-E-					530		540	+	390							Hepes buffer pH 7.0	JACS 1984 106(8) 2435-2437
		all-E-	375 ε 40100				538			+								str. R1, in 50 mM phosphate buffer at pH 7.0	Bioorgan Khim (Rus), 1981, 7(11), 1731-1733
		all-E-	375		440		538			+	400	+++		4140				str. 353-P, pH 6.0, 20-23^{0}C. Cycle BRA ("M" "O") similar to BR, but time constants altered. Rate of "M"-intermediate decay is	Archiv. Biochem Biophys. 1989. 270(1), 184 -197

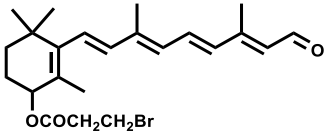
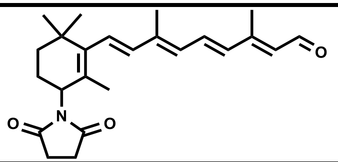
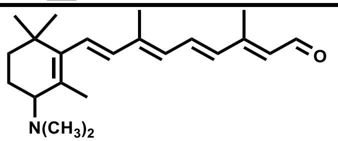
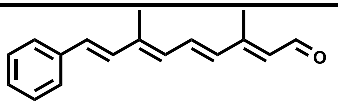
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
		all-E-	375		440		538			+	400	+++		4140				higher than the relaxation rate to BRA. ϕ_{rel} 0.7±0.1. str. 353-P, pH 6.0, 20-23^{0}C. Cycle BRA ("M" "O") similar to BR, but time constants altered. Rate of "M"-intermediate decay is higher than the relaxation rate to BRA. ϕ_{rel} 0.7±0.1.	Biolog. membranes (Rus), 1984, 1(11), 1125-1142.
		all-E-					538			+	400							In 100 mM NaCl, 5 mM MES, 3 mM potassium citrate pH 6.0.	Sensors and Actuators B: 1997, 39(1-3), 218-221
175.		all-E-					556 610 552											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
176.		all-E- 4-[$O^{13}CH_3$]	370 ε 42000			+	470										450+	str. R1, in 50 mM phosphate buffer at pH 7.0	Bioorgan Khim (Rus), 1981, 7(11), 1731-1733
		all-E-	370		440		475			+		+		1680				str. 353-P, pH 6.0, 20-23^{0}C, BRA consists from at least 2 species with independent cycles. No long-wave intermediates were	Biolog. membranes (Rus), 1984, 1(11), 1125-1142.

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
		all-E-	370		440		475			+		+		1680				detected in 4-methoxyBRA. ϕ_{rel} 0.15±0.04. str. 353-P, pH 6.0, 20-23°C, BRA consists from at least 2 species with independent cycles. No long-wave intermediates were detected in 4-methoxyBRA. ϕ_{rel} 0.15±0.04.	Archiv. Biochem Biophys. 1989. 270(1), 184 -197
177.		all-E-	375 ε 43000			+	500										460+	str. R1, in 50 mM phosphate buffer at pH 7.0	Bioorgan Khim (Rus), 1981, 7(11), 1731-1733
178.		all-E-	375 ε 40000			+	500-530										460+	str. R1, in 50 mM phosphate buffer at pH 7.0	Bioorgan Khim (Rus), 1981, 7(11), 1731-1733
179.		all-E-	375 ε 40500			+	500-530										460+	str. R1, in 50 mM phosphate buffer at pH 7.0	Bioorgan Khim (Rus), 1981, 7(11), 1731-1733
180.		all-E-	375 ε 41000			+	470										470+	str. R1, in 50 mM phosphate buffer at pH 7.0. slowly hydrolysed in 4-hydroxyBRA	Bioorgan Khim (Rus), 1981, 7(11), 1731-1733

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
181.		all-E-	375 ε 40500			+	455											str. R1, in 50 mM phosphate buffer at pH 7.0. easily hydrolysed in 4-hydroxyBRA	Bioorgan Khim (Rus), 1981, 7(11), 1731-1733
182.		all-E-	376	355	436		457		460					1050 1200				str R1S9, pH 7.0 τ_{rec} 4 h	29
183.		all-E-					455		455	+	390							Hepes buffer pH 7.0.	JACS 1984 106(8) 2435-2437
		all-E-		360	440		455							750				Hepes buffer pH 7.0	Retinal Proteins 1987. 205–216 17
																		Molecular Dynamics Study BRA.	Biochem 1994 33(12) 3668-3678
																		Molecular Dynamics Study BRA	BiophysJ 1995 68(4) 1270-1282
H. Alteration of the trimethylcyclohexenic ring. Replacement ring to aromatic or heterocyclic fragments																			
184.		all-E-	391 ε 56700	371	452		508		504	+ +	+	+		2440 2260				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 10-12 h	Bioorgan .Khim. 1987, 13(2), 238-251 27
		13Z-	385 ε 55400	368	448		499		501	+ +				2280 2360					

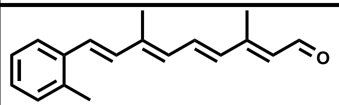
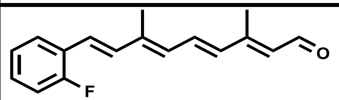
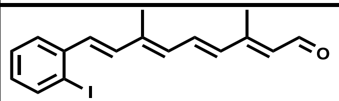
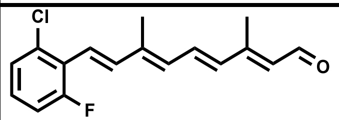
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
		all-E-			455			480						1150				str. R1, pH 7.0 in water	PhotochemPhotobiol 1981 33(4) 483-488
		all-E-	388[a]	357, 372, 387	453	+		480	487	+				1240 1540			485+ 555-	str. R1, in 10mM HEPES buffer, pH 7.0	Photochem.Photobiol., 1984, 39(5), 661-665
		all-E-	391[a] ε 54600				510 ε 43000			+	+	20-50				stable		In 100 mM phosphate Na, pH 6.5. τ_{rec} <1 min Maximun BRA shifted to 480 nm at high pH values in Tris-phosphate buffer in the presence of NaCl or KCl. SB pK 8.1. Without NaCl 512 - 509 nm.	JBiolChem 1981 256(8) 3797-3801
		all-E-		367	448		512			+	+	+		2790				Hepes buffer pH 7.0	Retinal Proteins 1987. 205–216 17
		all-E-	385[a]		448[a]			507	512	+	400	+		2600 2790				100 mM Hepes buffer pH 7.0. $\tau_{1/2Kdec}$ 30 μs Cycle BRA with "K,L,M,O" intermediates	PhotochemPhotobiol 1983 38(2) 197-203
		all-E-	390[a]		452	+	440, 480, 520		505		+	+	95/5 20/80	1290 2890 2320				str. R1M1, 5mM phosphate buffer /50% glycerol, pH 6.8, 3^0C. τ_{rec} BRA520nm 40h. Two species BRA 520/480nm	Biochem 1984. 23(11), 2507-2513

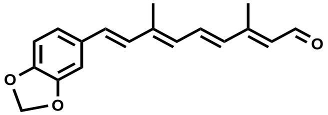
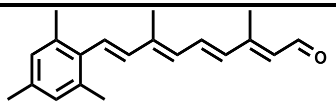
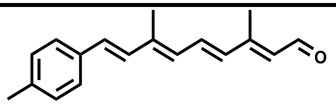
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
		all-E-	373		455		480							1150	unstable in 0.1 M NH_2OH.			in distilled water or 67 mM phosphate buffer, pH 7.0, τ_{rec} BRA480 nm 1 h.	JACS. 1980. 102(27), 7947 - 7949
		all-E-					510											str. ET1001. In 4 *M* NaCl, 25 mM Tris-HCl buffer, pH 7.2, $\tau_{1/2rec}$ <1 min.	PhotochemPhotobiol 1994 60(4) 388-393
		all-E-	391		452		508		504	+	+	20-50						str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^0C. ϕ_{rel} >0.5. all-E-BRA cycle has "M" and compared with BR cycle. In 13Z-BRA cycle"M" absent and have at least 2 long-waved intermediates. L-D-adaptation drastically retarded.	Biokhimia (Rus). 1987, 52(9), 1559-1569.
		13Z-					499		501										Biokhimia (Rus.), 1993, 58(6), 819-826 Colloque INSERM 1992. 221. 167 -170
		all-E-					512 509 508	508	508	+	+							str. 353-P, ET1001, D96N, 100 mM NaCl, 5 mM MES, pH 6.0, 20-23^0C, τ_{rec} 1h. str. 353-P str. ET1001 str. D96N BRA cycle similar to BR (M, O). Strong retardation of the "M" time decay BRA (τ_{Mdec}) it was shown	Biolog. membranes (Rus), 2009 26(3) 40-46

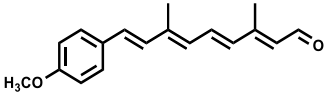
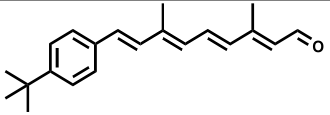
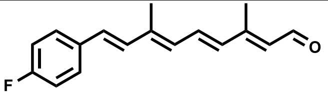
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	Pigments DA	Pigments LA	Photocycle	Photocycle M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
		all-E-					500											for str. ET1001 BR and mutant D96N. Second harmonic generation signal BRA	JACS 2002, 124(40), 11844-11845
185.		all-E-	387[a]		453		540 dif							3560				str. R1M1 in 5 mM phosphate buffer, apomembrane suspensions in 50% glycerol pH 6.6, 20⁰C	Biochem 1984, 23(11), 2507-2513
		13Z-	381[a]				+						5/95						
186.		13Z-	383				504 492 ε 43000											str. R_1M_1 100 mM sodium acetate buffer pH 5.0, τ_{rec} ~ h. X-ray photoelectron spectroscopy	JPhysSocJapan. 1982, 51(8), 2383 – 2384
		all-E-	380	363	440		506 ε 54000							2960					JPhysSocJapan 1984, 53(4), 1557-1564
187.		all-E-	218, 273, 355, 372, 390[a]				466											str. R_1M_1 pH 7.0, 25⁰C 10 mM HEPES buffer X-ray photoelectron spectroscopy	J. Sci Ind Res. 1982, 41(11), 665-673
188.		all-E-	378[a]		434	430/ 460	470, 510							890 3020				str. R1M1 in 5 mM phosphate buffer, apomembrane suspensions in 50% glycerol pH 6.6, 20⁰C	Biochem 1984, 23(11), 2507-2513
		13Z-	371[a]				520 Dif 490						5/95	3810					

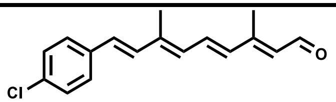
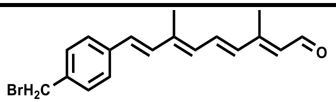
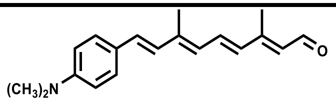
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
189.		all-E- 13Z-					+ +											str. R1M1 in 5 mM phosphate buffer, apomembrane suspensions in 50% glycerol pH 6.6, 20^{0}C	Biochem 1984. 23(11), 2507-2513
190.		all-E-	380 ε 50800	359	439		474		485	+	+			1680 2160				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C	27 Bioorgan.Khim. 1987, 13(2), 238-251
		13Z-	375 ε 49700	352	436		490		485					2530 2320					
		all-E-	384[a] ε 46500				460 ε 39000	460		+	375 -60^{0}C	+						str. R1, in 40 mM phosphate buffer pH 7.0	PhotochemPhotobiol 1985 41(3) 303-307
		13Z-	380[a]																
		all-E-	380[a]		442		460 500sh 535 dif		485				96/4 15/85	890 2010 3930				str. R1M1 in 5 mM phosphate buffer, apomembrane suspensions in 50% glycerol pH 6.6, 20^{0}C. τ_{rec} 3 h	Biochem 1984. 23(11), 2507-2513
191.		all-E-	395 ε 48100	373	463		493		503	+	+			1320 1720				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 10-12 h	Bioorgan.Khim. 1987, 13(2), 238-251 27
		13Z-	389 ε 45200	369	456		505		498					2130 1850					
		all-E-			458		497	497	498				66/34 30/70	1700 1750				pH 7.0, 50 mM Hepes	PhotochemPhotobiol 1991 54(6) 969-976
		all-E-					524											Second harmonic generation signal BRA	JACS 2002, 124(40),

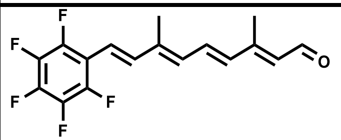
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																			11844-11845
192.		all-E-	404 ε 49600		471		530		521	+		+		2360 2040				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 10-12 h	Bioorgan .Khim. 1987, 13(2), 238-251 27
		13Z-	400 ε 49800	379	474		512		520					1570 1870					
193.		all-E-	397,5 ε 49700	376	462		491		494					1280 1400				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 12 h	Bioorgan .Khim. 1987, 13(2), 238-251 27
		13Z-	390 ε 51600	372	460		493		495					1460 1540					
194.		all-E-	387,5 ε 47700	369	452		524		510	+		+		3040 2520				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 10-12 h	Bioorgan .Khim. 1987, 13(2), 238-251 27
		13Z-	383 ε 43200	366	443		503		508	+				2690 2880				str. 353P, in 50mM MES, 5mM EDTA, pH 6.0, 20^{0}C. all-E-BRA cycle has "M" and compared with BR cycle. In 13Z-BRA cycle"M" absent and have at least 2 long-waved intermediates. L-D-adaptation drastically retarded.	Biokhimia (Rus), 1987, 52(9), 1559-1569. Biokhimia (Rus.), 1993, 58(6), 819-826 Colloque INSERM 1992. 221. 167-170
		all-E-					514			+	395							100 mM NaCl, 5 mM MES, 3 mM potassium citrate, pH 6.0	Sensors and Actuators B: 1997.

