



Opsin and Calcium Marker Characteristics

Application Note

Version 1.0.0

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Opsins

Table 1.1: *Depolarising Opsin Specifications*

OPSIN	WAVELENGTH RANGE (nm) (photocurrent >80%)	WAVELENGTH PEAK (nm)	EPD50 (mW/mm ²) (Steady State)	τ_{off} (ms)	Ref.
ChR2	424-485	470	0.90	11.4	1
VChR1	500-555	530	0.13	85	5
eNpHR3.0	542-650 (approx.)	590	5.44	4.2	1
ChR2_R/ChR2(H134R)	425-485	470	0.63	23.6	1
ChETA_A/ChR2(E123A)	445-500	470	1.26	7.3	1
TC/ChR2(T159C)	430-493	470	0.54	24.7	1
ChETA_TC/ChR2(E123T/T159C)	460-523	495	0.60	13.6	1
CatCh/ChR2(L132C)	426-497	470	0.43	60.8	1
ChIEF	425-482	470	0.93	9.9	1
FR/ChRFR	418-490	445	0.44	16.9	1
GR/ChRGR	435-519	470	0.48	16.6	1
C1V1_T/C1V1 ChETA(E162T)	492-559	540	0.34	59.6	1
C1V1.TT/C1V1 ChETA(E122/E162T)	515-563	540	0.31	45.8	1
Chrimson	548-615	590	0.82	3.6	4
Chronos	470-515	495	0.32	22.2	4
bReaChES	455-590	570	-	49.0	3
SFO (EPD50 peak)	-	450 (activated) 540 (inactivated)	3.3E-3	1.09E+5	6
SSFO (EPD50 peak)	-	450 (activated) 540 (inactivated)	9.57E-4	1.80E+6	6

Table 1.2: *Hyperpolarising Opsin Specifications*

OPSIN	WAVELENGTH RANGE (nm) (photocurrent >80%)	WAVELENGTH PEAK (nm)	EPD50 (mW/mm ²) (Steady State)	τ_{off} (ms)	Ref.
Arch1.0	502-585	520	7.89	4.8	1
EArch3.0 (2 peaks)	502-592	520/560	8.01	4.6	1
eArchT3.0	498-570	520	6.44	4.2	1
ArchT1.0 (2 peaks)	495-600	520/560	5.96	5.1	1
eMac3.0	500-570	542	1.79	41.9	1
Jaws (EPD50 approx)	530-630	590	2.60	6.7	2

