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Computational model for Halorhodopsin photocurrent kinetics[1]

JAIME BRAVO, Department of Biomedical Engineering, The Ohio State University, ROXANA STEFANESCU, Department of Pediatric Neurology, University of Florida, SACHIN TALATHI, Department of Biomedical Engineering, University of Florida — Optogenetics is a rapidly developing novel optical stimulation technique that employs light activated ion channels to excite (using channelrhodopsin (ChR)) or suppress (using halorhodopsin (HR)) impulse activity in neurons with high temporal and spatial resolution. This technique holds enormous potential to externally control activity states in neuronal networks. The channel kinetics of ChR and HR are well understood and amenable for mathematical modeling. Significant progress has been made in recent years to develop models for ChR channel kinetics. To date however, there is no model to mimic photocurrents produced by HR. Here, we report the first model developed for HR photocurrents based on a four-state model of the HR photocurrent kinetics. The model provides an excellent fit (root-mean-square error of 3.1862×10^{-4}, to an empirical profile of experimentally measured HR photocurrents. In combination, mathematical models for ChR and HR photocurrents can provide effective means to design test light based control systems to regulate neural activity, which in turn may have implications for the development of novel light based stimulation paradigms for brain disease control.

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