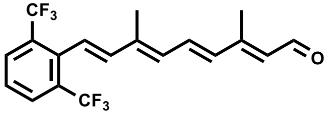
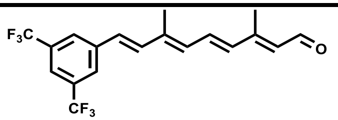
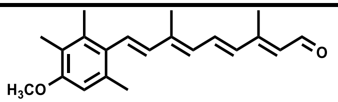
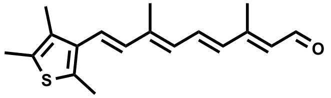
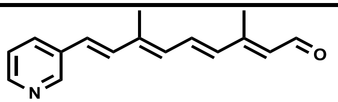
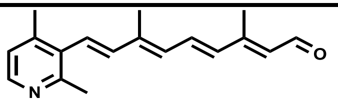
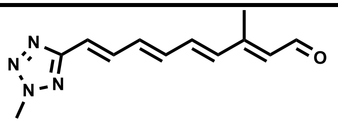
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																			39(1-3), 218-221 Mol. Cryst. Liq. Cryst 2000, 345, 317-322
195.		all-E- 13Z-	389 ε 46500 385 ε 42100	375 369	450 439		518 503		 506 506	 +		 +		2920 2460 2900 3020				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 10-12 h	Bioorgan.Khim. 1987, 13(2), 238-251 27
196.		all-E-	385[a]		448[a]			480	 484	 +	 410			1490 1660				100 mM Hepes buffer pH 7.0. $\tau_{1/2Kdec}$ 35 μs	PhotochemPhotobiol 1983 38(2) 197-203
197.		all-E- all-E- all-E- all-E-	438[a] 442 442	400[a]	533[a] 550 550		570 570 611 618	 535 535	 545 545	+				1220 -510 -170 -510 -170	 destroyed after 5.5 h			20mM HEPES pH 7.0. BRA cycle similar to BR "K" and "M", "L" not observed. pH 7.0 in water in water. pH 7.0 pH 2.5 pH 0.5 in distilled water or 67 mM phosphate buffer, pH 7.0, τ_{rec} BRA535 nm 20 h	Biochem 1985. 24(5), 1260 - 1265 PhotochemPhotobiol 1981 33(4) 483-488 BiophysJ 1989 56(6) 1259-1265 JACS. 1980. 102(27), 7947 -

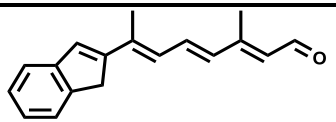
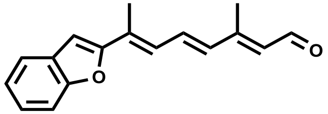
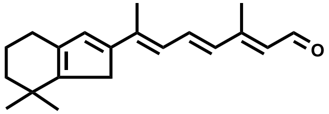
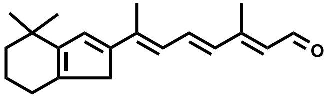
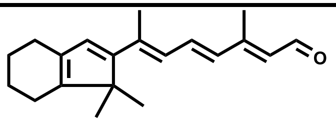
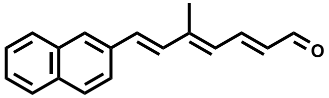
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			7949
																		Atomic force sensing (AFS) for dynamically probe BRA protein conformational changes with microsecond time resolution. BRA reduced by $NABH_4$	PNAS 1997, 94(15), 7937-7941
																		Spin-labeled Pigments (BRA mutants A103C, M163C, or E74C). Reduction reaction with NH_2OH is light-catalyzed in the A103C-labeled pigment, but not in E74C or M163C. ESR data. BRA reduced by $NABH_4$	JBiolChem 2000 275(28) 21010-21016
																		Protein-*b*-Ionone Ring Interactions. Second harmonic generation (SHG) to probe the light-induced dipolar changes.	JPhysChem B 2003 107(25) 6221-6225
198.		all-E-	367				493, 460sh		474	+	+							str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 10-12 h	29
		13Z-	364	346	424		475		478					1420 2660					
		all-E-					496				+							str. 353P, in 50mM MES, 5mM EDTA, pH 6.0, 25^{0}C. τ_{Mdec} > 1 min L-D-adaptation drastically retarded.	
		13Z-					473												

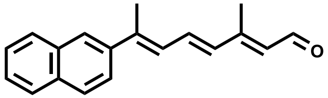
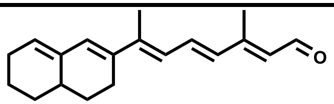
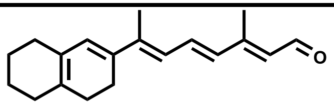
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
199.		all-E-			410[a]		442							1700	replaced in 12-24 h	unstable		str. M1 ^{19}F-NMR δ -56.9 ppm In 5% DDM / D_2O	J.Phys. Chem. 1996. 100(21), 9172 - 9174
200.		all-E-			429[a]		452							1200	replaced in 12-24 h	unstable		str. M1 ^{19}F-NMR δ -66.2 ppm In 5% DDM / D_2O	J.Phys. Chem. 1996. 100(21), 9172 - 9174
201.		all-E-					480			+		15						str. S9 in distilled water	Biochem Biophys. Res. Com 1977. 78(2), 669-675
202.		all-E-					510			+		31						str. S9 in distilled water	Biochem Biophys. Res. Com 1977. 78(2), 669-675
203.		all-E-	380	350, 367, 375	419			485	473					3250 2720				str. R1, in 10mM HEPES buffer, pH 7.0	Photochem.Photobiol., 1984, 39(5), 661-665
204.		all-E-	368	351	410			476	465					3380 2880				str. R1, in 10mM HEPES buffer, pH 7.0	Photochem.Photobiol., 1984, 39(5), 661-665
205.		all-E-	356	333, 349, 367	398			445	457					2650 3240				str. R1, in 10mM HEPES buffer, pH 7.0	Photochem.Photobiol., 1984,

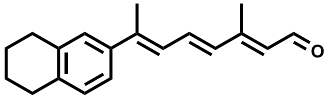
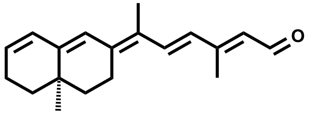
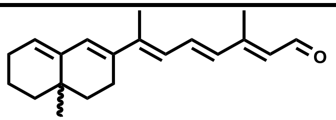
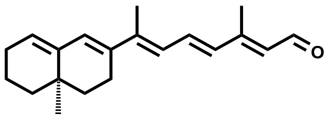
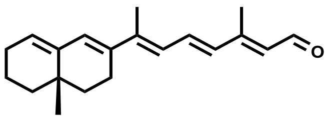
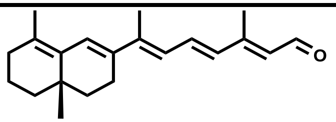
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			39(5), 661-665
206.		all-E-	403[a]	380	470			535	535					2950 2950			507+ /575-	str. R1, in 10mM HEPES buffer, pH 7.0	Photochem.Photobiol., 1984, 39(5), 661-665
207.		all-E-		376	454		510							2300					Photochem.Photobiol. 1993, 58(5), 701-705.
208.		all-E-	425		503		574							2500				in 10 mM HEPES buffer. τ_{rec} 30 min	Photochem.Photobiol. 1992, 56(6), 921-927.
209.		all-E-	425		502		594/ 505					173		3100				in 10 mM HEPES buffer. τ_{rec} 30 min. Two bands or two species of BRA formed in depend of Ret/BO ratio.	Photochem.Photobiol. 1992, 56(6), 921-927.
210.		all-E-	425		504		584					63		2700				in 10 mM HEPES buffer. τ_{rec} 2 h	Photochem.Photobiol. 1992, 56(6), 921-927.
211.		all-E- 2Z-	362[c]				 +	482	485	+	370	+			stable during 4h	replaced in several hours		30 mM sodium phosphate buffer, pH 7.2.	Photochem.Photobiol. 1986, 43(3), 297 -303 18

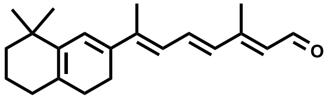
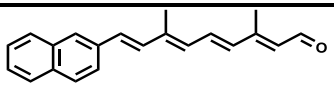
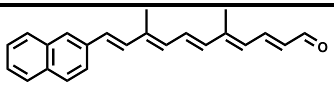
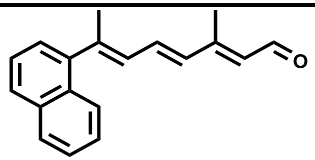
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
212.		all-E-		353	425		504							3700					Photochem.Photobiol. 1993, 58(5), 701-705.
		all-E-	368[a] ε 47000		425[e]		504 ε 43000							3700		relatively stable		in 200 mM potassium phosphate buffer, pH 5.0, in the presence of NaCl. τ_{rec} BRA rate was about 3 times faster than BR.	JChemSoc_ChemCommun 1982 (1) 44-46
																		str. R1M1, in 10 mM sodium phosphate buffer (pH 6.8) or 10 mM HEPES buffer (pH 6.8)	Biochem 1984 34(5) 838-843
		all-E-	370[a]			400	442	442	480	+	390 -65°C	++	88\12 37\63		$\tau_{1/2dest}$ 40 min	replaced	440+	ratio RCHO:BO from 1 / 12 – 1 / 1	Biochem 1988 27(7) 2416-2419
							503	503	503	+	390 -65°C	++	87\13 83\17		$\tau_{1/2dest}$ 200 min	replaced	460+ 530-	ratio RCHO:BO < 1 / 10 BRA442 converted in BRA503 during several days.	
213.		all-E-	395 381[c]	369	467		552	546	552 ε 54000	+		51		3300 3100 3300		Not displaced in 24h		str. R1S9, 4°C. τ_{rec} 15 min - BRA rather than BR rate. BRA does show light-dark adaptation. Full analysis of the ^{1}H-NMR spectrum.	Recl. 1993, 112(4), 237-246 Recl. 1994 113(2), 99 - 108
214.		all-E-	416 402[c]	391	490			582 / 504		+		20		3230 570	destroyed	Not displaced in 24h		str. R1S9, 4°C. τ_{rec} BRA rather than BR rate. BRA582 band converted in BRA504 in 2 h.	Recl. 1993, 112(4), 237-246

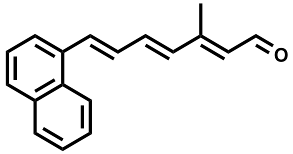
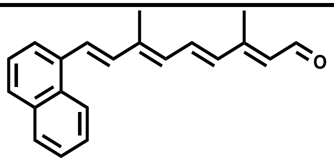
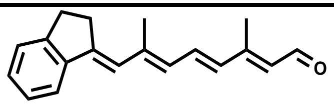
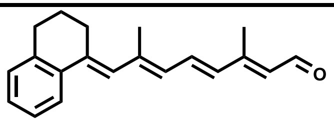
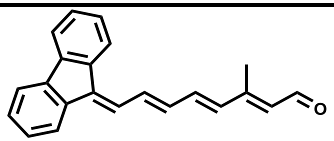
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
215.		all-E-	372 358[c]	355	428			501	501 ε 47000	+		23		3410 3410		Not displaced in 24h		str. R1S9, 4^0C. τ_{rec} 30 min. L-D adaptation absent.	Recl. 1993, 112(4), 237-246
216.		all-E-	410[a]		480[a]			513	518	+	405			1390 1580				100 mM Hepes buffer pH 7.0. $\tau_{1/2Kdec}$ 100 μs	Photochem Photobiol 1983 38(2) 197-203
217.		all-E- rac	397[a] ε 47000 395	373	467	438	552 ε 57000	547	552			52		3300 3130 3300				str. R1S9, 4^0C. τ_{rec} 20 min - BRA rather than BR rate. 1R BRA formed 2.1 times more rapidly than1S BRA rate.	Recl. 1992. 111(1), 29 - 40.
		all-E- (1R)				441	552 ε 56000	547	552			48		3300 3130 3300				str. R1S9, 4^0C. τ_{rec} 10 min. CD(1R-CHO) 273(+)/383(+)	
		all-E- (1S)				436	552 ε 62000	547	552			44		3300 3130 3300				str. R1S9, 4^0C. τ_{rec} 21 min. CD(1R-CHO) 273(-)/383(-) full analysis of the [1]H-NMR spectrum	Recl. 1994 113(2), 99 - 108
218.		all-E-	400		465	430-460	564			+		90		3780				τ_{rec} 68 min, 2^0C. BRA does show light-dark adaptation.	JACS 1986. 108(20) 6410 – 6411
		all-E-	400	376	465	435		564	570 ε 60000	+		90		3780 3950					Recl. 1989. 108(3), 83 - 92

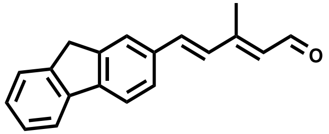
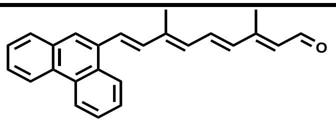
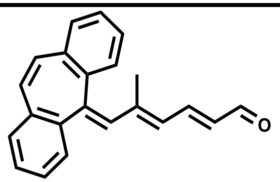
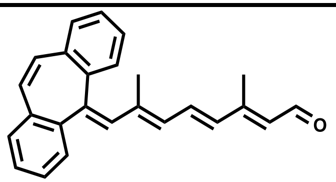
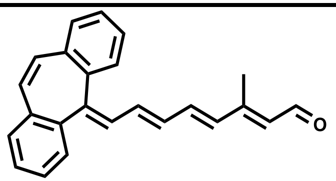
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
219.		all-E-	415		485		509, 596			+		20		970 3840				τ_{rec} 16 h, L-D adaptation absent	JACS 1986. 108(20) 6410 – 6411
		all-E-	415	388	485	435	509, 596							970 3840					Recl. 1989. 108(3), 83 - 92
220.		all-E-	395	267, 381	277, 321, 463		493		501	+				1320 1640				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 10-12 h	29
		2Z-	390				498		495										29
		all-E-	395[c]					492	497	+	395	++			reasonably stable	reasonably stable		30 mmol sodium phosphate buffer, pH 7.2. "O"-580-590nm Slow BRA cycle in 5 times than BR cycle.	Photochem.Photobiol. 1986. 43(3), 297 -303
		6Z-					460	492	497				6Z- 60/40 all-E		in dark de-composed within 30 min	in dark decomposed within 30 min			18
		2Z-					+						no 6Z-						
221.		all-E-	405[c]					460-480	460-480	+	405	+			unstable decomposed within 1h	unstable decomposed within 1h		30 mM sodium phosphate buffer, pH 7.2.	Photochem.Photobiol. 1986. 43(3), 297 -303 18
222.		all-E-		333	390		NO												Photochem.Photobiol. 1993. 58(5), 701-705.

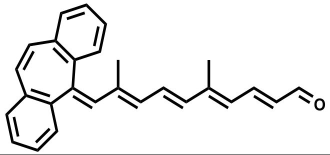
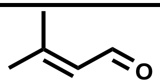
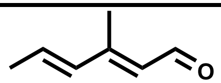
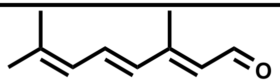
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
223.		all-E-		369	425		472							2300					Photochem.Photobiol. 1993, 58(5), 701-705
224.		all-E-	398	382	460			490						1330				str. S 9	Tetrahedron Lett. 1999, 40(13), 2645-2648
		all-E-																electronic and structural properties of retinal analog were studied using semiempirical, ab initio Hartree-Fock, and DFT methods	J. Chem. Phys., 2006, V. 125, 144901
225.		all-E-		382	472		540							2700					Photochem.Photobiol. 1993, 58(5), 701-705.
226.		all-E-		374	456		502							2000					Photochem.Photobiol. 1993, 58(5), 701-705
227.		all-E-		411	470		472							0					Photochem.Photobiol. 1993, 58(5), 701-705.