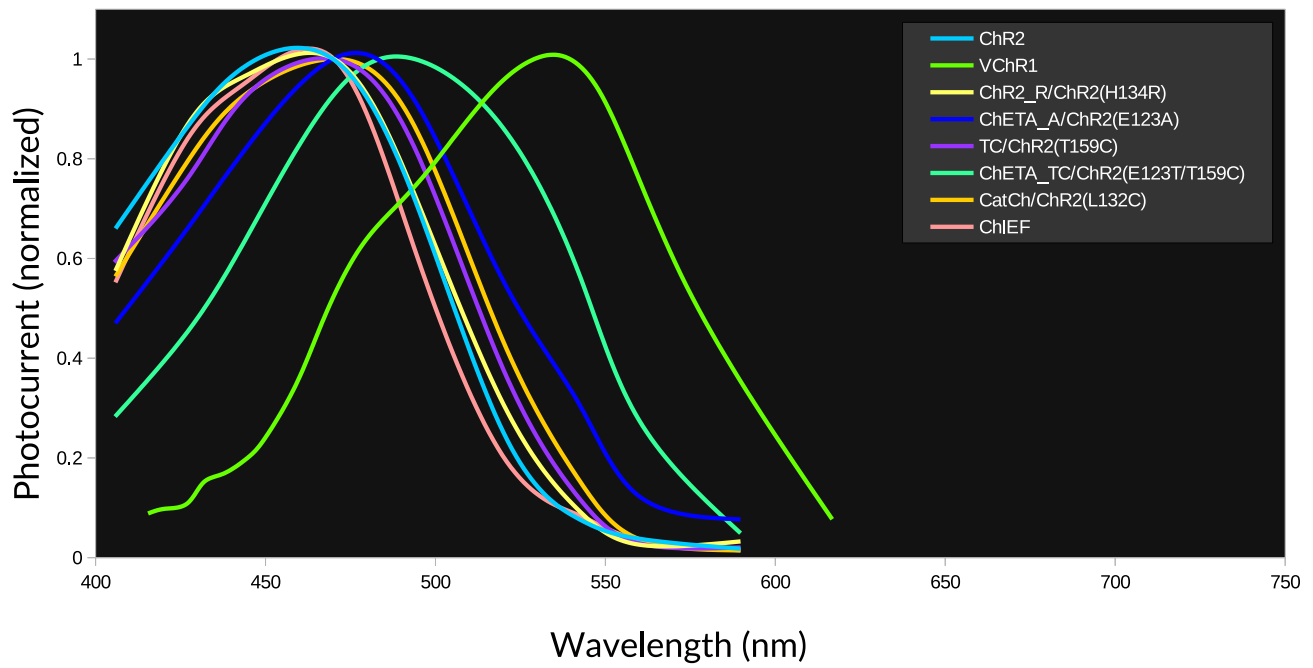


Figure 1.1: Spectral Photocurrent of Various Depolarising Opsins

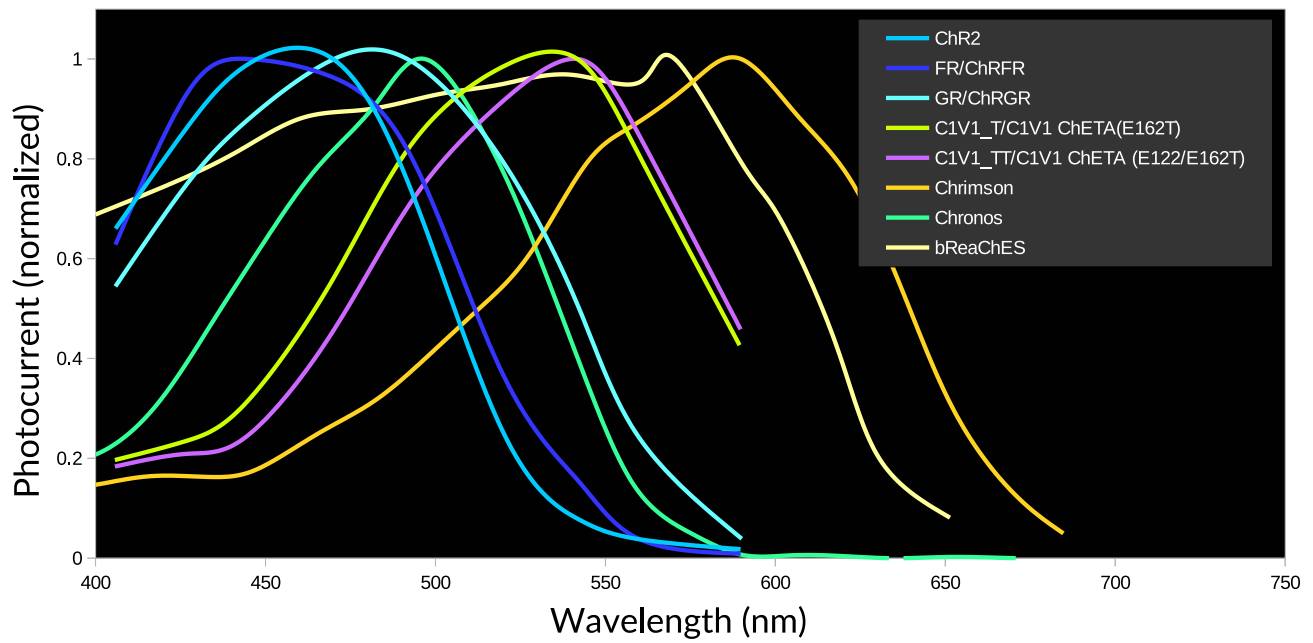


Figure 1.2: Spectral Photocurrent of Various Depolarising Opsins

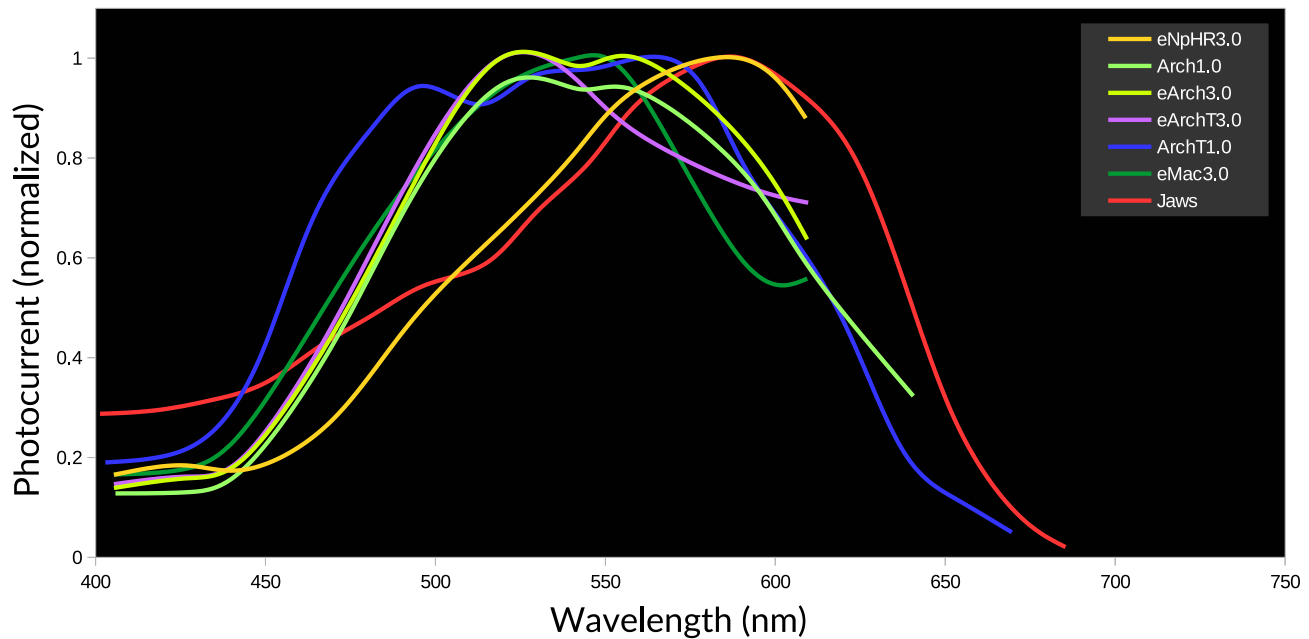


Figure 1.3: Spectral photocurrent of various hyperpolarising opsins

1.0.1 Definitions

- **Wavelength Range:** range of wavelengths where the produced photocurrent is greater than 80% peak value.
- **Wavelength Peak:** wavelength where photocurrent is maximal.
- **EPD50:** effective power density for 50% activation.
- τ_{off} : off kinetics, the rate of channel closure at the end of a light pulse.

1.0.2 References

Each Reference is followed by a list of opsins associated with each reference. Data presented in this document for each opsin comes from these references.

