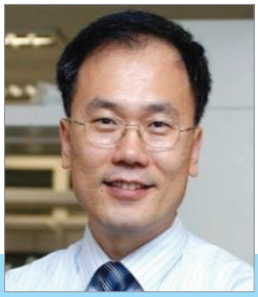
NanoBiotech Laboratory



Park, Je-Kyun
Professor

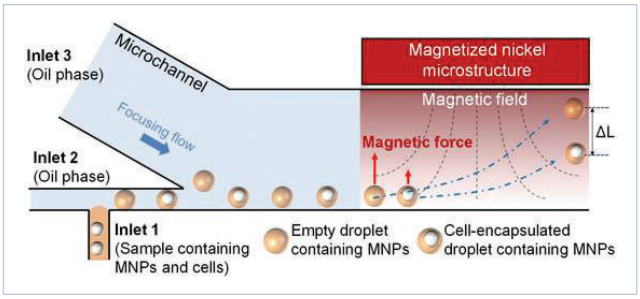
PH.D., KAIST [1992]
jekyun@kaist.ac.kr
http//nanobio.kaist.ac.kr

Director, The Chemical and Biological Microsystems Society (CBMS)
2016 President, The Korean BioChip Society (KBCS)

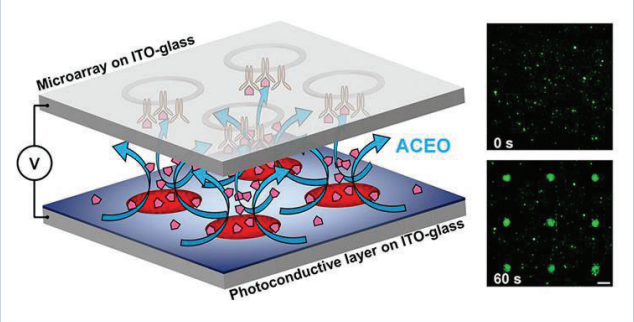
Recent progress in lab-on-a-chip technology is a challenge for the development of nanobiotechnology and integrative bioengineering. In particular, micro/nano fluidics is a key technology for the realization of micro total analysis systems (μTAS) or lab-on-a-chip, as well as the next generation bio-tools for drug discovery, diagnostics and tissue engineering. This research area includes the design and development of miniaturized devices that manipulate liquid samples at nanoliter volumes, allowing biological assays to be integrated and accomplished on a small scale with minimum time and cost. Prof. Park's research focuses on the development of a nanobiosensor, microfluidic device and lab-on-a-chip as a new platform for biological sample processing, separation, and detection, including optoelectrofluidics, hydrophoretic separation, magnetophoretic assay, and cell-based assay. 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, ICT and Future Planning

Stackable micropatterned hydrogel sheets for 3D cellular architecture: A simple method for forming large-scale cell–hydrogel assemblies has been developed by stacking cell-embedded mesh-like hydrogel sheets to create complex macroscale cellular scaffolds [1]. In particular, we focused on the fabrication of mesh-like hydrogel sheets with precise micropatterns and simple stacking of the same or different hydrogel sheets. Good alignment and easy manipulation of the stacked hydrogel sheets were also demonstrated using a PDMS drainage well and a filter paper. This cell–hydrogel assemblies provide high cell viability and functional improvement as compared to a single hydrogel sheet. The stacked hydrogel sheets have significant potential as a macroscale cell culture and assay platform with complex microenvironments for biologically relevant in vitro tissue-level drug assays and physiological studies.

Single cell sorting using magnetophoresis: Droplet microfluidics is a promising tool for single-cell analysis, since single cell can be comparted inside a tiny volume. In this work, the same-sized droplets contain approximately equal amounts of magnetic nanoparticle (MNPs) showing the same degree of magnetization under the constant magnetic field in a microchannel. However, the droplets containing single cells have

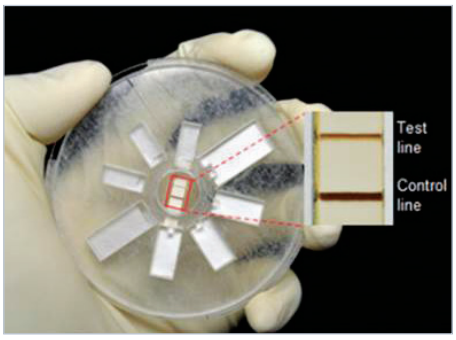


a reduced number of MNPs as much as the volume of the cell inside the droplet, resulting in a low magnetic force. To sort out the single cell-encapsulated droplets, we exploit this different magnetic force between the single cell-encapsulated droplet and empty droplet caused by the change in the number of MNPs inside the droplet [2]. Consequently, we sorted single microalgae-containing droplets from empty droplets with 〉 94% purity. We expect this new platform to be integrated into a single cell analysis system considering effectiveness and convenience.