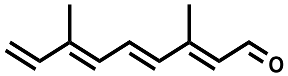
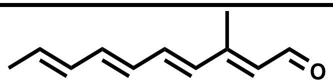
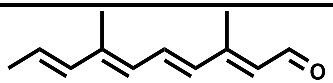
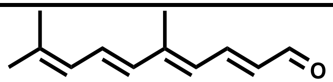
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
228.		all-E-	365	353	420		432											str. S 9 low yield	Tetrahedron Lett. 1999, 40(13), 2645-2648
229.		all-E-	399	385	461		499							1650				str. S 9 electronic and structural properties of retinal analog were studied using semiempirical, ab initio Hartree-Fock, and DFT methods	Tetrahedron Lett. 1999, 40(13), 2645-2648 J. Chem. Phys., 2006, V. 125, 144901
230.		all-E-		342	407		NO												Photochem.Photobiol. 1993. 58(5), 701-705
231.		all-E-		371	450		482							1500					Photochem.Photobiol. 1993. 58(5), 701-705
232.		all-E-		370	446		480							1600					Photochem.Photobiol. 1993. 58(5), 701-705

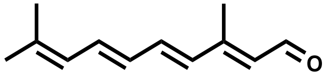
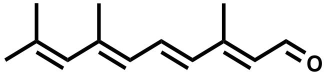
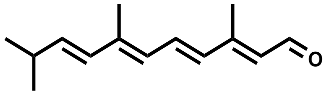
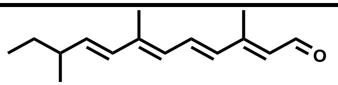
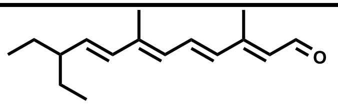
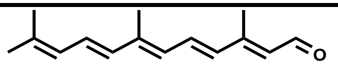
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
233.		all-E-		392	477		NO												Photochem.Photobiol. 1993, 58(5), 701-705
I. Alteration of the trimethylcyclohexenic ring. Acyclic analogs																			
234.		E-	277[c]				NO											In 50 mM sodium phosphate buffer pH 7.2. 24 h	Biochem 1986, 25(8), 2022-2027.
			257[a]				NO												18
235.		all-E-	268[c]				NO											In 50 mM sodium phosphate buffer pH 7.2. 24 h	Biochem 1986, 25(8), 2022-2027. 18
236.		all-E-			382		446		446				40/60 69/31	3750 3750				pH 7.0, 50 mM Hepes	PhotochemPhotobiol 1991 54(6) 969-976
		all-E-	335		385		430 ε 6000		430			NO		2700		displaced after 24 h		str. R1S9 BRA formation rates of the in H_2O compared to BR. Irreversible decomposition on 50% after 10 min illumination.	EurJBiochem 1984 140(1) 173-176
		all-E-	312[c]				422		425	NO		NO			moderately stable destroyed after1 h, in the dark	displaced after 1 h		In 50 mM sodium phosphate buffer pH 7.2. 24 h. no flash-induced absorption changes. $\tau_{1/2rec}$ 20 min	Biochem 1986, 25(8), 2022-2027.
		2Z-	310[c]				420		425			NO							18

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
237.		all-E-	351		405		452 ε 12000		452			NO		2600 2600		displaced after 24 h		str. R1S9 BRA formation rates of the in H_2O compared to BR. Irreversible decomposition on 50% after 10 min illumination	EurJBiochem 1984 140(1) 173-176
238.		all-E-					460	460	500				75/25 60/40					pH 7.0, 50 mM Hepes The formation stable long-lived BRA 500 nm under illumination. k_{decay} 44.9 x 10^{-4} s^{-1} at 303 K.	PhotochemPhotobiol 1991 54(6) 969-976
239.		all-E-			418		470	470	470				72/28 80/20	2650 2650				pH 7.0, 50 mM Hepes	PhotochemPhotobiol 1991 54(6) 969-976
		all-E-	364		422		472 ε 11000		472			NO		2600 2600				str. R1S9 BRA formation rates of the in H_2O compared to BR. Irreversible decomposition on 30% after 10 min illumination	EurJBiochem 1984 140(1) 173-176
		all-E- 2Z-	347[c] 346[c]				462 460		466 466	+	365	+			reasonably stable destroyed after 1.5 h, in the dark	displaced after 1.5 h		In 50 mM sodium phosphate buffer pH 7.2. $\tau_{1/2rec}$ 10 min	Biochem 1986, 25(8), 2022-2027. 18
240.		all-E- 2Z- 4Z-	370[f] 370[f] 370[f]				NO NO NO												PhotochemPhotobiol 1985 41(2) 171-174

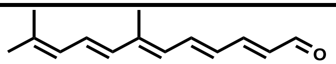
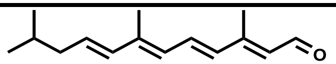
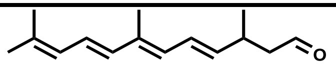
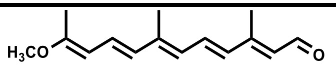
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
241.		all-E-					460		500				46/54 52/48					pH 7.0, 50 mM Hepes The formation stable long-lived BRA 500 nm under illumination. k_{decay} 15.9 x 10^{-4} s^{-1} at 303 K.	Photochem Photobiol 1991 54(6) 969-976
242.		all-E-			401		490		490				37/63 63/37	4550 4550				pH 7.0, 50 mM Hepes	Photochem Photobiol 1991 54(6) 969-976
243.		all-E- 2Z-	364[a] 358[a]				487 ε 28000 477		487 477	+	365	++			stable destroyed after 5h, in the dark	displaced after 24 h		$\tau_{1/2rec}$ 285-305 s Raman spectra data	JACS 1984 106(26) 8325-8327 18
244.		all-E- 2Z-	364[a] 361[a]				487 ε 28000 477		487 477	+	363	++			stable destroyed after 5h, in the dark	displaced after 72 h		$\tau_{1/2rec}$ 160-180 s Raman spectra data	JACS 1984 106(26) 8325-8327 18
245.		all-E- 2Z-	373[a] 368[a]				487 ε 28000 476		487 476	+	372	++			stable destroyed after 5h, in the dark	displaced after 72 h		$\tau_{1/2rec}$ 160-180 s Raman spectra data	JACS 1984 106(26) 8325-8327 18
246.		all-E-	400	373	468 pKa 7.4		527 pKa 12.1			+				2400					17 Retinal Proteins 1987. 205–216
		all-E-	393		465	420/460	538	528 ε 34000	538	+		30		2600 2900		stable		str. R1S9 τ_{rec} 16 min. BRA formation rates of the in H_2O compared to BR.	EurJBiochem 1984 140(1) 173-176

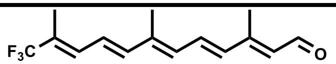
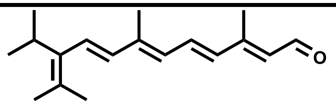
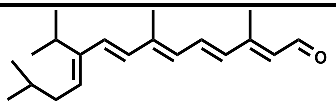
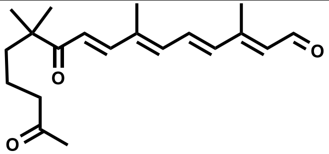
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
		all-E-	400[a]				513	519				++							18
		all-E-	400[f] ε 52400				524		528						stable destroyed after 3h, in the dark	displaced after 4.5h		$\tau_{1/2rec}$ 156 s	Photochem Photobiol 1985 41(2) 171-174
		2Z-	400[f] ε 41600				522		528						stable destroyed after 3h, in the dark	displaced after 4.5h		$\tau_{1/2rec}$ 168 s	
		6Z-	400[f] ε 40700				487		528						unstable destroyed after 35 min , in the dark	displaced after 30 min		$\tau_{1/2rec}$ 750 s	
		all-E-			468			530	532				59/41 25/75	2500 2550				pH 7.0, 50 mM Hepes	Photochem Photobiol 1991 54(6) 969-976
		all-E-					527 558 533											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
		all-E-	400	373	468		527			+				2400				10 mM Hepes buffer, pH 6.5 at 25°C for 1 hr. pKa (SBH^+) = 7.4, pKa (SB BRA) = 12.1	PNAS 1986, 83(10), 3262-3266.
		all-E-					532											Molecular Dynamics Study BRA	Biochem 1994 33(12) 3668-3678
		all-E-					535												BiophysJ 1995

Properties of artificial bacteriorhodopsin analogs

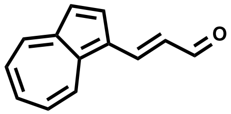
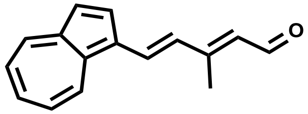
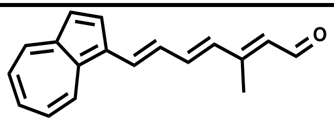
No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
		all-E-	380[a]				530											Molecular Dynamics Study BRA Protein-*b*-Ionone Ring Interactions. Second harmonic generation (SHG) to probe the light-induced dipolar changes.	68(4) 1270-1282 JPhysChem B 2003 107(25) 6221-6225
247.		all-E- all-E-	 390[a]	373	468		527	 520	 522			+ +		2400					15 18
248.		all-E-	364		423		483 ε 29000		483		390	very low		2900 2900				str. R1S9 slow decomposition under irradiation	EurJBiochem 1984 140(1) 173-176
249.		all-E-	307[a] 2 sh				321							1420				in 20 mM Tris/HCl and 4 M NaCl at pH 7.0. τ_{rec} 40 min Mutagenesis studies and two photon spectroscopy studies argue against a discrete charge in the binding site but not against the local electrostatic fields, which would fulfill the conditions of the original point charge model. 11-fold inhibition of the native retinal Incorporation in BRA.	JBiolChem. 1995, 270(50), 29668-29670
250.		all-E-					572 615											in water. pH 7.0 pH 2.5	BiophysJ 1989 56(6)

Properties of artificial bacteriorhodopsin analogs

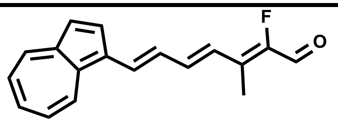
No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
							590											pH 0.5	1259-1265
251.		all-E-	377	363	428 pK_a 7.1		480 pK_a 11.9			+				2500					17 Retinal Proteins 1987 205–216
		all-E-	377	423	468		480			+				2500				10 mM Hepes buffer, pH 6.5 at 25°C for 1 h. pKa (SBH^+) = 7.1, pKa (SB BRA) = 11.9	PNAS 1986, 83(10), 3262-3266.
252.		all-E-					565											str. ET1001. In 4 *M* NaCl, 25 mM Tris-HCl buffer, pH 7.2, $\tau_{1/2rec}$ <1 min	Photochem Photobiol 1994 60(4) 388-393
253.		all-E- 13Z- 5Z- 5Z,13Z-						479 479 480 480											Bioorgan Chem 1989 17(2) 217-223
254.		all-E-	269 364 ε 49900	270 364 381	399 409		450 450 440 445sh			NO						displaced in 2 h		100mM NaCl, 5 mM MES, pH 6.0, τ_{rec} 10 min. ET1001 D96N JW5, No photo-responses on light flash, no cyclic photoreactions BRA.	29 Rus. J. Bioorg Chem., 2002, 28(6), 487–493 Mironova E.V. Ph.D. thesis, 2002

J. Miscellaneous modifications

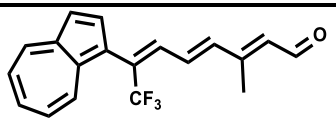
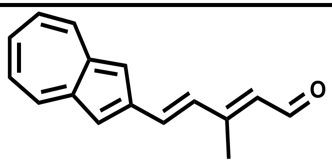
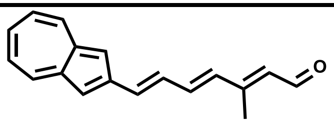
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
255.		E-		418	494													Experimental and calculated data of UV-Vis spectra	Organic Lett. 2000 2(3), 269–271
256.		all-E-	435[a]		575		620							3300	$\tau_{1/2dest}$ 40 min			$\tau_{1/2rec}$ 17h	JPhotochemPhotobiol C: 2003 4(3) 179–194
		all-E-					621							3300				$\tau_{1/2rec}$ 17h	Tetrahedron Lett. 1998, 39(1/2), 5-8
		all-E-		414	515													Experimental and calculated data of UV-Vis spectra	Organic Lett. 2000 2(3), 269–271
		all-E-	435[a]		575		620							3300	$\tau_{1/2dest}$ 40 min			$\tau_{1/2rec}$ 17h	PhotochemPhotobiol 2001 74(6) 837–845
257.		all-E-		430	541		644							3000					Photochem.Photobiol. 1993, 58(5), 701-705.
		all-E-	446[c]	430[a]	541[a]		644							2960					JACS 1990, 112(20), 7398 – 7399
		13Z-	444[c]	426[a]	542[a]		631							2600					
		all-E-	446[a]	430	542[a]		644							2960					

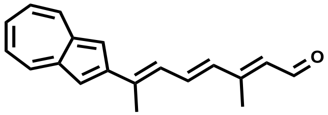
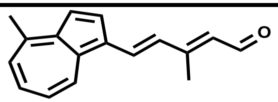
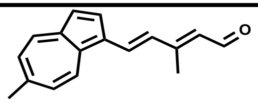
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH₂OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
		all-E-	455[a]		542		645							3000	$\tau_{1/2dest}$ 1 min			$\tau_{1/2rec}$ 4h	Photochem.Photobiol. 1991. 54(4), 625-631
																			JPhotochemPhotobiol C: 2003 4(3) 179–194
							644											Transient absorption studies of the BRA shown that no transient absorption changes were detected.	J.Phys.Chem. A 1998 102(28), 5481–5483.
		all-E-		430	541													Experimental and calculated data of UV-Vis spectra	Organic Lett. 2000 2(3), 269–271
		all-E-	455[a]		542		645							3000	$\tau_{1/2dest}$ 1 min			$\tau_{1/2rec}$ 4h	PhotochemPhotobiol 2001 74(6) 837–845
258.		all-E-		436	572		730							3800					Photochem.Photobiol. 1993. 58(5), 701-705.
		all-E-	463[a]		572[a]		694 / 748							2400 4100				$\tau_{1/2rec}$ 40 min	JPhotochemPhotobiol C: 2003

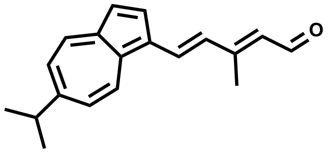
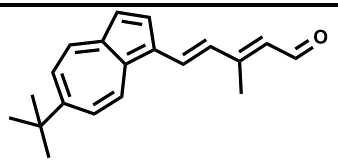
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
		all-E-	463[a]		572		694 / 748							2400 4100				$\tau_{1/2rec}$ 40 min	4(3) 179–194 Photochem Photobiol 2001 74(6) 837–845
259.		all-E-		401	489		520							1200					Photochem.Photobiol. 1993. 58(5), 701-705.
		all-E-	416[c]	401[a]	489[a]		520							1220					JACS 1990. 112(20), 7398 – 7399
260.		all-E-		401	443													Experimental and calculated data of UV-Vis spectra	Organic Lett. 2000 2(3), 269–271
261.		all-E-		425	405		475							1200					Photochem.Photobiol. 1993. 58(5), 701-705.
		all-E-					475							1170					JACS 1990. 112(20), 7398 – 7399

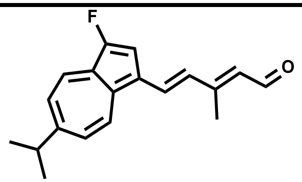
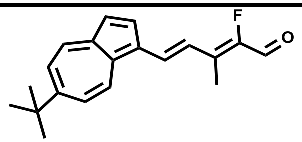
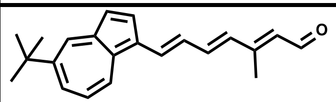
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
262.		all-E-			450													Experimental and calculated data of UV-Vis spectra	Organic Lett. 2000 2(3), 269–271
263.		all-E-	438[a]		522[a]		618/ 620							3000 3100	$\tau_{1/2dest}$ 4 min			$\tau_{1/2rec}$ 20h	JPhotochemPhotobiol C: 2003 4(3) 179–194
		all-E-					618							3000				$\tau_{1/2rec}$ 20h	Tetrahedron Lett. 1998, 39(1/2), 5-8
		all-E-	438[a]		522		620							3000	$\tau_{1/2dest}$ 4 min			$\tau_{1/2rec}$ 20h	PhotochemPhotobiol 2001 74(6) 837–845
264.		all-E-	440[a]		540[a]		629/ 674							2600 3700	$\tau_{1/2dest}$ 100 min			$\tau_{1/2rec}$ 50min	JPhotochemPhotobiol C: 2003 4(3) 179–194
		all-E-					674							3700				$\tau_{1/2rec}$ 53min	Tetrahedron Lett. 1998, 39(1/2), 5-8
		all-E-	440[a]		540		629/ 674							2600 3700	$\tau_{1/2dest}$ 100 min			$\tau_{1/2rec}$ 50min	PhotochemPhotobiol 2001 74(6) 837–845

