****

臺灣大學應用力學研究所
演 講 公 告

****

主 講 人：陳定璿 副教授
香港城市大學 生物醫學工程學系

講　　題：Quantitative At-home Rapid Tests Based on Microfluidic Particle Dam: Sample-to-Result on a Single Chip for Remote Healthcare

摘　　要： 如附件

主 持 人： 陳建甫教授

時　　間： 114年04月14日（星期一）下午2時20分開始

地　　點： 臺灣大學應用力學研究所國際會議廳

☆☆ 歡迎聽講，敬請張貼 ☆☆

Quantitative At-home Rapid Tests Based on Microfluidic Particle Dam: Sample-to-Result on a Single Chip for Remote Healthcare

Department of Biomedical Engineering, City University of Hong Kong, Hong Kong S.A.R.
E-mail : thchen@cityu.edu.hk

Abstract

The COVID-19 pandemic has popularized the use of home-use rapid tests, demonstrating immense potential of at-home self-screening and management of personal healthcare. With the fading of COVID-19, the concept of at-home self-tests are repurposed to management of other chronic or infectious diseases, hoping to attenuate the time-consuming and complicated re-examination in the hospital and relax the healthcare systems. Many healthcare indices need quantitative results determine conditions. For example, urinary albumin concentration has been used to evaluate the risk of cardiovascular disease or stage of chronic kidney disease, while antibody level can self-evaluate the immune protection after vaccination during pandemic. However, the commonly used rapid test based on lateral flow immunoassay is only qualitative, which is insufficient to give out the actual levels of health indices. On the other hand, chronic diseases or infectious diseases are highly prevalent in high-risk, elderly population who may be physically challenged or socially underprivileged. Therefore, despite in-vitro diagnostic devices (IVDs) for quantitative measurement are widely available, they are often too expensive for home use.

Here I will report a concept of quantitative at-home rapid tests. This device uses a pair of magnetic microparticles (MMPs) and polystyrene microparticles (PMPs) that bind to target analytes directly, or bind to a target-dependent linker. After loading to a capillary-driven microfluidic chip, the altered interparticle connection, which reflects the quantitative level of target analytes, can be visualized by the length of PMP accumulation at the microfluidic particle dam after magnetic separation. This generic platform has been applied for detecting trace heavy metals such as Pb^{2+}, Cu^{2+}, Ag^{+}, Cd^{2+}, in our water systems. Moreover, we also demonstrate the application of protein biomarkers for applications such as immune protection after COVID vaccination, risk level of hepatocellular carcinoma, and early diagnosis of malignant melanoma when integrating with microneedle patches. Additionally, using short DNA oligonucleotide as the mediator, this platform can also reflect small molecules such as creatinine, and enzymatic activities of uracil-DNA glycosylase and flap endonuclease 1. This all-in-one, self-contained detection kit eliminates the need for external devices, offering rapid, simple, affordable, and quantitative detection truly penetrative to all classes of society, providing unprecedented home healthcare for our aging society.

摘要

新冠疫情引領了家用快測的廣泛使用，體現居家自我健康篩查與管理的巨大潛力。隨著新冠的消退，居家自檢的概念也被推及至慢性病或傳染病的管理，有望減少耗時且繁瑣的醫院複檢，舒緩醫療系統。然而，許多健康指數需定量結果來評估病情，例如尿液白蛋白濃度用於評估心腦血管病風險或慢性腎病的階段，或是借抗體濃度在大規模傳染病時自我評估疫苗保護力。但坊間通行的膠體金快測僅定性，無法適用。另外，由於慢性病或傳染病高發於老年人群，其面臨身體上的挑戰或社會上的不利條件。因此，儘管有許多體外診斷設備（IVDs）可提供定量結果，但其昂貴價格使其無法家用普及。

這裡我將介紹一種可定量的家庭快速檢測概念。該裝置使用一對磁性微球（MMPs）和聚苯乙烯微球（PMPs）。這些微球可以直接與目標分析物結合，或與目標反應依賴的連接物結合。載入到毛細驅動的微流晶片後，目標分析物的定量水平造成的粒子連接變化可借磁分離後 PMP 在微流粒子壩處積累

的長度進行視覺量化。這個通用平臺已被應用于檢測我們水系統中的痕量重金屬，如Pb^{2+}、Cu^{2+}、Ag^{+}、$Cd2^{+}$。此外，我們還展示了在與微針貼片整合時，該平臺在蛋白質生物標誌物上的應用，例如 COVID 疫苗接種後的免疫保護、肝細胞癌的風險水準，以及惡性黑色素瘤的早期診斷。另外，使用 DNA 短鏈寡核苷酸作為介質，該平臺還可以反映小分子如肌酐，以及尿嘧啶-DNA 糖基化酶和瓣狀核酸內切酶 1 的酶活性。這個一體化、自包含的檢測套件無需外部設備，提供快速、簡單、經濟和定量的檢測，能真正滲透到社會的各個階層，為我們的老齡化社會提供前所未有的家庭醫療保健。

Short Bio

Ting-Hsuan Chen received his B.S. degree (2003) and M.S. degree (2005) in National Tsing Hua University, Taiwan, and obtained his Ph.D. degree in Mechanical Engineering at University of California, Los Angeles (2012). He is currently an Associate Professor in Biomedical Engineering at City University of Hong Kong. Dr. Chen has been spearheading projects leveraging the micro/nanotechnology for biomedical applications. Using micropatterning to study the pattern formation of mammalian cells, he has made a fundamental discovery of cell's intrinsic left-right bias and successfully exploited this finding to engineer patterns of microtissue. More recently, he has pioneered in combining microparticles in microfluidics for visual quantification of target molecules such as metal ions for intoxication or protein biomarkers for point-of-care applications. The research achievement has led to establishment of Cimple Biotechnology, which has been awarded with HK Tech 300 Angel Fund, the Incu-Bio Programme of Hong Kong Science and Technology Park, and secured Technology Start-up Support Scheme for Universities (TSSSU). Many of his achievement was featured as cover stories in prestigious journals such as Circulation Research, ACS Sensors, and Biotechnnology and Bioengineering, or published in top-tier journals such as Science Advances, Advanced Science, ACS Nano, and Biomaterials. He has served on the organizing committee for several international IEEE conferences, including IEEE NEMS and IEEE NANOMED.