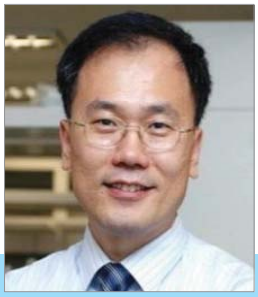
NanoBiotech Laboratory 2018



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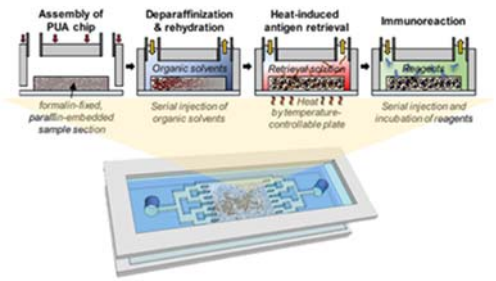
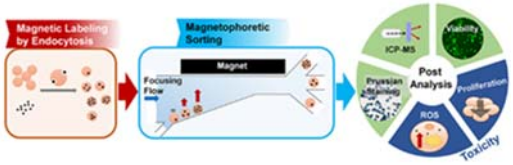
NanoBiotech Laboratory (NBL) has been interested in developing novel microfluidic and lab-on-a-chip devices as a new platform for biological sample processing, separation, and detection. Microfluidics is a key technology for the realization of micro total analysis systems (μTAS) and lab-on-a-chip in the areas of drug discovery, medical diagnostics, and tissue engineering due to several advantages such as precise fluid handling, low reagent consumption and potentially massive parallelization of experiments. In particular, microfluidic cell culture allows control of fluid flow on the micrometer-scale on the basis of diffusion transport and provides more in vivo-like environments for organ function-on-a-chip. Our recent development of microfluidic analytical technologies includes optoelectrofluidics, hydrophoretic separations, magnetophoretic assays, and microfluidic immunohistochemistry. Currently, we are focusing on the practical aspects of microfluidic diagnostic devices and multicellular 3D assay platforms. Since June 2008, his laboratory has been selected to receive a National Leading Research Laboratory Program grant through the National Research Foundation of Korea, funded by the Ministry of Science and ICT.

Microfluidic on-chip immunohistochemistry: In this study, we first demonstrate a novel microfluidic platform that can perform whole immunohistochemistry (IHC) processes on a formalin-fixed paraffin-embedded (FFPE) section slide. To enable whole IHC processes in an organic solvent-resistant device, our microfluidic chip was fabricated using polyurethane acrylate (PUA). After assembling a FFPE sample section with a PUA chip using a pressure-based reversible sealing method, the deparaffinization, antigen retrieval, and immunostaining processes were carried out continuously. Based on all on-chip IHC processes, we characterized the effectiveness of each on-chip process and compared with conventional IHC results using cancer cell or tissue-section slides. It is expected that our on-chip microfluidic platform will provide a practical application of microfluidics in local clinical laboratories.

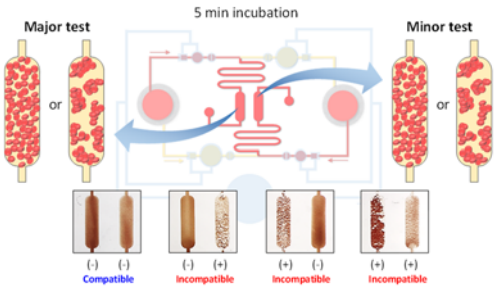


Toxicity assessment in magnetophoretic sorted cells: For the assessment of the toxicity of iron oxide nanoparticles based on cellular magnetic loading, we describe a microfluidic magnetophoresis device consisting of a trapezoidal channel and a narrow rectangular channel. This unique structure enables the sequential separation of cells loaded with tiny amounts of iron oxide (less than 10 pg of iron per cell) and cells heavily labeled with iron oxide, labeled with iron oxide, in a single device. As a demonstration of the concept, we evaluated the toxicity of

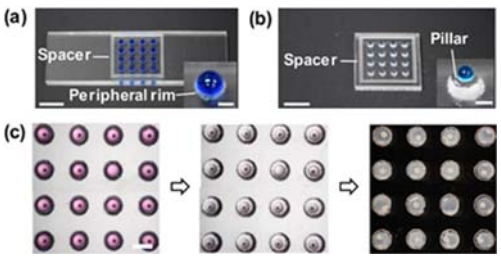


magnetically labeled Raw 264.7 cells, which were sorted into seven subpopulations according to their mean iron oxide loading. The proposed system could be useful to assess the toxicity of iron oxide nanoparticle labeled cells based on their magnetic loading.

