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Bio-inspired membrane nanoplatforms for engineering, biotechnology and medical applications

Carbon nanotubes have three key attributes 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 water is 4-5 orders of magnitude faster inside CNTs than conventional Newtonian flow [*Nature* **2005**, 438, 44] approaching speeds of aquaporin protein channels. This is due to atomically flat graphite planes inducing nearly ideal slip conditions. However the act of placing selective functional chemistry at pore entrance or along the core of CNTs, dramatically/completely eliminates the enhanced flow effects [*ACS Nano* **2011** 5 3867]. Needed is a protein channel biomimetic mechanism to pump chemicals through the pore where the selective chemistry. This has been achieved with electroosmotic pumping [*Nature Nano* **2012** 7 133-39] and is the active element of a smart-phone programmable transdermal nicotine patch [*PNAS* . **2010** 107 11698]. Also introduced here are biomimetic platforms using sequential enzymatic flow reactors, nanobubble valves and biomolecular separation pumps.

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