5 - 37 Study on the Conductive Hysteresis of Mg^{2+} in Single Conical Nanopores

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A fundamental understanding of the ion transport mechanism in nanopores is of great importance for developing high-performance energy storage devices[1]. Previous studies have found the adsorption of multivalent cations (Mg^{2+}, Fe^{3+}) in high-concentration solution, and the resulting special effects including hysteresis have immense potential in the field of biological and chemical applications. However, the fundamental mechanism is not well-understood yet.

In this study, the ion conduction of the single conical nanopore in 0.01 mol/L $MgCl_2$ solution was investigated by measuring the current-voltage ($I-V$) characteristic with Ag/AgCl electrodes. The single conical nanopore was produced in polyethylene terephthalate (PET) film using single-ion hit combined with chemical etching. The measurements were performed at room temperature (about 25 ℃). The scanning voltage range was -2 to +2 V, and the scanning rate was 0.04 V/s.

Hysteresis is observed during the measurement, which is a phenomenon in that the current decreases with the increase of voltage when the voltage reaches a threshold. It is also found that the hysteresis became more obvious in subsequent scans as shown in Fig. 1. In particular, the hysteresis occur stably when the voltage reaches about 1.5∼2 V, and it may be attributed to the swing of carboxyl groups. When the voltage reaches the threshold, carboxyl groups swing towards the tip and combine with Mg^{2+}, resulting in the reduction of the free charge in the nanopore. The mechanism and modeling of the threshold in multivalent cations solution will be investigated in the future.

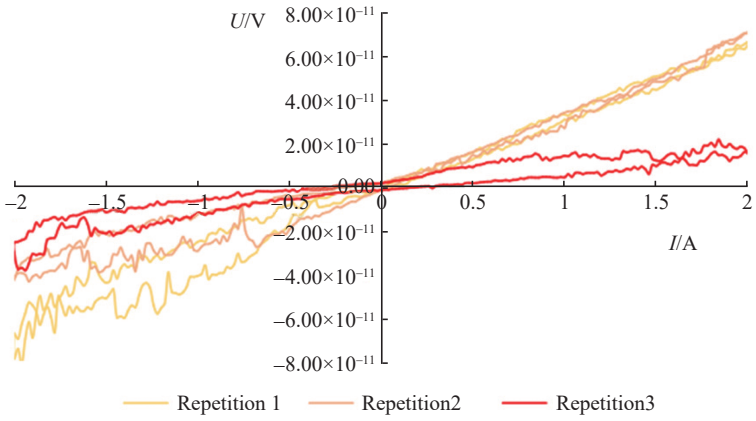

Fig. 1 (color online) Current-voltage characteristic of 0.001 mol/L Mg^{2+}. Three cycles were measured.

Reference

[1] T. Rukshan. Perera, P. Johnson, Martin A. Edwards, Henry S. White, Journal of Physical Chemistry C, 119(2015)24299.