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Experimental Study of Proteins under Strong Electric Fields on the Order of 100 MV/m

Sunao Katsuki*(1), Yuya Sato(1), and Koki Tsurusaki(1)
(1) Kumamoto University, Kumamoto, Japan; e-mail: katsuki@cs.kumamoto-u.ac.jp

Electric field on plasma membrane of mammalian, plant or bacterial cells, exposed to a pulsed electric field (PEF) of hundred's kV/m, is automatically enhanced and exceeds 100 MV/m. The enhanced field is known to permeabilize the membrane and induces trans-membrane ion mobilization, while being predicted to affect the functions and/or structures of membrane proteins as dielectric materials with diverse structures. Several molecular dynamics simulations have predicted that 100 MV/m-class PEF stimulates membrane proteins and activates their functions. There is growing interest in the PEF effects on proteins not only from scientific view but also from the applications to physical control of protein functions or structures. However, it is not easy to identify the PEF effect on proteins in living cells since other impact biological events such as Ca influx and the subsequent biochemical processes occur dominantly and hide the PEF effect on proteins. Previously, we experimentally demonstrated that intense electrical pulses on the order of 20 MV/m destroy urease protein in its aqueous solution using the specially adjusted electrophoresis [1]. Moreover, we reported the 100 MV/m-class electrical pulses disintegrate transthyretin aggregate [2]. Here, we investigated the primary, secondary and tertiary structures in Bovine Serum Albumin (BSA), exposed to 10 PEFs with the field up to 130 MV/m, by characterizing the structures, molecular weight and size. Electrophoresis (Native-PAGE) indicates that the electric field exceeding 50 MV/m affects the tertiary structure of BSA. Also, both the surface thiol group measurement and the dynamic light scattering (DLS) indicate the tertiary structure of BSA was loosen and expanded, which coincide with the result of Native -PAGE. On the other hands Circular dichroism (CD) analysis indicated no significant change in the number of α-helices, which leads to the conclusion 130 MV/m PEFs do not affect the secondary structure in BSA. Through the experiment, we carefully monitored the change in pH, temperature and hydrogen peroxide concentration, which could affect the protein conformation, none of these factors affected any of proteins.

References

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