Hysteretic Ion Transport in 2D Layered Nanochannels for Memcapacitance

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Two-dimensional materials provide an unprecedented opportunity to fabricate ion nanochannels for exploring memcapacitance. However, the full understanding of ion transport remains vague due to complex interfacial reactions and potential interactions between ions and nanochannels. Described herein are the memcapacitors based on two kinds of 2D materials, a biocomposite paper composed of reduced graphene oxide (rGO) and silk fibroin (SF) and layered MXene. The presented memory stacks exhibit analog, reversible, and nonvolatile memcapacitance characteristics. Impressively, the stacks have a broad range of high capacitance states. This memcapacitive behavior for the rGO-SF paper is ascribed to an interfacial charge build-up (capacitive double layer) modulated by the H^+ migration, which is trapped/detrapped by the rGO-SF paper depending on bias conditions. Through investigating the interfacial electrochemical information, it is found that a weak interaction of hydrogen bond is created between H ions and the hydroxyl (OH) termination of MXene surface during the pseudo-intercalation of H^+ ions. As a result, the hydrogen bond leads to the trapping and hysteretic transport of H^+ ions, which triggers the memcapacitance effect. These works demonstrate that 2D materials with rich surface chemistry could be selected as a promising candidate for constructing ion nanochannels for creating novel nanoionic devices.

References

[1] Xin Guo, Lei Huang, Xinge Zhou, et al., Adv. Funct. Mater. 2020, 2003635
[2] Quanhong Chang, Wei Chen, Jiaxuan Song, et al., Applied Surface Science 639 (2023) 158229

Figures

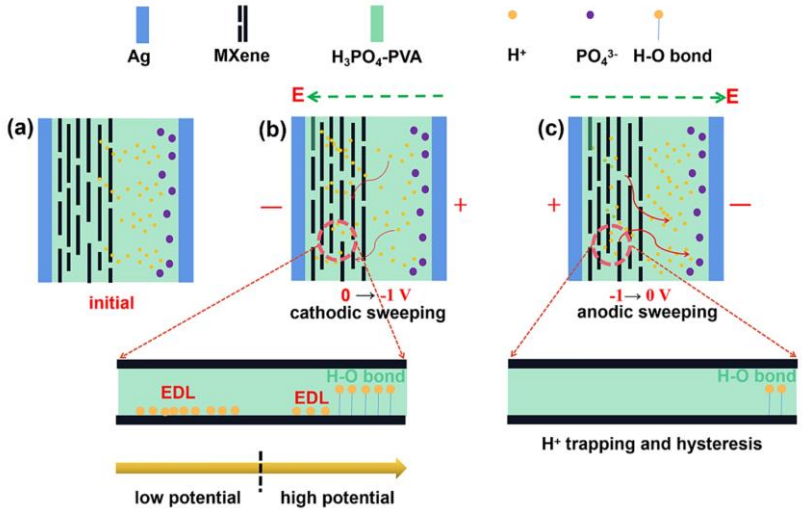

Figure 1: Modulation of H^+ ion transport behavior. (a) The initial state without external applied voltage. (b) Under the cathodic sweeping toward negative potential, and the corresponding EDL and weak hydrogen bond. (c) Under the anodic sweeping toward zero potential, and the trapping of H^+ ions due to the hydrogen bond.