Exploring 1/f noise behavior of ion current in a single channel of conically shaped pipette filled with electrolyte solution

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To address a fundamental question on the origin of 1/f noise of ion current observed in various artificial nanopore systems is considered to be a big challenge. Several experimental parameters such as pH, electrolyte concentration and bias voltage have been examined in order to insight into its mechanism [1-2]. These parameters have shown large effect on noise level. Among noise level, ion current, frequency and number of charged carrier, they follow a Hooge rule for most nanopores. So far, two possible mechanisms of 1/f noise have been proposed. It is supposed to be either related to different surface charge states or fluctuation of ion current depending on the different types of nanopores. To have a better understanding about origin and characters of 1/f noise, a new nanopore system is necessary to be tested.

Here, we utilize a single channel of quartz pipette with conical shape to investigate the 1/f noise behavior of ion current under different conditions. The pipette utilized has a pore size ranging from 4 nm to 12 nm (see fig.1a). For noise spectra measurement, the pipette filled with KCl solution remains a concentration difference from the bulk solution. The result from power spectrum density (PSD) shows that the noise level gradually increases with raising the bias voltage. The shape of noise spectrum at high frequency doesn't change with bias voltage attributed to capacitance, which is not significant in our study. Interestingly, we found that the noise exponent (α) obtained by fitting the noise spectra in a bandwidth ranging from 100 Hz to 10 kHz can be tuned by changing the bias voltage. The result in fig.1c gives the change tendency of noise exponent with bias voltage. With increasing the absolute value of bias voltage, the noise exponent increases. In addition, the results from fig.1b-c also suggest that the potential polarity has a large effect on the noise level and noise exponent. Our work will provide new insights into the noise behavior of ion current. Also, using proper frequency bandwidth of noise spectra will provide high efficiency and accuracy measurement for detecting single molecule and investigating protein-protein interactions

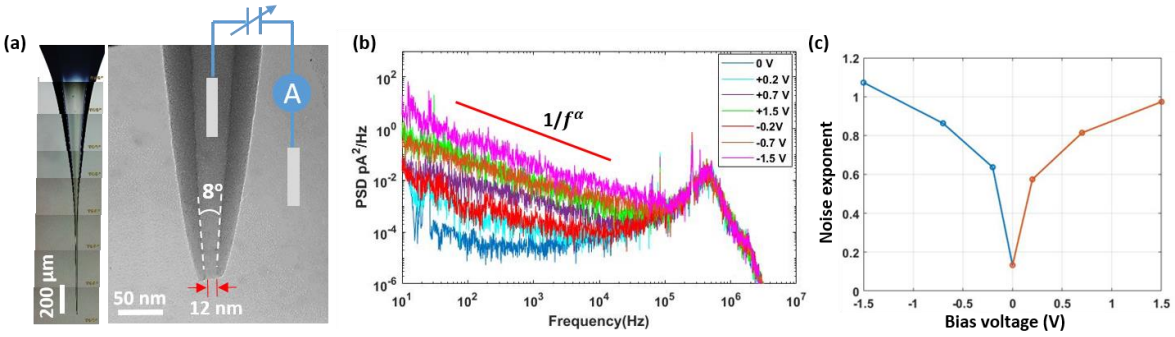

Figure 1 Analysis for noise spectrum of a conically shaped pipette (a) characterizing geometry and pore size of pipette, (b) power spectrum density of noise with changing bias voltage in a single channel of pipette and (c) change tendency of noise exponent with bias voltage.

Reference

1. S.M Bezrukov et.al., Phys Rev Lett. 2000, 85(1), 202-205.

2. D.P Hoogerheide et.al., Phys Rev Lett. 2009, 102, 1-4