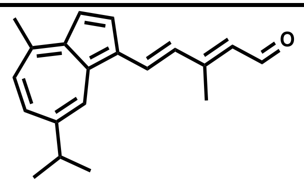
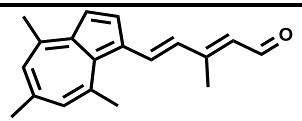
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
265.		all-E-	438[a]		535[a]		630/ 674							2800 3900	$\tau_{1/2dest}$ 9 h			$\tau_{1/2rec}$ 50min	JPhotochemPhotobiol C: 2003 4(3) 179–194
		all-E-					674							3860				$\tau_{1/2rec}$ 50min	Tetrahedron Lett. 1998, 39(1/2), 5-8
		all-E-	438[a]		535		630/ 674							2800 3900	$\tau_{1/2dest}$ 9 h			$\tau_{1/2rec}$ 50min	PhotochemPhotobiol 2001 74(6) 837–845
266.		all-E-	436[a]		532[a]		628/ 673							2900 3900	$\tau_{1/2dest}$10 h			$\tau_{1/2rec}$ 53min	JPhotochemPhotobiol C: 2003 4(3) 179–194
		all-E-					673							3900				$\tau_{1/2rec}$ 53min	Tetrahedron Lett. 1998, 39(1/2), 5-8
		all-E-					675											In water. τ_{rec} 2 h. Transient absorption studies of the BRA shown that no transient absorption changes were detected.	J.Phys.Chem. A 1998 102(28), 5481–5483.
		all-E-	436[a]		532		628/ 673							2900 3900	$\tau_{1/2dest}$10 h			$\tau_{1/2rec}$ 53min	PhotochemPhotobiol 2001

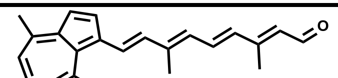
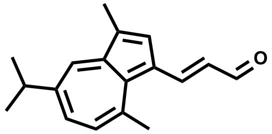
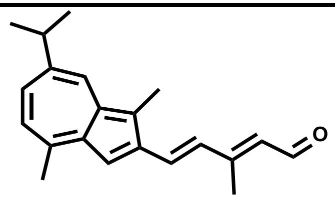
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			74(6) 837–845
267.		all-E-	443[a]		526[a]		630 / 672							3200 4130	$\tau_{1/2dest}$ 3 h			$\tau_{1/2rec}$ 48min	JPhotochemPhotobiol C: 2003 4(3) 179–194
		all-E-					672							4130				$\tau_{1/2rec}$ 48min	Tetrahedron Lett. 1998, 39(1/2), 5-8
		all-E-	443[a]		526		630 / 672							3200 4130	$\tau_{1/2dest}$ 3 h			$\tau_{1/2rec}$ 48min	PhotochemPhotobiol 2001 74(6) 837–845
268.		all-E-	450[a]		558[a]		632/ 686							3000 3340	$\tau_{1/2dest}$ 12 min			$\tau_{1/2rec}$ 47min	JPhotochemPhotobiol C: 2003 4(3) 179–194
		all-E-					686							3340				$\tau_{1/2rec}$ 47min	Tetrahedron Lett. 1998, 39(1/2), 5-8
		all-E-	450[a]		558		632/ 686							3000 3340	$\tau_{1/2dest}$ 12 min			$\tau_{1/2rec}$ 47min	PhotochemPhotobiol 2001 74(6) 837–845
269.		all-E-	653[a]		562[a]		664							2700				$\tau_{1/2rec}$ 72h	JPhotochemPhotobiol C: 2003

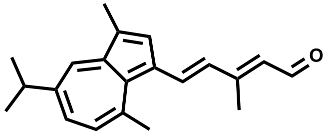
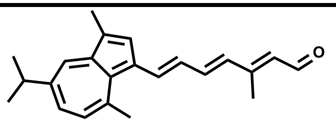
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
																			4(3) 179–194
		all-E-	453[a]		562		664							2700				$\tau_{1/2rec}$ 72h	Photochem Photobiol 2001 74(6) 837–845
270.		all-E-	450[a]		538[a]		595							1800	$\tau_{1/2dest}$ 6 min			$\tau_{1/2rec}$ 36h	JPhotochem Photobiol C: 2003 4(3) 179–194
		all-E-					596							1800				$\tau_{1/2rec}$ 36h	Tetrahedron Lett. 1998, 39(1/2), 5-8
		all-E-	450[a]		538		595							1800	$\tau_{1/2dest}$ 6 min			$\tau_{1/2rec}$ 36h	Photochem Photobiol 2001 74(6) 837–845
271.		all-E-	444[a]		533[a]		629							2900				$\tau_{1/2rec}$ 96h	JPhotochem Photobiol C: 2003 4(3) 179–194
		all-E-					608							2300				$\tau_{1/2rec}$ 4 days	Tetrahedron Lett. 1998, 39(1/2), 5-8
		all-E-	444[a]		533		629							2300				$\tau_{1/2rec}$ 4 days	Photochem Photobiol 2001

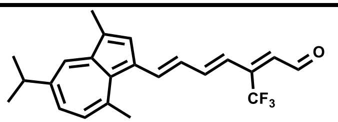
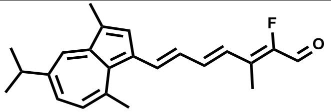
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			74(6) 837–845
272.		all-E-	246 290 355 467	245 285 355 445	241 302 328 579		308 605		306 457 602					740 660				τ_{rec} 70h	29
273.		E-	436[a]	418	494		519			NO				980				τ_{rec} 15days	Photochem.Photobiol. 1991. 54(4), 625-631
		E-					520			NO								The pigment was found to be stable at pH 7; however, no steady-state absorption changes were detected.	J.Phys.Chem. A 1998 102(28), 5481–5483.
		E-	436[a]				519 br			+	400	20						WT BO. 10^0C. τ_{rec} 20 days, pH 9.5. "M" like 400 nm forms???? Sample possible contaminated by BR due to RETоxime hydrolisys.	PhotochemPhotobiol 1996, 64(5), 867-869
274.		all-E-		401	443		475							1500					Photochem.Photobiol. 1993. 58(5), 701-705.
		all-E-	403[a]		443[a]		514							3100				$\tau_{1/2rec}$ 36h	JPhotochemPhotobiol C: 2003 4(3) 179–194
		all-E-	403[a]		443		514							3100				$\tau_{1/2rec}$ 36h	PhotochemPhotob

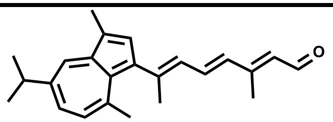
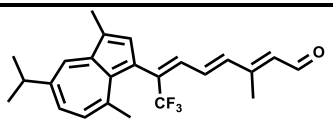
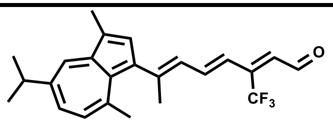
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			“CHO”	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																			iol 2001 74(6) 837–845
275.		all-E-		439	560		644							2330				τ_{rec} 23days	Photochem.Photobiol. 1993. 58(5), 701-705.
		mixture 69%-E- 31%-Z-	465[a]	439[a]	560 [a]		644							2330				$\tau_{1/2rec}$ 13 days	Photochem.Photobiol. 1991. 54(4), 625-631
		all-E-	465[a]		560[a]		642							2300	$\tau_{1/2dest}$1 min			$\tau_{1/2rec}$ 13 days	JPhotochemPhotobiol C: 2003 4(3) 179–194
		all-E-					644							2300				$\tau_{1/2rec}$ 13 days	Tetrahedron Lett. 1998, 39(1/2), 5-8
		all-E-	465[a]		560		640							2300	$\tau_{1/2dest}$1 min			$\tau_{1/2rec}$ 13 days	PhotochemPhotobiol 2001 74(6) 837–845
276.		all-E-	484[a]	450	590		694, 750sh							2540				τ_{rec} 20days	Photochem.Photobiol. 1991. 54(4), 625-631
		all-E-	473[c]	450	590		694							2540					

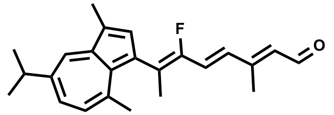
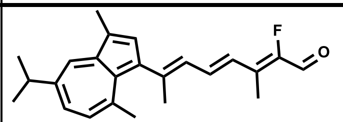
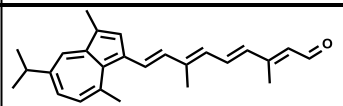
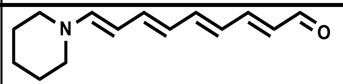
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH⁺	NC	Pigments (P)	DA	LA	Photocycle	M	H⁺-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH₂OH	all-E-RET	Remarks CD	others	Ref.
																			JACS 1990. 112(20), 7398 – 7399
		all-E-	482[a]		590[a]		660/ 764							1700 3800	$\tau_{1/2dest}$1 min			$\tau_{1/2rec}$ 20min	JPhotochemPhotobiol C: 2003 4(3) 179–194
		all-E-	482		590		660/ 764							1700 3800	$\tau_{1/2dest}$1 min			$\tau_{1/2rec}$ 20min	PhotochemPhotobiol 2001 74(6) 837–845
277.		13Z-	506[c]	388[a]	545[a]		830							6300					JACS 1990. 112(20), 7398 – 7399
		13Z-	506[a]		556		640/ 830							2400 6000	$\tau_{1/2dest}$1 min			$\tau_{1/2rec}$ 10min	JPhotochemPhotobiol C: 2003 4(3) 179–194
			506[a]		506		640/ 830							2400 6000	$\tau_{1/2dest}$1 min			$\tau_{1/2rec}$ 10min	PhotochemPhotobiol 2001 74(6) 837–845
278.		all-E-	490[c]	460[a]	640[a]	~605	795							3050				τ_{rec}~ 18h	JACS 1990. 112(20), 7398 – 7399
		13Z-	465[c]	450[a]	638[a]		795							3100					
		all-E-	493[a]		640[a]		684/							1000	$\tau_{1/2dest}$1 min			$\tau_{1/2rec}$ 16 min	

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH₂OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
							799							3100					JPhotochemPhotobiol C: 2003 4(3) 179–194
		all-E-	493[a]		640		684/ 799							1000 3100	$\tau_{1/2dest}$ 1 min			$\tau_{1/2rec}$ 16 min	PhotochemPhotobiol 2001 74(6) 837–845
279.		all-E-		450	590		694							2500					Photochem.Photobiol. 1993. 58(5), 701-705.
280.		all-E-		421	532		601							2200					Photochem.Photobiol. 1993. 58(5), 701-705.
		all-E-	444[c]	421[a]	532[a]		601							2160					JACS 1990. 112(20), 7398 – 7399
		13Z-	442[c]	418[a]	510[a]		596							2830					
281.		all-E-		450	556		830							5900					Photochem.Photobiol. 1993. 58(5), 701-705.

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
282.		all-E-		455	590		753							3700					Photochem.Photobiol. 1993. 58(5), 701-705.
283.		all-E-		460	640		795							3100					Photochem.Photobiol. 1993. 58(5), 701-705.
284.		all-E-		465	614		750							3000					Photochem.Photobiol. 1993. 58(5), 701-705.
		all-E-	496[a]	465	614		750							2950				τ_{rec} 23 days	Photochem.Photobiol. 1991. 54(4), 625-631
		all-E-	477[a]		614[a]		624/ 774							260 3000				τ_{rec} 10 min	JPhotochemPhotobiol_C: 2003 4(3) 179–194
285.		all-E	477 ε 61000		606			662				NO		1400	decomposed in 5 h	stable	640+ /680-	str. R1. In 10 mM HEPES pH 7.0, 20^{0}C BRA formed were stable in the dark, only ca. 20% reduction in the 662-nm maxima being observed at 6 days at 22 "C. Light >530 nm irradiation 80%	JACS 1983 105(3) 646-648 19

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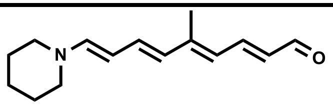
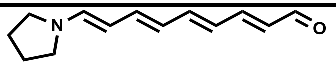
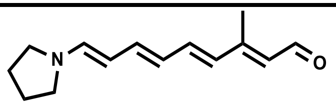
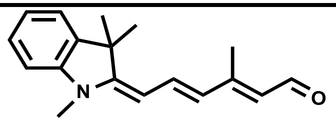
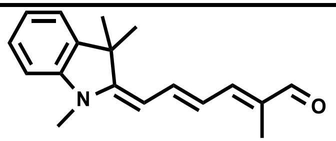
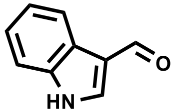
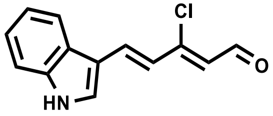
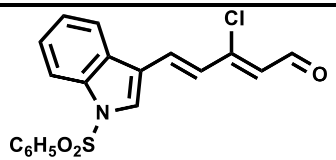
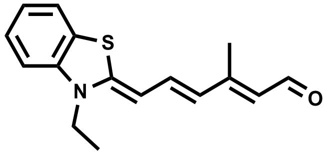
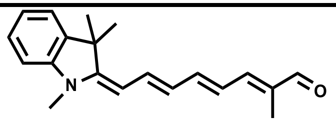
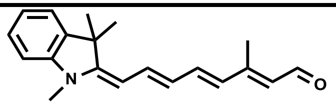
No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																		bleached in 4 h at 20^0C. Spin-labeled Pigments (BRA mutants A103C, M163C, or E74C). Reduction reaction with NH_2OH is light-catalyzed in the A103C-labeled pigment, but not in E74C or M163C. ESR data. BRA reduced by $NABH_4$	JBiolChem 2000 275(28) 21010-21016
		all-E					646										640+ /680-	in 20 mM sodium phosphate buffer, pH 7.0. CD spectra.	Chirality 2006 18(2) 72-83
286.		all-E	475 ε 74000		623			662 ε 13000				NO		950	decomposed in 2 h, 20^oC	stable	635+ /670-	str. R1 In 10 mM HEPES pH 7.0, 20^0C $\tau_{1/2rec}$~40min BRA formed were stable in the dark, only ca. 20% reduction in the 662-nm maxima being observed at 6 days at 22^0C. Light >530 nm irradiation 90% bleached in 40 min at 20^0C.	JACS 1983 105(3) 646-648 15 19
287.		all-E-				480	530											pH 6.5, 20 mM HEPES buffer. 25^0C τ_{rec}~48h	Angew Chem IE 1986 98(3) 284-286
		all-E-					529 529 529											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6)

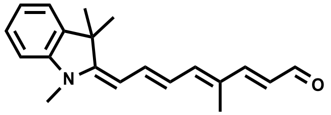
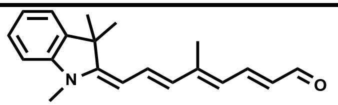
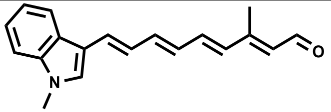
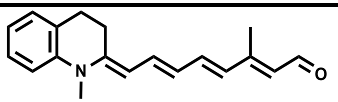
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																		Pulsed photolysis BRA red-shifted intermediate "I".	1259-1265 JACS. 1989 111(9), 3203-3211
288.		all-E- all-E-					640 640 640 640											pH 6.5, 20 mM HEPES buffer. 25^{0}C τ_{rec}~1h in water. pH 7.0 pH 2.5 pH 0.5	Angew Chem IE 1986 98(3) 284-286 BiophysJ 1989 56(6) 1259-1265
289.		all-E-					665 662 661											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
290.		all-E-	463[a]	420[a]	578[a]		610							910					Angew. Chem. IE 1997, 36(15), 1630 - 1633
291.		all-E-	456[a]	422[a]	567[a]		NO												Angew. Chem. IE 1997, 36(15), 1630 - 1633
292.			296	292	330		NO												Lettersin OrgChem 2007 4(4) 300-305

