UCRIVERSIDE | Mechanical Engineering

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“More is More”: Precision Microfluidics of Large Volumes

Microfluidics gained prominence with the application of microelectromechanical systems (MEMS) to biology in an attempt to benefit from the miniaturization of devices for handling of minute samples of fluids under precisely controlled conditions. Microfluidics exploits the differences between micro- and macro-scale flows, for example, the absence of turbulence, electro- osmotic flow, surface and interfacial effects, capillary forces in order to develop scaled-down biochemical analytical processes. The field also takes advantage of MEMS and silicon micromachining by integrating micro-sensors, micro-valves, and micro-pumps as well as physical, electrical, and optical detection schemes into microfluidics to develop the so-called “micro-total analysis systems (mTAS)” or “lab-on-a-chip” devices. However, the ability to process ‘real world-sized’ volumes efficiently has been a major challenge since the beginning of the field of microfluidics. This begs the question whether it is possible to take advantage of microfluidic precision without the limitation on throughput required for large-volume processing? The challenge is further compounded by the fact that physiological fluids are non-Newtonian, heterogeneous, and contain viscoelastic living cells that continuously responds to the smallest changes in their microenvironment. Our efforts towards moving the field of microfluidics to process large-volumes of fluids was counterintuitive and not anticipated by the conventional wisdom at the inception of the field. We metaphorically called this “hooking garden hose to microfluidic chips.” We are motivated by a broad range of applications enabled by precise manipulation of extremely large-volumes of complex fluids, especially those containing living cells or bioparticles. This presentation will provide a summary of our efforts in bringing microfluidics to large volumes and complex fluids as well as various applications such as the isolation of extremely rare circulating tumor cells from whole blood. The use of high-throughput microfluidics to process large-volumes of complex fluids (e.g., whole blood, bone marrow, bronchoalveolar fluid) has found broad interest in both academia and industry due to its broad range of utility in medical applications.

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Mehmet Toner

Mehmet Toner, PhD, received a Bachelor of Science degree from Istanbul Technical University in 1983 and a Master of Science degree from the Massachusetts Institute of Technology (MIT) in 1985, both in Mechanical Engineering. He subsequently completed his PhD in Medical Engineering at the Harvard-MIT Division of Health Sciences and Technology (HST) in 1989. Dr. Toner joined the faculty at the Massachusetts General Hospital and Harvard Medical School as an Assistant Professor of Biomedical Engineering in 1989, and was promoted to Associate Professor in 1996, and to Professor in 2002. Dr. Toner has a joint appointment as a Professor of Health Sciences and Technology at the Harvard-MIT Division of HST. Dr. Toner serves as a member of the Senior Scientific Staff at the Shriners Hospital for Children. He has published over 200 scientific publications and has delivered over 350 invited and scientific meeting presentations. In the field of tissue engineering, he is working to create a bioartificial liver device, engineer skin tissue and is examining cell-cell interactions in engineered complex tissues. In the field of cryobiology and biostabilization, his research focuses on stabilizing mammalian cells and engineered tissues, anhydrobiosis and metabolism, and also the thermodynamics and physical chemistry of phase changes in tissue. In the field of microfluidics and micro/ nanosystems engineering, he is working on living cell devices, microfluidics in biology and medicine, microfluidic blood processing, and the integration of living cells and micro-engineered tissue units into micro-devices. In the field of global health, he creates point of care monitoring for HIV/AIDS, more efficient methods of diagnosing and monitoring of tuberculosis, and manipulating viral particles. In the field of cancer metastasis, Dr. Toner is researching circulating tumor cell biology, and developing a microchip to help sort rare cells.