MAR13-2012-020813

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

Dramatic nano-fluidic properties of carbon nanotube membranes as a platform for protein channel mimetics[1]

BRUCE HINDS, University of Kentucky

Carbon nanotubes have three key attributes that make them of great interest for novel membrane applications: 1) atomically flat graphite surface allows for ideal fluid slip boundary conditions and extremely fast flow rates 2) the cutting process to open CNTs inherently places functional chemistry at CNT core entrance for chemical selectivity and 3) CNT are electrically conductive allowing for electrochemical reactions and application of electric fields gradients at CNT tips. Pressure driven flux of a variety of solvents (H2O, hexane, decane ethanol, methanol) are 4-5 orders of magnitude higher than conventional Newtonian flow [Nature 2005, 438, 44] due to atomically flat graphite planes inducing nearly ideal slip conditions. However this is eliminated with selective chemical functionalization [ACS Nano 2011 5(5) 3867-3877] needed to give chemical selectivity. These unique properties allow us to explore the hypothesis of producing "Gatekeeper" membranes that mimic natural protein channels to actively pump through rapid nm-scale channels. With anionic tip functionality strong electroosmotic flow is induced by unimpeded cation flow with similar 10,000 fold enhancements [Nature Nano 2012 7(2) 133-39]. With enhanced power efficiency, carbon nanotube membranes were employed as the active element of a switchable transdermal drug delivery device that can facilitate more effective treatments of drug abuse and addiction. Recently methods to deposit Pt monolayers on CNT surface have been developed making for highly efficient catalytic platforms. Discussed are other applications of CNT protein channel mimetics, for large area robust engineering platforms, including water purification, flow battery energy storage, and biochemical/biomass separations.

[1]DOE EPSCoR (DE-FG02-07ER46375) and DARPA, W911NF-09-1-0267