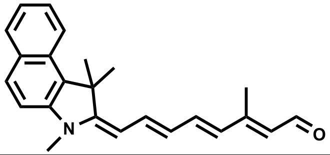
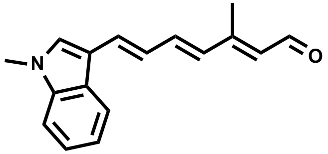
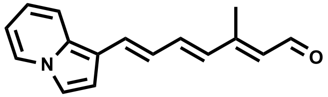
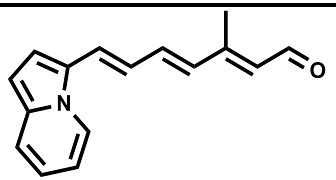
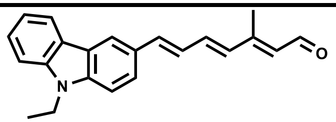
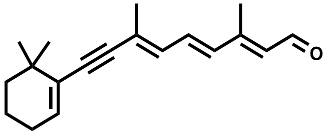
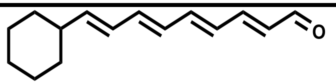
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
293.		all-E-	406[a]		502		522							760					PhotochemPhotobiol 2007 83(1) 50-62 Lettersin OrgChem 2007 4(4) 300-305
294.		all-E-	358	344	422		NO												Lettersin OrgChem 2007 4(4) 300-305
295.		all-E-	511		701		736							680					VII Internat Conference on Retinal Proteins. 1996. 66.
296.		all-E-	482[a]	482[a]	657[a]		700							940			680+ /730-	BRA shown photochemical properties remarkably different from that of BR. No changes in the parent state absorption could be detected time range of about 100 ns to 10 ms	Angew. Chem. IE 1997. 36(15). 1630 - 1633
297.		all-E-	487[a]	448[a]	666[a]		755							1770		stable	740+ /770-	τ_{rec}~12h BRA shown photochemical properties remarkably different from that of BR. No changes in the parent state absorption could be detected time range of about 100 ns to 10 ms.	Angew. Chem. IE 1997. 36(15). 1630 - 1633

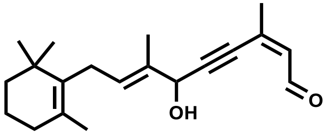
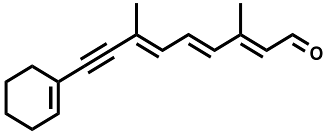
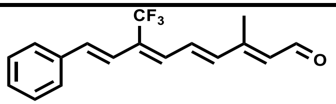
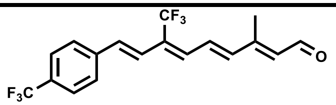
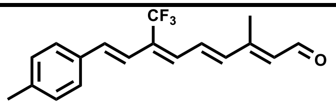
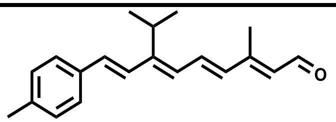
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH₂OH	all-E-RET	Remarks CD	others	Ref.
298.		all-E-	490[a]	452[a]	657[a]		698							890				BRA shown photochemical properties remarkably different from that of BR. No changes in the parent state absorption could be detected time range of about 100 ns to 10 ms.	Angew. Chem. IE 1997. 36(15). 1630 - 1633
299.		all-E-	491[a]	453[a]	665[a]		711							970				BRA shown photochemical properties remarkably different from that of BR. No changes in the parent state absorption could be detected time range of about 100 ns to 10 ms. Formation of the blue-shifted species BRA 648 nm under ilumination10 min, but is followed by an even slower process after several days in the dark the initial BRA at 698 nm is partially restored.	Angew. Chem. IE 1997. 36(15). 1630 - 1633
300.		all-E-	441		533		NO												VII Internat Conference on Retinal Proteins. 1996. 66
301.		all-E-	540		730		766							640					VII Internat Conference on Retinal Proteins. 1996. 66

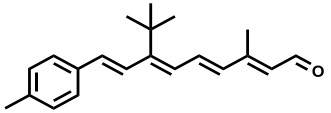
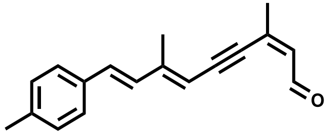
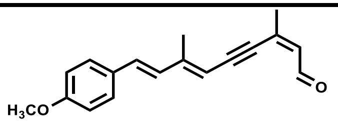
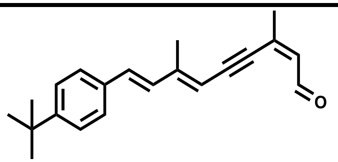
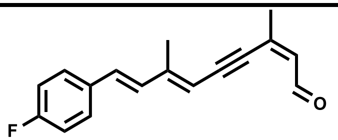
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
302.		all-E-	502[a]				NO											Computation of Vertical Excitation Energies of Retinal Analogs	J.Comput.Chem., 2006 27(1) 116-123
303.		all-E-	420 ε 17270	390	510			558/ 582						1690 2430	decomposed in 2 days, 20ºC	stable several days		str. S9 in 50 mM phosphate buffer, pH 6.5. $\tau_{1/2rec}$ 22.3 min. At acidic pH values, BRA shows a main band at 616 nm, with a minor species absorbing around 592 nm	ChemBioChem 2005 6(11) 2078-2087
304.		all-E-	460 ε 5330	428	574			545/ 693						-930 2990	decomposed in 1 h, 20ºC	stable 48 h		str. S9 in 50 mM phosphate buffer, pH 6.5. $\tau_{1/2rec}$ 61.2min	ChemBioChem 2005 6(11) 2078-2087
305.		all-E-	472 ε 8160	424	610			552/ 571/ 725						-1720 -1120 2600	decomposed in 1 h, 20ºC	stable 48 h		str. S9 in 50 mM phosphate buffer, pH 6.5. $\tau_{1/2rec}$ 32.6 min	ChemBioChem 2005 6(11) 2078-2087
306.		all-E-	406[a]					NO										Computation of Vertical Excitation Energies of Retinal Analogs	J.Comput.Chem., 2006 27(1) 116-123
307.		all-E- 13Z-					518 500			+ +	390	24	70-90%-E					H+-pump in JW5 cells τ_{rec} 15min "O" - 590 nm τ_{Odec} 200ms $\tau_{1/2Mdec}$ 6ms	JACS 1984, 106(19), 5654-5659
308.		all-E-	340[a]			370	460	460	450	+	350	++			1h,dark	replaced		in distilled water at 25⁰C pH 6.8. τ_{rec} 3 h, Light-induced absorption changes relatively small,	Biochem 1981, 20(2), 428-435

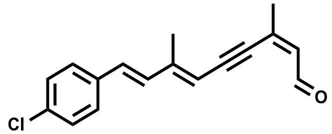
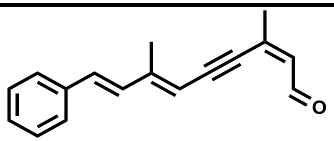
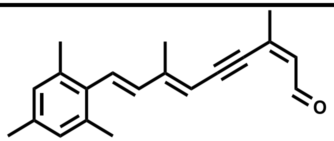
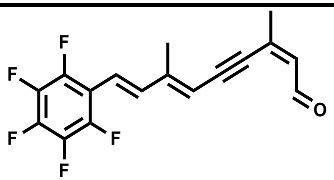
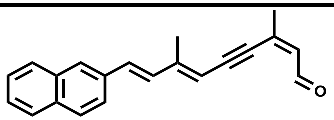
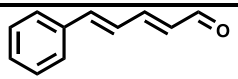
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																		although they are consistent with a BR cycle. There is no apparent L→D-adaption. 'M" produces an absorption near 350 nm that reverts in the dark to the BRA.	18
309.		13Z-				+	NO											str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C	29
310.		all-E- 13Z-					504 486			+ +		7.5	70-90%-E					H+-pump in JW5 cells inactive in photophosphorylation	JACS 1984, 106(19), 5654-5659
311.		all-E-					450											Second harmonic generation signal BRA	JACS 2002, 124(40), 11844-11845
312.		all-E-					430											Second harmonic generation signal BRA	JACS 2002, 124(40), 11844-11845
313.		all-E-					462											Second harmonic generation signal BRA	JACS 2002, 124(40), 11844-11845
314.		all-E-					480											Second harmonic generation signal BRA	JACS 2002, 124(40), 11844-11845

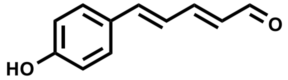
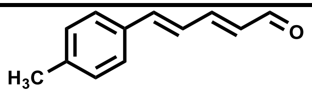
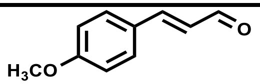
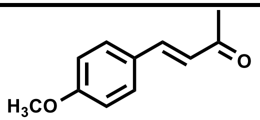
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	Pigments DA	Pigments LA		M				NH_2OH	all-E-RET	CD	others	
315.		all-E-					430											Second harmonic generation signal BRA	JACS 2002, 124(40), 11844-11845
316.		13Z-	368 ε 37700	358	432		485		450					2530 930				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 13 h	27 Bioorgan.Khim. 1987, 13(2), 238-251
317.		13Z-	379 ε 38300	366	444		493		462					2240 780				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 13 h	27 Bioorgan.Khim. 1987, 13(2), 238-251
318.		13Z-	368 ε 34800	357	431		473		466					2060 1270				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 13 h	27 Bioorgan.Khim. 1987, 13(2), 238-251
319.		13Z-	359 ε 25400	354	428		474		451	+				2270 1190				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 10 h light adaptation slowed ≥ 80 times	27 Bioorgan.Khim. 1987, 13(2), 238-251

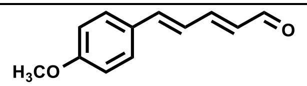
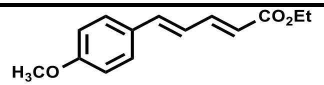
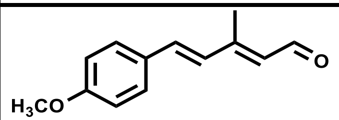
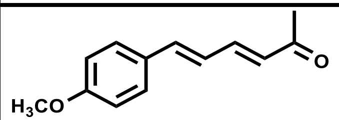
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M				NH_2OH	all-E-RET	CD	others	
							(P)	DA	LA										
320.		13Z-	358 ε 31700	353	426		475		442					2370 850				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 14 h	27 Bioorgan.Khim. 1987, 13(2), 238-251
321.		13Z-	357 ε 38000	352	423		471		448	+				2410 1320				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 14 h	27 Bioorgan.Khim. 1987, 13(2), 238-251
322.		13Z-	357 ε 28700	343	415		468		447					2730 1730				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 15 h	27 Bioorgan.Khim. 1987, 13(2), 238-251
323.		13Z-	347	339	411		442		423					1710 690				str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 11 h	27 Bioorgan.Khim. 1987, 13(2), 238-251
324.		13Z-	274, 368				481		475									str. 353P, in 50mM MES, 5mM EDTA, pH 6.5, 20^{0}C, τ_{rec} 24h	29
325.		all-E-	323[a]		378 [a,k]		406							1820				strain JW5 in water Donor−acceptor substituted retinal analogs with substituents varying in donor and acceptor strength have reconstituted with BO.	J. Phys. Chem. A, 2010, 114(5), 2179–2188

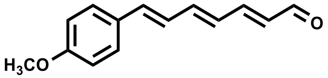
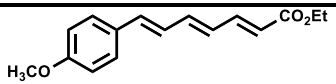
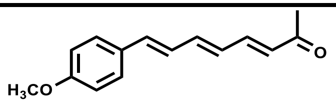
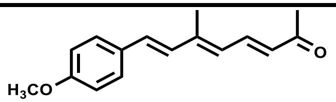
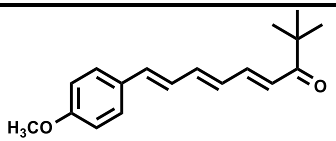
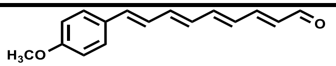
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																		Quantum-chemical calculations chromophore-protein complexes were investigated.	
326.		all-E-	357 [a]		433 [a,k]		480							1930				strain JW5 in water Donor−acceptor substituted retinal analogs with substituents varying in donor and acceptor strength have reconstituted with BO. Quantum-chemical calculations chromophore-protein complexes were investigated.	J. Phys. Chem. A, 2010, 114(5), 2179–2188
327.		all-E-	334 [a]		391 [a,k]		423							2260				strain JW5 in water Donor−acceptor substituted retinal analogs with substituents varying in donor and acceptor strength have reconstituted with BO. Quantum-chemical calculations chromophore-protein complexes were investigated.	J. Phys. Chem. A, 2010, 114(5), 2179–2188
328.		all-E-	319[a] ε 30800 324[d]	303[d], 312sh	366[d]	329	412			+		NO					340+ /429-	str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
329.		all-E-	320[a] ε 26300			325 ε 26000	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194

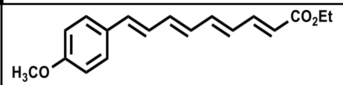
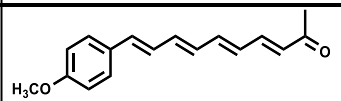
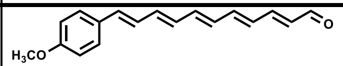
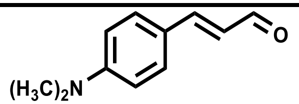
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
330.		all-E-	349[a] ε 40400			364	453			+							360+ /460-	str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
			356[d]	339[d]	403[d]														
			351[a]		420[a,k]		459							2020				strain JW5 in water Donor−acceptor substituted retinal analogs with substituents varying in donor and acceptor strength have reconstituted with BO. Quantum-chemical calculations chromophore-protein complexes were investigated.	J. Phys. Chem. A, 2010, 114(5), 2179–2188
331.		all-E-	333[a] ε 38300			342 ε 28700	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
332.		all-E-	355[a] ε 34200			370	460			+								str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
			359[d]	337[d]	406[d]														
333.		all-E-	348[a] ε 41700			360 ε 33500	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194

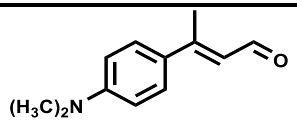
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
334.		all-E-	377[a] ε 49400 383[d]	358[d], 370sh	431[d]	393	489			+		NO			stable nearly several hours	stable nearly several hours	375+ /485-	str. R1 in 10mM MES, pH 6.0. L--D adaptation absent. BRA cycle with low efficiency.	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
335.		all-E-	382[a] ε 55900			370 ε 34000	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
336.		all-E-	375[a] ε 48300			+	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
337.		all-E-	378[a] ε 50400			398 ε 39300	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
338.		all-E-	378[a] ε 50000			+	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
339.		all-E-	398[a] ε 58700 408[d]	369sh 379[d], 396sh	462[d]	380, 408, 434	531			+		+?			stable nearly several hours	stable nearly several hours	510+	str. R1 in 10mM MES, pH 6.0 L--D adaptation absent. BRA cycle with low efficiency.	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194

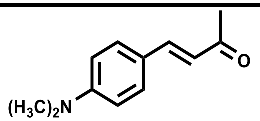
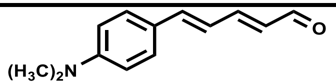
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
340.		all-E-	382[a] ε 55900			+	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
341.		all-E-	397[a] ε 47300			+	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
342.		all-E-	417[a] ε 68000 428[d]	380sh 400[d], 421	481[d]	385, 414, 433	567					NO			stable nearly several hours	stable nearly several hours	555+	str. R1 in 10mM MES, pH 6.0. L--D adaptation absent. BRA cycle with low efficiency.	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
343.		E-	389[a] ε 37500 390[d]	364[d]	464[d]	405	508			+		NO			stable nearly several hours	stable nearly several hours	395+ /524-	str. R1 in 10mM MES, pH 6.0. L--D adaptation absent. BRA cycle with low efficiency	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
		E-		352	460		510							2130					Retinal Proteins 1987, 205–216 17
		E-	390[a]	352	460		510			+				2130				20mM HEPES pH 7.0. BRA cycle has "K", but "O" and "L", "M" not observed.	Biochem 1985, 24(5), 1260 - 1265
		E-					518 540											in water. pH 7.0 pH 2.5	BiophysJ 1989 56(6)

