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Ionic contrast across a lipid membrane for Debye length extension: towards an ultimate bioelectronic transducer

Donggeun Lee[1,2,7], Woo Hyuk Jung[3,7], Suho Lee[4], Eui-Sang Yu[1], Taikjin Lee[1], Jae Hun Kim[1], Hyun Seok Song[1], Kwan Hyi Lee[5,6], Seok Lee[1], Sang-Kook Han[2], Myung Chul Choi[4], Dong June Ahn[3,6,8✉], Yong-Sang Ryu[1,6,8✉] & Chulki Kim[1,8✉]

Despite technological advances in biomolecule detections, evaluation of molecular interactions via potentiometric devices under ion-enriched solutions has remained a long-standing problem. To avoid severe performance degradation of bioelectronics by ionic screening effects, we cover probe surfaces of field effect transistors with a single film of the supported lipid bilayer, and realize respectable potentiometric signals from receptor–ligand bindings irrespective of ionic strength of bulky solutions by placing an ion-free water layer underneath the supported lipid bilayer. High-energy X-ray reflectometry together with the circuit analysis and molecular dynamics simulation discovered biochemical findings that effective electrical signals dominantly originated from the sub-nanoscale conformational change of lipids in the course of receptor–ligand bindings. Beyond thorough analysis on the underlying mechanism at the molecular level, the proposed supported lipid bilayer-field effect transistor platform ensures the world-record level of sensitivity in molecular detection with excellent reproducibility regardless of molecular charges and environmental ionic conditions.

[1] Sensor System Research Center, Korea Institute of Science and Technology, Seoul, Republic of Korea. [2] Department of Electrical & Electronic Engineering, Yonsei University, Seoul, Republic of Korea. [3] Department of Chemical and Biological Engineering, Korea University, Seoul, Republic of Korea. [4] Department of Bio and Brain Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea. [5] Center for Biomaterials, Korea Institute of Science and Technology, Seoul, Republic of Korea. [6] KU-KIST Graduate School of Converging Science and Technology, Korea University, Seoul, Republic of Korea. [7] These authors contributed equally: Donggeun Lee, Woo Hyuk Jung. [8] These authors jointly supervised this work: Dong June Ahn, Yong-Sang Ryu, Chulki Kim. ✉email: ahn@korea.ac.kr; ysryu82@kist.re.kr; chulki.kim@kist.re.kr