Synthetic Proton-Gated Ion Channels via Single Solid-State Nanochannels Modified with Responsive Polymer Brushes

Yameen B, Ali M, Neumann R, Ensinger W, Knoll W, Azzaroni O
Nano Letters xxxx Vol. XX No. x

The creation of switchable and tunable nanodevices displaying transport properties similar to those observed in biological pores poses a major challenge in molecular nanotechnology. Here, we describe the construction of a fully “abiotic” nanodevice whose transport properties can be accurately controlled by manipulating the proton concentration in the surrounding environment. The ionic current switching characteristics displayed by the nanochannels resemble the typical behavior observed in many biological channels that fulfill key pH-dependent transport functions in living organisms, that is, the nanochannel can be switched from an “off” state to an “on” state in response to a pH drop. The construction of such a chemical nanoarchitecture required the integration of stable and ductile macromolecular building blocks constituted of pH-responsive poly(4-vinyl pyridine) brushes into solid state nanopores that could act as gate-keepers managing and constraining the flow of ionic species through the confined environment. In this context, we envision that the integration of environmental stimuli-responsive brushes into solid-state nanochannels would provide a plethora of new chemical alternatives for molecularly design robust signal-responsive “abiotic” devices mimicking the function of proton-gated ion channels commonly encountered in biological membranes.