3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

Microtubule detachment and translocation by pulsed electric field

D. Havelka [(1)], I. Zhernov[(2)] , M. Teplan[(3)], Z. Lánský[(2)], D.E. Chafai[(1,4)], M. Cifra [(1)]
(1) Institute of Photonics and Electronics of the Czech Academy of Sciences, Chaberská 1014/57, Prague 8, Czechia, 18251, cifra@ufe.cz
(2) BIOCEV, Institute of Biotechnology of the Czech Academy of Sciences, Vídeňská 1083, Prague 4, 14220 Czechia
(3) Institute of Measurement Science of the Slovak Academy of Sciences, Dúbravská cesta 5801/9, 841 04 Bratislava Slovakia
(4) Institute of Physiology of the Czech Academy of Sciences, Vídeňská 1083, Prague 4, 14220, Czechia

Pulsed electric field (PEF) technology is promising for the manipulation of biomolecular components and has potential applications in biomedicine and bionanotechnology. Microtubules, nanoscopic tubular structures self-assembled from protein tubulin, serve as important components in basic cellular processes as well as in engineered biomolecular nanosystems. Recent studies in cell-based models have demonstrated that PEF affects the cytoskeleton, including microtubules. However, the direct effects of PEF on microtubules are not clear. In this work, we developed a lab-on-a-chip platform integrated with a total internal reflection fluorescence microscope system to elucidate the PEF effects on a microtubules network mimicking the cell-like density of microtubules. The designed platform enables the delivery of short (microsecond-scale), high-field-strength (< 25 kV/cm) electric pulses far from the electrode/electrolyte interface. We showed that microsecond PEF is capable of overcoming the non-covalent microtubule bonding force to the substrate and translocating the microtubules. This microsecond PEF effect combined with macromolecular crowding led to the aggregation of microtubules. Our results expand the toolbox of bioelectronics technologies and electromagnetic tools for the manipulation of biomolecular nanoscopic systems and contribute to the understanding of microsecond PEF effects on a microtubule cytoskeleton.

Authors acknowledge support from the Czech Science Foundation p.no. 18-23597S and Scientific Grant Agency VEGA project 2/0124/22 and institutional support from CAS (RVO: 86652036). Authors are also participating in COST Action CA17115.