Ion Current Oscillations Caused by Femtoliter Volume Precipitation in a Nanopore

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Abstract

The fixed negative surface charges inside single conical polymer nanopores result in transport properties not encountered in micrometer-scale counterparts. A notable example of an effect caused by these permanent negative charges is the enhancement of ionic concentration inside the pore when compared to the bulk solution. The nanopores described here are created with the track etching technique resulting in a very high open area ratio of over 95%. A new phenomenon is presented detailing an oscillating ionic current through our conical nanopore when a small amount of a divalent cation is added to a buffered monovalent ionic solution. An ionic current enhancement brought on by the superposition of the electric field from the fixed negative surface charges and the externally applied electric field causes a formation and redissolution of nanoprecipitates that temporarily block the ionic current through the pore. The frequency and character of these ionic current oscillations is regulated by the transmembrane potential and the chemistry of the nanoprecipitate. This oscillating system could be used as a model for studying nonlinear electrochemical processes and early stages of crystallization.

Nanopore Fabrication

Heavy Ion Irradiation

Chemical Etching

PBS Buffer Dependence on Calcium Induced Oscillations

Magnesium Hydroxide Precipitation

Modeling of the Theoretical Concentration for the Magnesium Hydroxide Precipitation

Power spectra of the ionic current recordings above. The peak between 10 Hz and 20 Hz for the -1,000 mV time series corresponds to oscillations of that frequency, which can be clearly seen from the time series.

Acknowledgements:

Irradiation with swift heavy ions was performed at the Gesellschaft fur Schwerionenforschung (GSI), Darmstadt, Germany. We thank the Alfred P. Sloan Foundation, the Institute for Surface and Interface Science and the Institute for Complex Adaptive Matter for financial support.