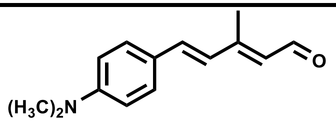
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
							540											pH 0.5	1259-1265
		E-			460[a] 460[a] 460[a]		508 492 494							2050 1400 1500				CB X=CHO NC X=NH^+CH_3 NC X=$NH^+(CH_2)_3CH_3$ The properties of noncovalently bound PSB pigments (NC) can be prepared in native BO that retains its Lys-216 residue in its binding site. Reconstitution was carried out at pH 7 using 5 mM phosphate buffer. Comparison of data of CB (polyenals) and NC (SB) pigments. pKa (PSB) 7.1 in ethanol/water, 1:1, solution containing 10 mM phosphate buffer. pKa (PSB) X=NH^+CH_3 CB pigment 12 pKa (PSB) X=NH^+CH_3 NC pigment 10.8	Biochem 2001 40(44) 13310-13319
344.		E-	390[a]	347[a]	464[a]		518			NO				2250				20mM HEPES pH 7.0.	Biochem 1985, 24(5), 1260 - 1265
		E-			460[a] 460[a] 460[a]		520 514 510							2500 2300 2130				CB X=CHO NC X=NH^+CH_3 NC X=$NH^+(CH_2)_3CH_3$ The properties of noncovalently bound PSB pigments (NC) can be prepared in native BO that retains its Lys-216 residue in its binding site.	Biochem 2001 40(44) 13310-13319

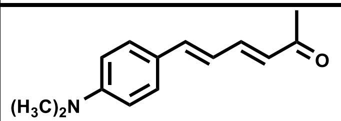
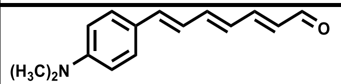
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
																		Reconstitution was carried out at pH 7 using 5 mM phosphate buffer. Comparison of data of CB (polyenals) and NC (SB) pigments. pKa (PSB) 6.6 in ethanol/water, 1:1, solution containing 10 mM phosphate buffer. pKa (PSB) $X=NH^+CH_3$ CB pigment 11.5 pKa (PSB) $X=NH^+CH_3$ NC pigment 10.6	
		E-	380[a]				520											Protein-β-Ionone Ring Interactions. Second harmonic generation (SHG) to probe the light-induced dipolar changes	JPhysChem_B 2003 107(25) 6221-6225
345.		E-	384[a] ε 33800			390 ε 29500	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
346.		all-E-	418[a]	384[a]	509[a]		582			+				2470				20mM HEPES pH 7.0. BRA cycle" has 2 "L", blue-shifted	Biochem 1985, 24(5), 1260 - 1265
		all-E-					582 630 634											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
		all-E-	416[a]		533[a,k]		580							1520				strain JW5 in water	J. Phys.

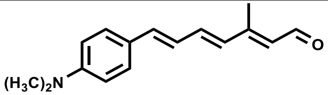
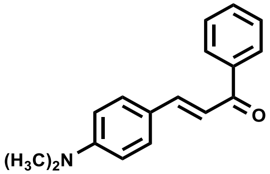
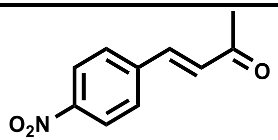
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																		Donor−acceptor substituted retinal analogs with substituents varying in donor and acceptor strength have reconstituted with BO. Quantum-chemical calculations chromophore-protein complexes were investigated.	Chem. A, 2010, 114(5), 2179–2188
347.		all-E-		384	511		576			+				2210					Retinal Proteins 1987 205–216 17
		all-E-	407[a]	384[a]	511[a]		576			+				2210				20mM HEPES pH 7.0. BRA cycle "K","O" and"L", but "M" not observed	Biochem 1985, 24(5), 1260 - 1265
		all-E-					576 620 631											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
		all-E-			511		580							2300				pKa (SBH^+) = 7.0, pKa (BRA SB) = 12.0. Titrations of BRA data	Biochem 1995, 34(37), 12059-12065
																		pKa (BRA Asp85) = 5.2. Titrations of BRA data	Biochem 1995 34(37) 12066-12074
		all-E-			510[a] 510[a]		578 618							2300 3430				CB X=CHO NC X=NH^+CH_3	Biochem 2001

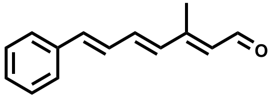
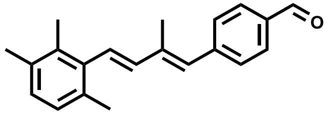
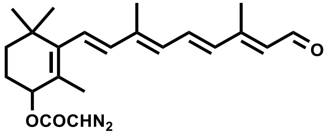
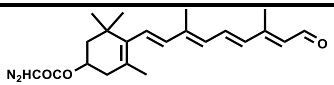
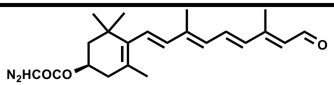
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
					510[a]		600							2950				NC X=$NH^+(CH_2)_3CH_3$ The properties of noncovalently bound PSB pigments (NC) can be prepared in native BO that retains its Lys-216 residue in its binding site. Reconstitution was carried out at pH 7 using 5 mM phosphate buffer. Comparison of data of CB (polyenals) and NC (SB) pigments. pKa (PSB) 6.2 in ethanol/water, 1:1, solution containing 10 mM phosphate buffer. pKa (PSB) X=NH^+CH_3 CB pigment 12 pKa (PSB) X=NH^+CH_3 NC pigment 10.9	40(44) 13310-13319
		all-E-	424[a]				570											Protein-*b*-Ionone Ring Interactions. Second harmonic generation (SHG) to probe the light-induced dipolar changes	JPhysChem_B 2003 107(25) 6221-6225
348.		all-E-	408[a] ε 35300			420 ε 30500	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
349.		all-E-	435[a]	396[a]	525[a]		615			+				2790				20mM HEPES pH 7.0. BRA cycle similar to BR "K"[720],"O"[520] and "M" but "L" not observed.	Biochem 1985. 24(5), 1260 - 1265
		all-E-					615											in water. pH 7.0	BiophysJ 1989

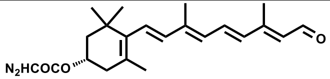
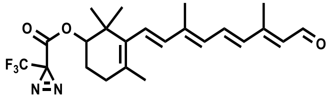
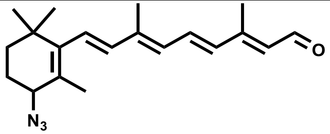
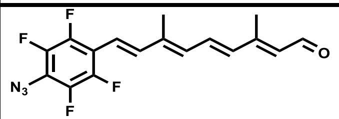
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH[+]	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
							650 650											pH 2.5 pH 0.5	56(6) 1259-1265
350.		all-E-		398	524		590			+				2140					Retinal Proteins 1987. 205–216 17
		all-E-	414[a]	398[a]	524[a]		590			+								20mM HEPES pH 7.0. BRA cycle similar to BR "K","O" and "M" but "L" not observed.	Biochem 1985. 24(5), 1260 - 1265
		all-E-					590 635 635											in water. pH 7.0 pH 2.5 pH 0.5	BiophysJ 1989 56(6) 1259-1265
		all-E-	428[a]				620											Protein-*b*-Ionone Ring Interactions. Second harmonic generation (SHG) to probe the light-induced dipolar changes	JPhysChem B 2003 107(25) 6221-6225
351.		all-E-	419[a] ε 37400			+	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8), 1169-1194
352.		all-E-	305[a] ε 24300			+	NO											str. R1 in 10mM MES, pH 6.0	Bioorgan Khim. (Rus), 1981, 7(8),

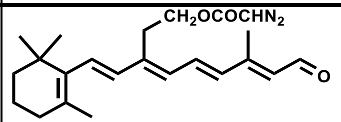
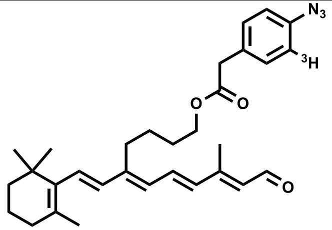
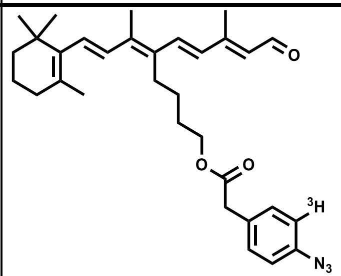
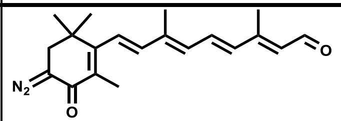
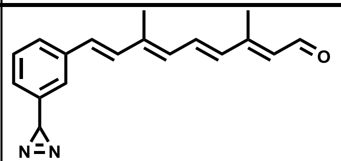
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																			1169-1194
353.		all-E-			406			438	438				74/26 74/26	1800 1800				pH 7.0, 50 mM Hepes	PhotochemPhotobiol 1991 54(6) 969-976
354.		all-E-	326 ε 27500			+	NO											str. R1	Bioorgan Khim. (Rus), 1984, v. 10, N 2, 256-259
K. Labelled BR derivatives (radioactive, photo-affinic, fluorophoric, heavy-atom, paramagnetic (SL), ionophoric and photochromic probes)																			
355.		all-E-					540											BRA in dark in 67 mM phosphate buffer at pH 7.0 immediately hydrolysed in 4-hydroxyBR	PhotochemPhotobiol 1981 33(4) 483-488
356.		all-E-					525	525	+						unstable in dark			In water pH7.0, τ_{rec} 1.5 h. UV-induced cross-links. Reversible L-D adaptation	PhotochemPhotobiol 1981 33(4) 483-488
		all-E- 1-(^{14}C)	245 ε 18000 360[c] ε 49000					440sh 525	532	+		50	75\25		unstable under irradiation similar to natural BR	stable	LA-505+/590-	10 mM Hepes buffer, pH7.0. Reversible L-D adaptation. UV-induced cross-links 25%. BR532 stable to irradiation with light >530 nm	JACS 1983. 105(15), 5160 - 5162.
		13Z-					500												
357.		all-E- 3S(3β) 1-(^{14}C)						525	538	+	402	100						in distilled H_20 τ_{rec} 5 h "K" 610 nm. H+-transport in 4M NaCl, JW2N cells. UV irradiation at 254 nm generated highly reactive carbenes,	Tetrahedron Lett. 1988. 29(19), 2275 – 2278

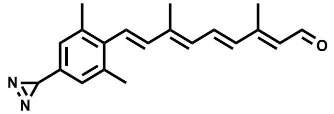
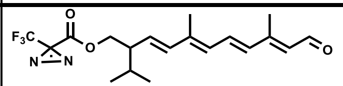
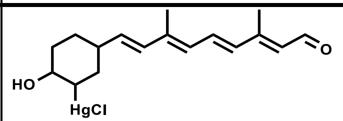
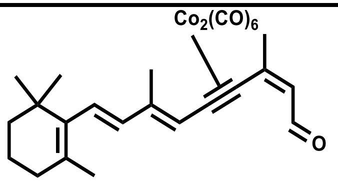
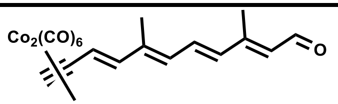
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M				NH_2OH	all-E-RET	CD	others	
							(P)	DA	LA										
																		which cross-linked the radiolabeled retinals to amino acid residues in the vicinity of the β-ionone ring. UV-induced cross-links with Thr121/ Gly122.	Biochem 1990 29(20), 4898 - 4904
358.		all-E- 3R(3α)-1-([14]C)						535	545	+	410	100						in distilled H_20 τ_{rec} 5 h "K" 590 nm. H+-transport in 4M NaCl, JW2N cells. UV irradiation at 254 nm generated highly reactive carbenes, which cross-linked the radiolabeled retinals to amino acid residues in the vicinity of the β-ionone ring. UV-induced cross-links.	Tetrahedron Lett. 1988. 29(19), 2275 – 2278 Biochem 1990 29(20), 4898 - 4904
359.		all-E-					475												Tetrahedron 1984. 40(3), 493- 500
360.		all-E-	272 ε 1300, 375 ε 39500			+	475											str. R1, pH7.0. Label stable to UV-induced cross-links formation.	Bioorgan Khim (Rus), 1981, 7(11), 1731-1733
361.		all-E-	390[a]				517		507	+	410	40			slowly destroyed in 2h	slowly displaced		In distilled water. Slowed "M"-decay kinetics. Interaction of tritiated RetA as a potential photoactivatable cross-linking agent to BR showed no labeling of the protein	Photochem.Photobiol. 1994, 60(1), 64-68

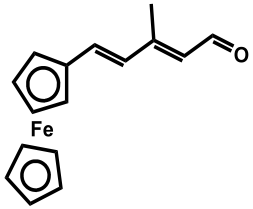
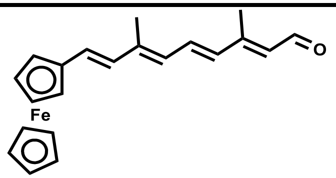
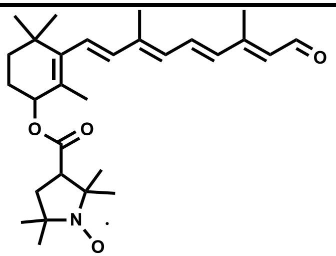
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	Pigments DA	Pigments LA	Photocycle	Photocycle M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
																		with a detection limit estimated at 5%.	
362.		all-E-					452					12						pH 7.0, 25°C in dark	JACS 1989, 111(13), 4997-4998.
363.		all-E-					475					+++		1430				τ_{rec} 2 h, 35% yield. BRA labeling resulted in cross-linking to many amino acids.	Biophys Chem 1995 56(1-2) 13-22 JACS 1994 116(15) 6823-6831
364.		all-E-					503					+++		2340			290-/496 +	τ_{rec} 186 h, 50% yield. UV-induced cross-links 7% Asn176/ Arg175	Biophys Chem 1995 56(1-2) 13-22 JACS 1994 116(15) 6823-6831
365.		all-E- 15-^{3}H	385 ε 50500				497					20						UV-induced cross-links 15% Ala126/ Leu127 and Trp137/138 1 min irradiation at 475 nm led to reduction in BR497 and rapid decrease in H-pump ability	JACS. 1990 112(21), 7779 – 7782
366.		all-E- 15-^{3}H	390[a] ε 45700				470 ε 35300											str. R1S9 pH 6.5, 22°C. τ_{rec} 6 h UV-induced cross-links 30% Ser193/ Glu194.	JBiolChem., 1982, 257(22), 13616-13623