1. Mattis, Joanna, et al. **"Principles for applying optogenetic tools derived from direct comparative analysis of microbial opsins."** Nature methods 9.2 (2012): 159-172. (ChR2, ChR2_R, ChETA_A, TC, ChETA_TC, CatCh, ChIEF, FR, GR, C1V1_T, C1V1_TT; eNpHR3.0, eArch1.0, eArch3.0, eArchT1.0, eArchT3.0, eMac3.0; ChETA_TR; SFO).
2. Chuong, Amy S., et al. **"Noninvasive optical inhibition with a red-shifted microbial rhodopsin."** Nature neuroscience 17.8 (2014): 1123-1129. (Jaws (note : EPD50 estimated)).
3. Rajasethupathy, Priyamvada, et al. **"Projections from neocortex mediate top-down control of memory retrieval."** Nature 526.7575 (2015): 653-659. (bReaChES (no EPD50)).
4. Klapoetke, Nathan C., et al. **"Independent optical excitation of distinct neural populations."** Nature methods 11.3 (2014): 338-346. (Chrimson, Chronos).
5. Zhang, Feng, et al. **"Red-shifted optogenetic excitation: a tool for fast neural control derived from Volvox carteri."** Nature neuroscience 11.6 (2008): 631-633. (VChR1).
6. Yizhar, Ofer, et al. **"Neocortical excitation/inhibition balance in information processing and social dysfunction."** Nature 477.7363 (2011): 171-178. (SFO, SSFO).

Calcium Markers

Table 2.1: Calcium Indicator General Specifications

PROTEIN	dF/F ₀ (10 AP)	SNR (10 AP)	T _{1/2} (s) (10 AP)	T _{Rise} (s) (10 AP)	Kd (nM)	Ref.
GCaMP3*	1.00	1.00	0.60	0.14	345	1
GCaMP5G	2.41	1.48	0.68	0.17	447	1
GCaMP6f	4.93	3.13	0.39	0.08	375	1
GCaMP6m	6.04	4.06	1.15	0.28	167	1
GCaMP6s	6.69	4.62	1.78	0.48	144	1
PROTEIN	dF/F ₀ (10 AP)	SNR (10 AP)	T _{1/2} (s) (10 AP)	T _{half-rise} (s) (10 AP)	Kd (nM)	Ref.
R-GECO1*	0.66	1.00	0.42	0.09	337	3
jRGECO1a	1.59	1.84	0.45	0.08	148	3
RCaMP1h	0.10	0.24	0.73	0.23	1127	3
jRCaMP1a	0.88	1.71	2.25	0.08	214	3
jRCaMP1b	0.91	1.34	0.80	0.10	712	3

*For indicators related to GCaMP, GCaMP3 serves as a **dF/F₀(10 AP)** and **SNR** point of reference. For indicators related to RCaMP, R-GECO1 is used as a **SNR** point of reference.

Table 2.2: Calcium Indicator Wavelength Peak Specifications

PROTEIN	Excitation (Ca ₂₊ free)	Emission (Ca ₂₊ free)	Excitation (Ca ₂₊ saturated)	Emission (Ca ₂₊ saturated)	Ref.
GCaMP3*	497	504	513	516	2
GCaMP5G	497	504	513	516	2
GCaMP6f	497	504	513	516	2
GCaMP6m	497	504	513	516	2
GCaMP6s	497	504	513	516	2
R-GECO1*	565	586	579	596	3
jRGECO1a	565	586	579	596	3
RCaMP1h	573	594	573	596	3
jRCaMP1a	573	594	573	596	3
jRCaMP1b	573	594	573	596	3

2.0.1 Definitions

- **dF/F₀**: Variation of fluorescence in relation to background fluorescence. Value at peak, at 10 action potentials
- **SNR**: Signal to noise ratio at 10 action potentials.

- $T_{1/2}$: Half decay time.
- T_{Rise} : Rise time to reach peak fluorescence.
- $T_{Half-Rise}$: Half-rise time to reach peak fluorescence.

2.0.2 References

1. **Ultra-sensitive Fluorescent Proteins for imaging neuronal activity** (Chen et al.) (GCaMP3, GCaMP5G, GCaMP6s, GCaMP6m, GCaMP6f)
2. **Optimization of a GCaMP calcium indicator for neural activity imaging** (Akerboom et al.) (GCaMP wavelength information)
3. **Sensitive red protein calcium indicators for imaging neural activity** (Dana et al.) (R-GECO1, jRGECO1a, RCaMP1h, jRCaMP1a, jRCaMP1b)

Support

3.1 Contact us

For any questions or comments, do not hesitate to contact us by:

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