BK-channel as a fast and precise Ca^{2+} sensor: application to PMCA pump strength measurements

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Ca^{2+} diffusion within cells and penetration of Ca^{2+} through their membrane engages a wide field of theoretical and experimental research. Therefore, the monitoring of rapid changes of the Ca^{2+} concentration beneath the cell membrane is of great interest. Here, we make use of BK-type Ca^{2+}-activated K^+ channels to determine the Ca^{2+} activity of PMCA, which transport Ca^{2+} ions out of cells. Due to their large conductance and their particular gating kinetics the BK channels may be used as fast and reliable sensors for intracellular Ca^{2+} - concentration beneath the plasma membrane. Experimentally we monitor the PMCA-mediated Ca^{2+} clearance (or transport) by the decay of BK-currents following their activation by a short (0.8 ms) period of Ca^{2+} -influx through Cav2.2 channels. To relate the experimentally observed temporal evolution of the K^+ current to the underlying temporal evolution of the Ca^{2+} concentration we implement a theoretical model for the Ca^{2+}-dependence of the BK-current and of the PMCA pump strength. Next to the transport in and out of a cell and the diffusion of Ca^{2+} ions within the cell, we expand our model by the reaction of the Ca^{2+} concentration with a buffer solution, as well defined EGTA concentration is present in all experimental measurements. We fit the PMCA pump strength by the best match of the predicted time course of the K^+ current with the experimental data. It turns out that this pump strength is at least 2 orders of magnitude larger than what has been assumed so far.