Dear Faculty, IGERT Fellows, IGERT Associates and Students,

You are cordially invited to attend a Seminar presented by Dr. Valentine Vullev. Please plan to attend.

Dynamics in a Broad Scale

Valentine I. Vullev

Departments of Bioengineering, Chemistry, and Biochemistry, and
Materials Science and Engineering Program,
University of California, Riverside

Date: Friday, April 27, 2012
Location: WCH 205/206
Time: 11:10am

Abstract:

Understanding and utilizing dynamics, at various time scales and system sizes, represent an underlying theme for most research projects in my group. Subpicosecond charge separation (at a molecular scale) and millisecond to second fluid dynamics (in microfluidic devices, at micrometer and millimeter scales) represent some of the extreme length and time scales that we investigate. A range of synthetic, analytical, design and fabrication techniques, broadly used in my lab, offer a liaison between basic science and applied engineering. Nonlithographic fabrication, print-and-peel (PAP), allows for expedient and facile device prototyping, offering key venues for expanding of the microfludics application beyond their current realm. This presentation will review the development of PAP and focus on the means for utilizing fluid dynamics for time-resolved spectroscopy. The laminar nature of microflows characterized with low Reynolds numbers, allowed us to rely solely on steady-state imaging for extracting excited-state kinetics of luminescent systems, demonstrating space-domain time-resolved spectroscopy. Our microfluidics work in bacterial biosensing lead us to an important insight about the dynamics of staining as a key characteristic of bacterial species. We observed that, under certain conditions, the kinetics of fluorescence staining, quantified as a time constant of the

bacterium-induced emission enhancement, does not manifest concentration dependence. Concurrently, the kinetics did depend on the bacterium and on the staining dye and was statistically discernable for many of the different species that we investigated. This finding presents an important venue for bringing the bioanalytical methodologies beyond their century-old tradition of Boolean logic. In relevance to solar energy conversion, the second part of the talk will focus on the kinetics of photoinduced charge transfer mediated by biomimetic and bioinspired systems. Protein-mediated electron-transfer processes sustain a broad range of redox functions in biological systems, such as respiration and photosynthesis. Therefore, such biological systems are indispensable "working" models for molecular design and for the development of materials for solar-energy-conversion and electronics applications. Modulation of charge transfer by local electric fields presents an alternative approach for achieving long-lived charge-separated states. Macromolecular electrets provide local field gradients in the order of 0.1 GV/m and degeneracy of charge-transfer states essential for directionality of electron and hole entrainment. (Electrets are the electrostatic equivalent of magnets: i.e., they possess ordered electric dipoles.) The presentation will cover our designs of bioinspired electrets and discuss their properties. The third part of the talk will cover our advances in single-molecule force-modulated kinetics. This methodology offers unique capability for direct observation of a range of structure-function relations. For example, it is the only experimental approach that allows direct estimation of the displacements of the transition states during bimolecular interactions. Despite the conceptual simplicity of single-molecule force techniques, certain experimental design challenges, which will be discussed, have prevented such methodologies from becoming routinely used tools. Employing controlled surface chemistry, for example, allows us to address some of these issues.

Bio:

Val Vullev was born in Bulgaria and he graduated from the National Gimnazia (High School) for Science and Math, Chemistry Major, where he was involved in research in nitrogen fixation and transition-metal electrochemistry. Val started his higher education at University of Sofia, but after moving to U. S., he received an academic

scholarship to finish his undergraduate studies in chemistry and physics at Keene State College.

V. Vullev obtained his Ph.D. in chemistry from Boston University under the supervision of Prof. Guilford Jones. His research was in the areas of photochemistry and biophysics, encompassing polypeptide biomimetics of solar-energy-conversion systems and macromolecular self-assembly.

To expand his expertise in surface science, Val Vullev joined the group of Prof. George Whitesides at Harvard University, as a postdoctoral fellow. His postdoctoral research was in the areas of optofluidics, molecular electronics and single-molecule biophysics.

In 2006, Val Vullev moved from the Northeast to Southern California to join the faculty of Bourns School of Engineering. He was involved in the establishment of the Department of Bioengineering, placing him among the first faculty members of the newest department at UCR. He also is a faculty member of the Department of Chemistry and the Department of Biochemistry at UCR.

Presently, the Vullev group is involved in quite an interdisciplinary research in the areas of microfluidics, microbiology, biophotonics, photoinduced charge transfer, surface engineering and macromolecular biophysics.