Ionic Conductance and Selectivity of Carbon Nanotube Porins

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Carbon nanotubes (CNTs) have narrow hydrophobic inner channels with diameters comparable to those of protein pores (0.6-1.5 nm) and enable fast transport of water and ions.[1-3] We are interested in using these CNTs to create robust and versatile synthetic membrane pores that mimic protein channel functionality. In our group, we have developed ultrashort CNTs with lengths on the order of 5-20 nm – carbon nanotube porins (CNTPs)[1, 4] - that self-insert into lipid membranes and form stable channels.[1, 4] In this study, we use a modified planar lipid bilayer platform based on a silicon nitride solid-state nanopore to quantify the ionic conductance and selectivity of CNTPs with diameters of 0.8 nm and 1.5 nm, respectively. We report the conductance of individual CNTPs, and show that it scales with the electrolyte concentration in a manner reminiscent of biological ion channels. CNTPs' ion transport selectivity, determined from reversal potential measurements under different electrolyte concentration ratios, shows that electrostatic effects at the CNTP ends play a major role in the selectivity mechanism. Moreover, manipulation of those charges can change the CNTP selectivity. Comparison between the properties of CNTPs of two different diameters also highlights the role the spatial confinement plays in shaping CNTP transport characteristics. Unique transport properties of CNTPs should enable researchers to use this new material in a variety of applications including water treatment and energy harvesting.

References

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