Finger-actuated microfluidic device for the blood test: A new finger-actuated microfluidic device is designed to reduce finger actuation-induced user-dependent errors. The fluidic channel is separated into the pneumatic channels so that the pneumatic valves and the actuation chamber are indirectly controlled by the pressure change in the pneumatic channels. Due to the unique feature of the device, the dispensed volume is determined as a volume of the actuation chamber regardless of the pushed depth of the pressure chamber, the pushing time interval, and the end-users. In addition, multiple fluids can be simultaneously dispensed with a desirable ratio by connecting several pneumatic channels into a single pressure chamber. Finally, a blood cross-matching test in a finger-actuated microfluidic device was demonstrated.



Spheroid array using droplet contact-based spheroid transfer: Spheroids are one of the most representative models of 3D cell culture, which can be easily formed using conventional hanging drop method. However, medium changes and spheroid transferring processes are the bottlenecks that reduce the throughput of the entire process in the hanging drop culture. In addition, the embedment of spheroid into hydrogel still depends on the individual pipetting process. In this work, PDMS-based drop/pillar array chips (DAC/PAC) were designed to allow repetitive spheroid transfer with the contact of two drops on each side, which can be applied to both medium change and spheroid transfer, as well as long-term cultivation of the spheroid in the hanging drop. We also demonstrate a new method for simultaneously embedding the spheroids into the corresponding collagen hydrogel drops, contacting the spheroid-containing DAC with the PAC, and then contacting the spheroid-containing PAC with the collagen-loaded DAC. Besides the culturing and embedment of the spheroids, we expect that many kinds of multi-step assays for the spheroids will be possible in a high-throughput manner with the droplet-contact based spheroid transfer chips.



Key Achievements

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3. W. Lee, J. C. Debasitis, V. K. Lee, J.-H. Lee, K. Fischer, K. Edminster, J.-K. Park, and S.-S. Yoo*, "Multi-layered culture of human skin fibroblasts and keratinocytes through three-dimensional freeform fabrication," Biomaterials, Vol. 30, No. 8, pp. 1587-1595, March, 2009. (Cited by 307)
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5. M. G. Lee, J. H. Shin, C. Y. Bae, S. Choi, and J.-K. Park*, "Label-free cancer cell separation from human whole blood using inertial microfluidics at low shear stress," Analytical Chemistry, Vol. 85, No. 13., pp. 6213–6218, July, 2013. (Cited by 101)

Achievement in This Year

1. J. H. Shin, J. Hong, H. Go, J. Park, M. Kong, S. Ryu, K.-P. Kim, E. Roh*, and J.-K. Park*, "Multiplexed detection of foodborne pathogens from contaminated lettuces using a handheld multistep lateral flow assay device," *Journal of Agricultural and Food Chemistry*, Vol. 66, No. 1, pp. 290-297, January, 2018.
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3. J. Park and J.-K. Park*, “Finger-actuated microfluidic device for the blood cross-matching test,” *Lab on a Chip*, Vol. 18, No. 8, pp. 1215-1222, April, 2018.
4. S. Lee, J. Park, and J.-K. Park*, "Foldable paper-based analytical device for the detection of an acetylcholinesterase inhibitor using an angle-based readout," *Sensors and Actuators B: Chemical,* Vol. 273, pp. 322-327, November, 2018.
5. H. Kim, C. H. Cho, and J.-K. Park*, "High-throughput culture and embedment of spheroid array using droplet contact-based spheroid transfer," *Biomicrofluidics*, Vol. 12, No. 4, 044109, July, 2018.
6. C. H. Cho, S. Kwon, S. Kim, Y. Hong, P. Kim, E. S. Lee, and J.-K. Park*, "Microfluidic on-chip immunohistochemistry directly from a paraffin-embedded section," *Biomicrofluidics*, Vol. 12, No. 4, 044110, July, 2018.
7. G.-Y. Kim, J.-I. Han, and J.-K. Park*, "Inertial microfluidics-based cell sorting," BioChip Journal, Vol. 12, No. 4, pp. 257-267, December, 2018.