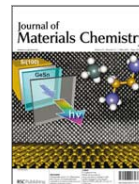


Journal of Materials Chemistry

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Hot paper: Carbon nanotube based biomimetic membranes: mimicking protein channels regulated by phosphorylation

13 April 2007

Leonidas Bachas tells *Journal of Materials Chemistry* about his hot paper.

1. Can you briefly describe what you achieved in this article?

This paper describes the use of membranes to mimic biological protein channels regulated by phosphorylation/dephosphorylation. The membranes consisted of an array of aligned carbon nanotubes (CNTs) with hollow graphitic cores passing across a solid polymer film. The open tips of the nanotubes were functionalized with a synthetic peptide. Phosphorylation and dephosphorylation of this synthetic peptide at the entrance of CNT cores are shown to modulate ionic flux through the membrane. Unlike protein channel models reported in the literature, to the best of our knowledge, this is the first report of a biomimetic system that is controlled by the same mechanism of phosphorylation/dephosphorylation that occurs in nature.

2. Could you explain the significance of your article to the non-specialist?

This research represents an example of man-made, large-area membrane that is gated by events that are found in natural protein channels. With this well-defined scaffolding with biochemical gating, we can have large scale chemical separations based on processes found in nature. Further, this architecture allows chemical sensing based on whether ionic diffusion is blocked by biochemical interactions at the pore entrance. An important point to make is that the CNT surface chemistry of the membrane allows for both enzyme activity and protein binding. Therefore, this protein channel mimetic approach is amenable to integration with many more protein channel systems.

3. What has motivated you to conduct this work?

It is a great challenge to engineer materials that mimic nature. The ability to reconstruct membrane protein channels using lipid bilayer membranes has led to important discoveries. Unfortunately, synthetic lipid bilayer membranes are fragile. The carbon nanotube-based membranes present a stable scaffold that can be functionalized with biomolecules. Biomolecular interactions can then be used to control the flow through the membrane.

4. Where do you see this work developing in the future?

This work is a biomimetic approach to a ligand binding protein channel. One can envision expansion of this work to other protein channels or channels that have different chemistries at the two ends of the nanotubes (inner and outer surface of the membrane). Thus, biological systems in which an extracellular binding event triggers a response in the intracellular surface of the membrane could be replicated.

5. Are there any particular challenges facing future research in this area?

One of the greatest challenges is to control the flow through the membrane of energy-rich molecules, such as adenosine 5'-triphosphate (ATP), and to couple this transport with additional microfabricated elements for the design of macro- and nanomachines. Such systems are of significant importance in various areas of research including nanomedicine.



Leonidas Bachas and Bruce Hinds

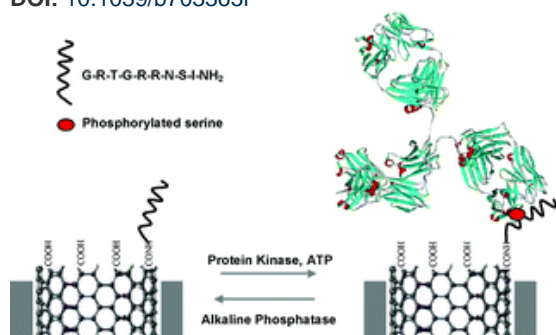
Leonidas Bachas (left) is the Frank J. Derbyshire Professor of Analytical and Biological Chemistry at the University of Kentucky. He received a B.S. degree from the University of Athens, Greece, an M.S. in Engineering from the University of Michigan, and a Ph.D. in Analytical Chemistry from the University of Michigan in 1986. After a postdoctoral appointment at Michigan, he joined the faculty at the University of Kentucky. His research interests include electrochemical and optical sensors, microfabrication, bionanotechnology, and the use of recombinant DNA techniques in the design of integrated sensing architectures. Dr. Bachas was the recipient of the 1993 Young Investigator Award of the Society for Electroanalytical Chemistry, as well as awards from the Society for Analytical Chemists of Pittsburgh and American Cyanamid.

Bruce Hinds (right) has a unique background in Chemistry and electronic device processing. Bachelor studies were in general Chemistry at Harvey Mudd College in California ('91). His Ph.D. ('96) work was on the CVD growth of high temperature superconductors at Northwestern University with Prof. Tobin Marks. Upon completion of the degree, he went on to post-doc with Gerry Lučovský at NC State Physics to learn about semiconductor processing and interface states in the Si/SiO₂ system. After 2 years, he then had an exciting opportunity to learn about nano-scale fabrication at the Tokyo Institute of Technology with Prof. Shunri Oda. This research effort was based on memory devices that stored a single electron in a nano-crystal of silicon. He then joined the faculty in Materials Engineering at the University of Kentucky in 2001 to develop novel nanofabrication methods.

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