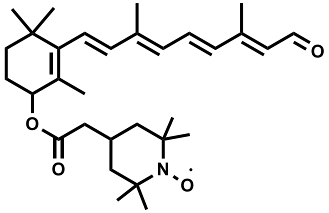
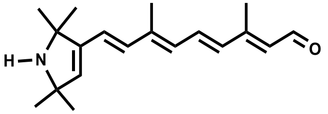
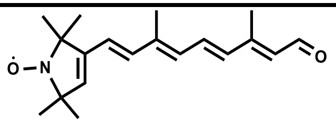
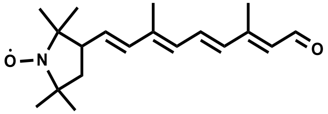
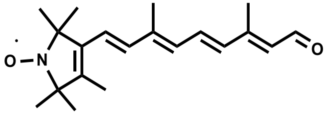
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
367.		all-E 15-^{3}H	364[c] ε 64000				450											In 100mM HEPES buffer solution pH 7.2. UV-induced cross-links 30%	J. Label. Compounds Radiopharm., 1987, 24(7), 787-795 PhotochemPhotobiol 1985 41(3) 303-307
368.		all-E-					448	453	450	+	345/ 360					slowly replaced			Biophys. J. 1993, 64(2-P2) A211
369.		all-E-					478	478			+	+				stable		str. ET1001, 25 mM phosphate buffer, pH 7.0. X-ray diffraction data. BRA cycle comparable to BR, but rate constants are altered.	PhotochemPhotobiol 1991 54(6) 873-879 Biophys. J. 1989, 55(2), 255a.
370.		13Z-	320 ε 22300, 578sh ε 2800			NO	NO											str. 353P, R1 and ET1001 pH 6.0 No pigment formation during 2 days incubation	Shevyakov S.V. Ph.D. thesis, 2000 BiochemM 2001 66(11) 1323-1333
371.		all-E-	390 ε 44900				450 500sh											str. 353P, R1 and ET1001 pH 6.0 τ_{rec}~2 h	Shevyakov S.V. Ph.D. thesis, 2000

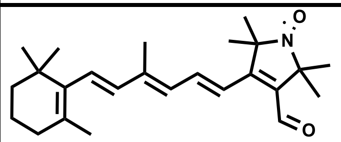
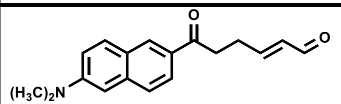
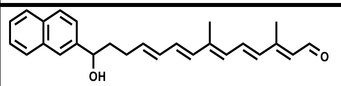
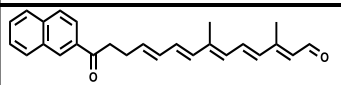
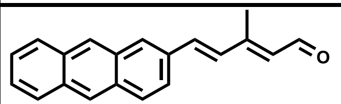
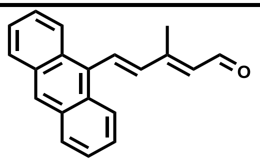
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	Pigments DA	Pigments LA	Photocycle	Photocycle M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
																		Unstable and self destroyed in 2 days	Biochem M 2001 66(11) 1323-1333
372.		all-E-	280 ε 8700 337 ε 26700 503 ε 3100	327 479sh	392 578		426 517							2040				str. 353P, R1 and ET1001 pH 6.0 τ_{rec}~25 days	Shevyakov S.V. Ph.D. thesis, 2000 Biochem M 2001 66(11) 1323-1333
373.		all-E-	296 ε 12900 394 ε 38700 508 ε 6400	373 484sh	454 568sh		485 590sh 483 593sh			NO				1410 1320				str. 353P, R1 and ET1001 pH 6.0 τ_{rec}~5 days Stable 2 months	Shevyakov S.V. Ph.D. thesis, 2000 Biochem M 2001 66(11) 1323-1333
374.		all-E-	380[a]				480								0.1M, 4h complete hydroxyla-minolysis of BRA480 without BRA480-> BRA535	stable		in 50 mM sodium acetate buffer pH 5.5. Easy hydrolyzed in 4-hydroxyBRA535 after 0.5 h. ESR spectrum	PhotochemPhotobiol 1981, 33(4), 489-494

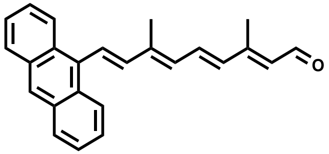
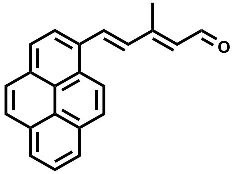
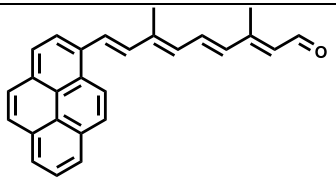
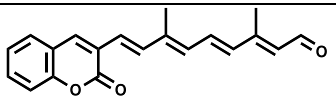
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	Pigments DA	Pigments LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
375.		all-E-	250 ε 4100, 370 ε 41500			+	465											str. R1, in 50 mM phosphate buffer at pH 7.0, slowly hydrolyzed in 4-hydroxyBRA. ESR spectrum	Bioorgan Khim (Rus), 1981, 7(11), 1731-1733
376.		all-E-	384[a] 366[c]	365				459	459			NO		1000		replaced in 48h		str. R1S9 in water. BRA not show light-dark adaptation. τ_{rec} ~several min	Recl. 1995. 114(9-10), 403 - 409
377.		all-E-	374					454	459		NO	0			stable 60 min 0.1M	stable		ESR spectrum. BRA show light-dark adaptation.	JACS 1981. 103(24), 7364 - 7366.
		13Z-	375					454	459										18
		all-E-	384[a] 366[c]	365			459	459	459			NO		1000		replaced in 48h		str. R1S9 in water. BRA not show light-dark adaptation. τ_{rec} ~several min. ESR spectrum.	Recl. 1995. 114(9-10), 403 - 409
		all-E-					460											τ_{rec} ~several h. Binding of Mn^{2+} to deionized wild-type and mutants E74C, A103C, and M163C	Biophys. J. 2001, 81(2), 1155-1162.
378.		all-E-	360[a]					440	450	+	365	++							18
379.		all-E-	270 ε 10800 377[a] ε															Synthetic route	Monatsh Chem. 2014 145

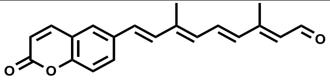
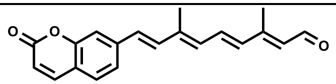
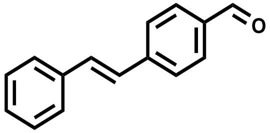
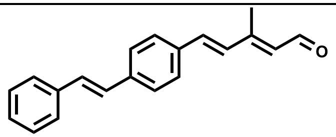
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
			33600																651–656.
380.		13Z-	258 ε 8300 384[a] ε 21300															Synthetic route	Monatsh Chem. 2014 145 651–656.
381.		E-	372[a] 351[c] 380[g]			352												In 10 mM Hepes buffer pH 6.5. Emission spectra for: CHO: 401[c], 445[f], 510[a]. NC: 440nm -> 425nm BRA: 532 nm	JACS 1987 109(5), 1594 - 1596.
382.		all-E-	380-390[g]		460[a]		460	460	460							stable, replaced within ~12h		flash-photolysis BRA460~>"K"1.5μs->"L"500μs>"M"100ms->P460	Biochem 1991. 30(23), 5400 - 5409
383.		all-E-	376[a] 380-390[g]		460[a]		460	460	460							stable, replaced within ~12h			Biochem 1991. 30(23), 5400 - 5409
384.		all-E- 13Z-	227, 249, 331, 368, 386 227, 251, 310, 329, 368, 386			345, 365, 440 345, 365, 440	NO NO												29 JAppl Spectroscopy (Rus) 1990. 52(1), 24 - 30
385.		all-E-	253 ε 20530 0 387 ε	254 386	254 456		552							3810	stable in 8 h	stable		in 10 mM Hepes buffer at 25^{0}C. Steady state fluorescence measurements.	CanJ Chem 1990 68(3) 383-390

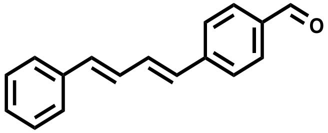
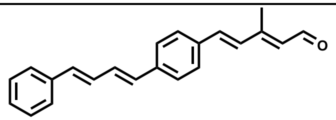
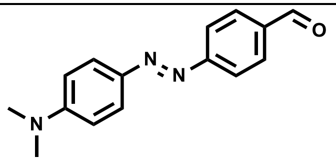
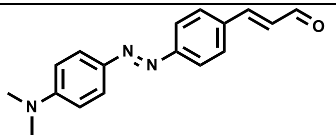
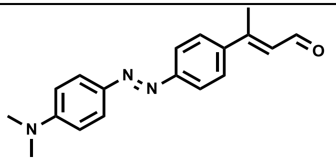
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
			11250																JPhotochemPhotobiol B 1991 8(3) 325-335
386.		all-E-	261 ε 80600 410 ε 24800	395 260 393	429 261 418		545		550	+	400			4820 5130	stable in 24 h	stable		in 10 mM Hepes buffer at 25^{0}C. Steady state fluorescence measurements.	CanJ Chem 1990 68(3) 383-390 JPhotochemPhotobiol B 1991 8(3) 325-335
387.		all-E-		384	466		498			+	400	++		1380	stable in 4 h	stable in 6 h		str. S9, in 50 mM phosphate buffer at pH 7.2. BRA do not show dark adaptation. BRA cycle "M".	Photochem.Photobiol. 1999, 70(6), 949-956
388.		all-E-		422 422 422	500 500 500		514 512 516			+	430	++		550 470 620	stable in 4 h	stable in 6 h		WT E194Q E204Q str. S9, in 50 mM phosphate buffer at pH 7.2, E194Q and E204Q mutants BRA do not show dark adaptation. BRA cycle "M" "O". "M" decay in 10 times slower. "O" decay τ = 200 ms.	Photochem.Photobiol. 1999, 70(6), 949-956
389.		all-E-	407	394	460		475			+								str. 353P, str. ET1001, 5mM MES, pH 6.0	Tetrahedron 1996, 52(28), 9581-9588

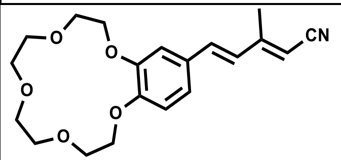
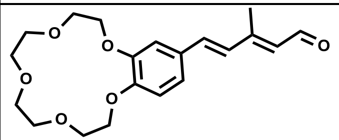
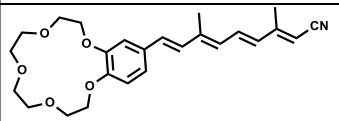
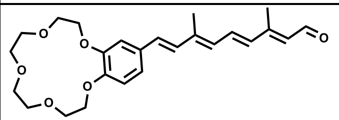
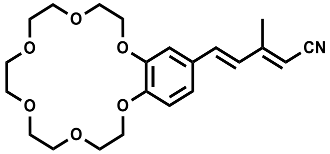
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
		all-E-																electronic and structural properties of retinal analog were studied using semiempirical, ab initio Hartree-Fock, and DFT methods	J. Chem. Phys., 2006, V. 125, 144901
390.		all-E-	391	388	464		478							630				str. S 9	Tetrahedron Lett. 1999, 40(13), 2645-2648
		all-E-																electronic and structural properties of retinal analog were studied using semiempirical, ab initio Hartree-Fock, and DFT methods	J. Chem. Phys., 2006, V. 125, 144901
391.		all-E-	401 420sh	395	460		497 438 413							1620				str. S 9	Tetrahedron Lett. 1999, 40(13), 2645-2648
392.		E-	330 ε 48700	325	373		NO											in HEPES buffer fluorescence emission spectra $\lambda_{f\,max}$ 435, 459(sh)	PhotochemPhotobiol 2003, 78(5), 503-510.
393.		all-E-	364 ε 50200	362	421		440							1025		stable τ_{repl} 340 min		in HEPES buffer τ_{rec}~20 min fluorescence emission spectra $\lambda_{f\,max}$ 550, 421(sh) nm No fluorescence emission in pigment	PhotochemPhotobiol 2003, 78(5), 503-510.

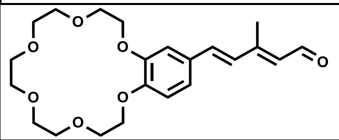
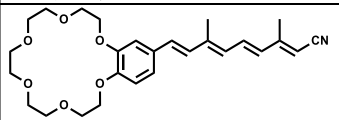
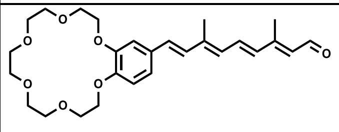
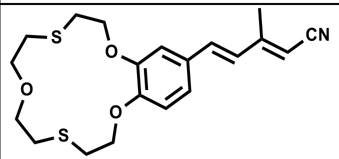
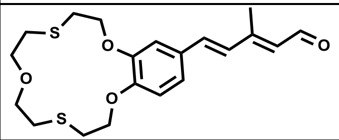
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H⁺-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH⁺	NC	Pigments (P)	DA	LA		M				NH_2OH	all-E-RET	CD	others	
394.		all-E-	355 ε 49100	347	405		NO											in HEPES buffer fluorescence emission spectra $\lambda_{f\,max}$ 500 nm	Photochem Photobiol 2003, 78(5), 503-510.
395.		all-E-	383 ε 38500	379	409		452							660		stable τ_{repl} 300 min		in HEPES buffer τ_{rec}~20 min fluorescence emission spectra $\lambda_{f\,max}$ 603 nm No fluorescence emission in pigment	Photochem Photobiol 2003, 78(5), 503-510.
396.		E-	229 ε 14500, 284 ε 18200, 449 ε 22500	436	465		458					+		-330		stable 1h $\%_{repl}$ after 24h – 26%		str. R_1M_1 10 mM TrisHCl buffer pH 5, $\tau_{1/2rec}$~7min Fluorescence behavior	JACS 1996 118(26)-6185-6191
397.		E-	253 ε 5382 313 ε 10928, 461 ε 18836	446	504		597					+		3090		stable 1h $\%_{repl}$ after 24h -15%		str. R_1M_1 10 mM TrisHCl buffer pH 5, $\tau_{1/2rec}$~11min Fluorescence behavior	JACS 1996 118(26)-6185-6191
398.		E-	251 ε 7422, 310 ε 8698, 450 ε 17460	434	484		485					NO		40		stable 1h $\%_{repl}$ after 24h -80%		str. R_1M_1 10 mM TrisHCl buffer pH 5, $\tau_{1/2rec}$~1min Fluorescence behavior	JACS 1996 118(26)-6185-6191

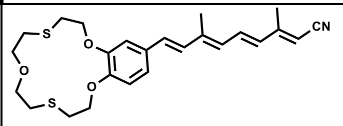
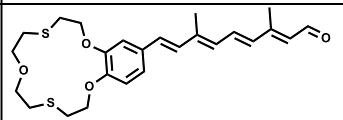
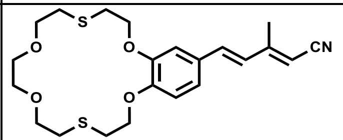
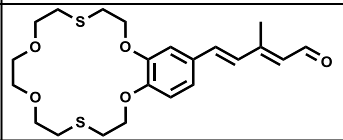
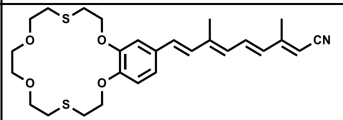
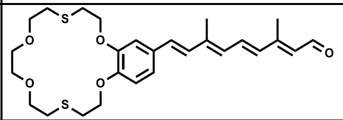
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M						CD	others	
							(P)	DA	LA						NH_2OH	all-E-RET			
399.		all-E-	340[h] ε 32400				NO											str. ET1001, 5mM MES, pH 6.0	Lukin A.Yu. Ph.D. thesis, 2004
400.		all-E-	356[h] ε 32600				450-460											str. ET1001, 5mM MES, pH 6.0 τ_{rec}~20 min	Lukin A.Yu. Ph.D. thesis, 2004
401.		all-E-	383[h] ε 45000				NO											str. ET1001, 5mM MES, pH 6.0	Lukin A.Yu. Ph.D. thesis, 2004
402.		all-E-	400[h] ε 52000					495				23						str. ET1001, 5mM MES, pH 6.0 τ_{rec}~2 h	Mol. Cryst. Liq. Cryst 2005, 431, 209-214 Vestnik MITHT, 2011, 6(2), 15-36 Lukin A.Yu. Ph.D. thesis, 2004
403.		all-E-	342[h] ε 34000				NO											str. ET1001, 5mM MES, pH 6.0	Lukin A.Yu. Ph.D. thesis, 2004