Optoelectrofluidic immunoassay based on optically-induced dynamic AC electroosmosis: A novel optoelectrofluidic immunoreaction system based on electroosmotic flow has been shown to enhance antibody–analyte binding efficiency on a surface-based sensing system [3]. Under the application of AC voltage, an illuminated light pattern on the photoconductive layer causes strong counter-rotating vortices to transport analytes from the bulk solution to the vicinity of the assay spot on the antibody-immobilized glass substrate. By integrating an optoelectrofluidic device with a glass-based conventional microarray format, optically-induced AC electroosmotic flows actively enhanced the mass transport of molecules to the multiple assay spots of the microarray simultaneously, thereby reducing reaction times. We believe that the proposed immunoreaction system could be used for enhanced multiple protein detection using a conventional microarray.

A rotary device for enzyme-linked immunosorbent assay: We Recently, we presented a new functional packaging method for simple the sequential delivery of multiple reagents to a lateral flow strip. Multistep lateral flow assays were considered to be complicated and laborious processes. By using this device, however, such a process can be performed by hand with simple rotary movement. As a demonstration, we perform an enzyme-linked immunosorbent assay on a lateral flow strip and detect Escherichia coli O157:H7. Instead of multiple pipetting and pad replacement steps, the detection was achieved simply by incremental rotation of the device. The device is expected to simplify many of the existing multistep assays and be applied for a wide range of purposes, including point of care testing, environmental monitoring, and on-site detection.



Key Achievements

1. K. S. Kim, **J.-K. Park**, "Magnetic force-based multiplexed immunoassay using superparamagnetic nanoparticles in microfluidic channel," *Lab on a Chip*, Vol. 5, No. 6, pp. 657-664, June, 2005. (Cited by 197)
2. M. S. Kim, J. H. Yeon, **J.-K. Park**, "A microfluidic platform for 3-dimensional cell culture and cell-based assays," *Biomedical Microdevices*, Vol. 9, No. 1, pp. 25-34, February, 2007. (Cited by 165)

3. S. Choi, S. Song, C. Choi, **J.-K. Park**, "Continuous blood cell separation by hydrophoretic filtration," *Lab on a Chip*, Vol. 7, No. 11, pp. 1532-1538, November, 2007. (Cited by 139)
4. H. Hwang, Y.-J. Choi, W. Choi, S.-H. Kim, J. Jang, **J.-K. Park**, "Interactive manipulation of blood cells using a lens-integrated liquid crystal display based optoelectronic tweezers system," *Electrophoresis*, Vol. 29, No. 6, pp. 1203-1212, March, 2008. (Cited by 78)
5. E. Um, D.-S. Lee, H. B. Pyo, **J.-K. Park**, "Continuous generation of hydrogel beads and encapsulation of biological materials using a microfluidic droplet-merging channel," *Microfluidics and Nanofluidics*, Vol. 5, No. 4, pp. 541-549, October, 2008. (Cited by 63)
6. M. S. Kim, T. Kim, S.-Y. Kong, S. Kwon, C. Y. Bae, J. Choi, C. H. Kim, E. S. Lee, **J.-K. Park**, "Breast cancer diagnosis using a microfluidic multiplexed immunohistochemistry platform," *PLoS One*, Vol. 5, No. 5, e10441, May, 2010. (Cited by 47)
7. M. G. Lee, J. H. Shin, C. Y. Bae, S. Choi, **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 59)

Achievement In This Year

1. a) J. Son, C. Y. Bae, **J.-K. Park**, "Construction of modular hydrogel sheets for micropatterned macro-scaled 3D cellular architecture," *Journal of Visualized Experiments*, Vol. 107, e53475, January, 2016; b) J. Son, C. Y. Bae, J.-K. Park, "Freestanding stacked mesh-like hydrogel sheets enable the creation of complex macroscale cellular scaffolds," Biotechnology Journal, Vol. 11, No. 4, pp. 585-591, April, 2016.
2. Y. Jo, F. Shen, Y. K. Hahn, J.-H. Park, **J.-K. Park**, "Magnetophoretic sorting of single cell-containing microdroplets," *Micromachines*, Vol. 7, No. 4, 56, April, 2016.
3. a) D. Han, **J.-K. Park**, "Optoelectrofluidic enhanced immunoreaction based on optically-induced dynamic AC electroosmosis," *Lab on a Chip*, Vol. 16, No. 7, pp. 1189-1196, April, 2016; b) D. Han, J.-K. Park, "Microarray-integrated optoelectrofluidic immunoassay system." Biomicrofluidics, Vol. 10, No. 3, 034106, May, 2016.
4. J. H. Shin, **J.-K. Park**, "Functional packaging of lateral flow strip allows simple delivery of multiple reagents for multistep assays," *Analytical Chemistry*, Vol. 88, No. 21, pp. 10374-10378, November, 2016.