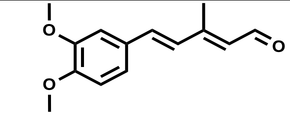
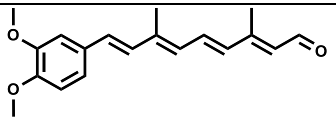
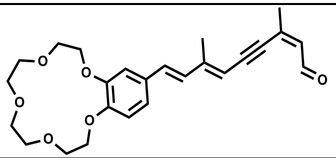
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH⁺	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
404.		all-E-	359[h] ε 28000				450-460											str. ET1001, 5mM MES, pH 6.0 τ_{rec}~20 min	Lukin A.Yu. Ph.D. thesis, 2004
405.		all-E-	387[h] ε 44000				NO											str. ET1001, 5mM MES, pH 6.0	Lukin A.Yu. Ph.D. thesis, 2004
406.		all-E-	400[h] ε 50000					495				22						str. ET1001, 5mM MES, pH 6.0 τ_{rec}~2 h	Mol. Cryst. Liq. Cryst 2005, 431, 209-214 . Vestnik MITHT, 2011, 6(2), 15-36 Lukin A.Yu. Ph.D. thesis, 2004
407.		all-E-	341[h] ε 32000				NO											str. ET1001, 5mM MES, pH 6.0	Lukin A.Yu. Ph.D. thesis, 2004
408.		all-E-	354[h] ε 27000				450-460											str. ET1001, 5mM MES, pH 6.0 τ_{rec}~20 min	Lukin A.Yu. Ph.D. thesis, 2004

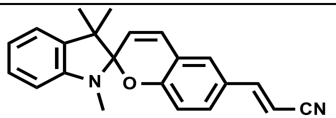
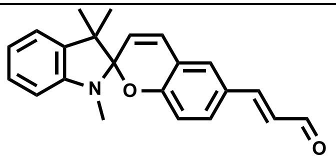
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	Pigments DA	Pigments LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	Reactions with all-E-RET	Remarks CD	Remarks others	Ref.
409.		all-E-	379[h] ε 44500				NO											str. ET1001, 5mM MES, pH 6.0	Lukin A.Yu. Ph.D. thesis, 2004
410.		all-E-	396[h] ε 51000					497										str. ET1001, 5mM MES, pH 6.0 τ_{rec}~2 h	Mol. Cryst. Liq. Cryst 2005, 431, 209-214 Vestnik MITHT, 2011, 6(2), 15-36 Lukin A.Yu. Ph.D. thesis, 2004
411.		all-E-	339[h] ε 23000				NO											str. ET1001, 5mM MES, pH 6.0	Lukin A.Yu. Ph.D. thesis, 2004
412.		all-E-	359[h] ε 29000				450-460											str. ET1001, 5mM MES, pH 6.0 τ_{rec}~20 min	Lukin A.Yu. Ph.D. thesis, 2004
413.		all-E-	379[h] ε 42000				NO											str. ET1001 pH 6.0	Lukin A.Yu. Ph.D. thesis, 2004
414.		all-E-	396[h] ε 55000					497										str. ET1001, 5mM MES, pH 6.0 τ_{rec}~2 h	Mol. Cryst. Liq. Cryst

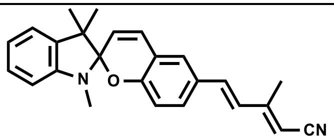
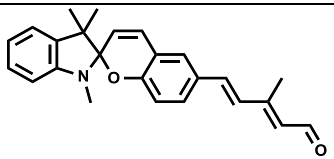
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λmax (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			2005, 431, 209-214 Vestnik MITHT, 2011, 6(2), 15-36 Lukin A.Yu. Ph.D. thesis, 2004
415.		all-E-	358 ε 34000				450-460											str. ET1001, 5mM MES, pH 6.0 τ_{rec}~20 min	Lukin A.Yu. Ph.D. thesis, 2004
416.		all-E-	400 ε 40000 402[h]				500			+		35						str. ET1001, 5mM MES, pH 6.0 τ_{rec}~1 h	Mol. Cryst. Liq. Cryst 2005, 431, 209-214 Vestnik MITHT, 2011, 6(2), 15-36 Lukin A.Yu. Ph.D. thesis, 2004
417.		all-E-	364 ε 35000	356	436		460			+		3.5-4		1200				str. ET1001 pH 6.0	Mol. Cryst. Liq. Cryst. 2000. 345 15–

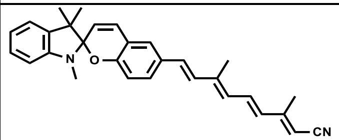
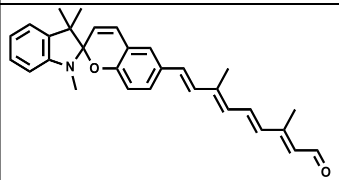
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			20. Biochem M 2001 66(11) 1323-1333 Mol. Cryst. Liq. Cryst 2005, 431, 209-214 Vestnik MITHT, 2011, 6(2), 15-36 Lukin A.Yu. Ph.D. thesis, 2004
418.		E-	320 ε 25100			-	NO											str. ET1001 pH 6.5	Rus J. Bioorgan Chem., 2008, V. 34, № 2, 252–260 Laptev A.V.. Ph.D. thesis, 2008
419.		E-	340 ε 26300			-	NO											str. ET1001 pH 6.5	Rus J. Bioorgan Chem., 2008, V. 34, № 2, 252–260

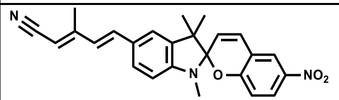
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																			DyesPigments 2012 92 831-837 Vestnik MITHT, 2011, 6(2), 15-36 JPhotochemPhotobiol A 2012 231(1) 41-44 Laptev A.V.. Ph.D. thesis, 2008
420.		all-E-	340 ε 35480	-	-	-	NO											str. ET1001 pH 6.5	Rus J. Bioorgan Chem., 2008, V. 34, № 2, 252–260 Laptev A.V.. Ph.D. thesis, 2008
421.		all-E-	365 ε 37160	338	384	-	440							3310				str. ET1001 pH 6.5 τ_{rec}~3 days	Rus J. Bioorgan Chem., 2008, V. 34, № 2, 252–260 DyesPigments

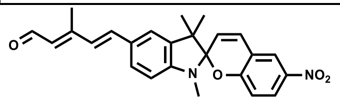
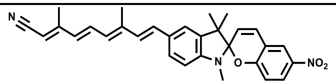
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			2012 92 831-837 Vestnik MITHT, 2011, 6(2), 15-36 JPhotochemPhotobiol_A 2012 231(1) 41-44 Laptev A.V.. Ph.D. thesis, 2008
422.		all-E-	390 ε 44670	-	-	400	NO											str. ET1001 pH 6.5	Rus J. Bioorgan Chem., 2008, V. 34, № 2, 252–260 Laptev A.V.. Ph.D. thesis, 2008
423.		all-E-	411 ε 51290	391	470	455	495							850				str. ET1001 pH 6.5 τ_{rec}~3 days	Rus J. Bioorgan Chem., 2008, V. 34, № 2, 252–260 DyesPigments 2012 92 831-837

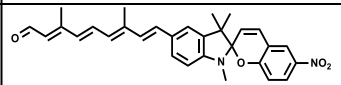
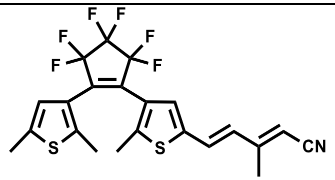
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																			Vestnik MITHT, 2011, 6(2), 15-36 JPhotochemPhotobiol_A 2011 222(1) 16-24 Laptev A.V., Ph.D. thesis, 2008
424.		all-E-	367 ε 45700	-	-		NO											str. ET1001 pH 6.5	Vestnik MITHT, 2011, 6(2), 15-36 JPhotochemPhotobiol_A 2011 222(1) 16-24 HighEnergyChem 2008 42(7) 601-603 Laptev A.V., Ph.D. thesis, 2008

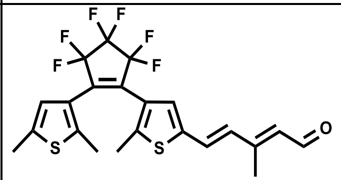
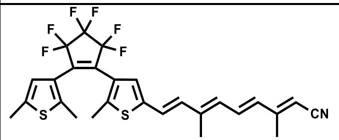
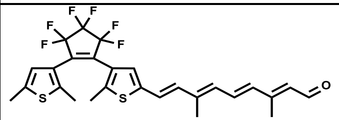
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1}) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
425.		all-E-	385 ε 47860	345		-	605											str. ET1001 pH 6.5 τ_{rec}~4 days	DyesPigments 2012 92 831-837 Vestnik MITHT, 2011, 6(2), 15-36 JPhotochemPhotobiol_A 2011 222(1) 16-24 HighEnergyChem 2008 42(7) 601-603 Laptev A.V.. Ph.D. thesis, 2008
426.		all-E-	405 ε 48980	-	-		NO											str. ET1001, pH 6.5	Vestnik MITHT, 2011, 6(2), 15-36 JPhotochemPhotobiol_A 2011 222(1) 16-24 HighEnergyChem 2008

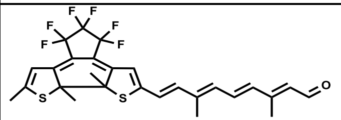
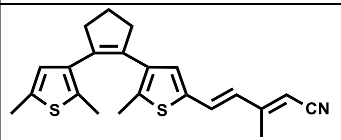
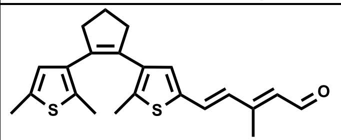
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$) "CHO"	SB	SBH^+	NC	Pigments (P)	DA	LA	Photocycle	M	H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with NH_2OH	all-E-RET	Remarks CD	others	Ref.
																			42(7) 601-603 Laptev A.V., Ph.D. thesis, 2008
427.		all-E-	266 324 410[a] ε 50120			480	500											str. ET1001, pH 6.5 τ_{rec}~7 days	DyesPigments 2012 92 831-837 Vestnik MITHT, 2011, 6(2), 15-36 JPhotochemPhotobiol_A 2011 222(1) 16-24 HighEnergyChem 2008 42(7) 601-603 Laptev A.V., Ph.D. thesis, 2008
428.		all-E-	278 338[a]				NO											str. ET1001, 5mM MES, 100mM NaCl pH 6.0	Belikov N.E., Ph.D. thesis, 2011 JPhotochemPhoto

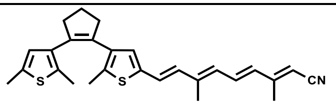
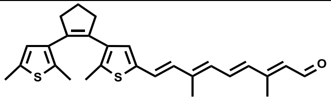
Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε (M^{-1} cm^{-1})							Photocycle		H^+-pump %	Isomer ratio all-E/13Z-	OS BR cm^{-1}	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M				NH_2OH	all-E-RET	CD	others	
							(P)	DA	LA										
																			biol A 2008 196(2-3) 262-267
429.		all-E-	355 355[a]	345	413		430							960				str. ET1001, 5mM MES, 100mM NaCl pH 6.0 τ_{rec}~7 days	Belikov N.E., Ph.D. thesis, 2011 JPhotochemPhotobiol A 2008 196(2-3) 262-267 DyesPigments 2012 92 831-837 Vestnik MITHT, 2011, 6(2), 15-36
430.		all-E-					NO											str. ET1001, 5mM MES, 100mM NaCl pH 6.0	DyesPigments 2012 92 831-837 Belikov N.E., Ph.D. thesis, 2011
431.		all-E-	390, 402	368	460		510							2130				str. ET1001, 5mM MES, 100mM NaCl pH 6.0 τ_{rec}~4 days	JPhotochemPhotobiol A 2008 196(2-3) 262-267

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
																			Belikov N.E., Ph.D. thesis, 2011 DyesPigments 2012 92 831-837 Vestnik MITHT, 2011, 6(2), 15-36
432.		all-E-	392, 409, 579				NO											str. ET1001, 5mM MES, 100mM NaCl pH 6.0 Incubation of closed cyclized form during ~48 days no BRA formation!!!	Belikov N.E., Ph.D. thesis, 2011 DyesPigments 2012 92 831-837 Vestnik MITHT, 2011, 6(2), 15-36
433.		all-E-	313 365[a]				NO											str. ET1001, 5mM MES, 100mM NaCl pH 6.0	Belikov N.E., Ph.D. thesis, 2011
434.		all-E-	330sh 390	365	444		450							300				str. ET1001, 5mM MES, 100mM NaCl pH 6.0 τ_{rec}~7 days Ret and BRA analogs destroyed under illumination.	Belikov N.E., Ph.D. thesis, 2011

Properties of artificial bacteriorhodopsin analogs

No	Structure	Isomer	λ_{max} (nm); ε ($M^{-1} cm^{-1}$)							Photocycle		H^+-pump	Isomer	OS BR	Reactions with		Remarks		Ref.
			"CHO"	SB	SBH^+	NC	Pigments				M	%	ratio	cm^{-1}			CD	others	
							(P)	DA	LA				all-E/13Z-		NH_2OH	all-E-RET			
435.		all-E-					NO											str. ET1001, 5mM MES, 100mM NaCl pH 6.0	Belikov N.E., Ph.D. thesis, 2011
436.		all-E-	397sh 420	400	500		535							1310				str. ET1001, 5mM MES, 100mM NaCl pH 6.0 τ_{rec}~7 days Ret and BRA analogs destroyed under illumination.	Belikov N.E., Ph.D. thesis, 2011

Notes:

[1]* Abbreviations: BRh - bacteriorhodopsin; BRA - bacteriorhodopsin analog; BO - bacterioopsin; AM –apomembranes; PM – purple membranes; OS - opsin shift; SB - the Schiff base; SBH^+ - protonated form of the Schiff base; P - pigment (covalent complex, containing protonated aldimine bond); NC - noncovalent complex; pK_a - pK of aldimine group of retinal or its analog in SBH^+ and in BRA. Usually, synthesis of retinal analogs and study of their properties are carried out at pH close to neutral (pH 6-7); if pH and temperature at which the reaction of BO with polyenal and other measurements were performed are given in the publication, these values are presented in "Remarks" column. In the same column, data on transitional spectral forms from their photocycles and their transitions in alkaline medium as well as some other non-standart properties of pigments (times of pigments formation, if ones differ substantially from natural BRh parametres, CD-; X-rays or ESR-data, etc.) are presented.

(+) - quality without quantitative assesment; (-) or (NO) - lack of quality; (blank) - no data; sh - shoulder.

[2]* Polyenals' structures are only given for *all-E*-isomers as their 6-*s-cis*-forms, except analogs (1b).

[3]* λ_{max} values for compounds (CHO, SB, SBH^+) are given for solutions in methanol (no index), ethanol (a), isopropanol (b), hexane (c), micells with octadecylamine (d), aldimine prepared with monoethanolamine (the others, with n-butylamine) (e), cyclohexane (f),– acetonitrile (h), – water (g), aldimine prepared with piperidine (k).

[4]* States of pigments, considered in the table: L - light-adapted; D - dark-adapted; (P) - pigment of which is not known to what form (dark or light) the λ_{max} value relates or the preparation was obtained in the dark, but this is definitely a non-equilibrium form to which reversion occurs in the dark after illumination or upon long-term storage of the sample.

[5]* (OS) = 1/λ(SBH^+) - 1/λ(pigment) [33,34]

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