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The Research Grants Council of Hong Kong
NSFC/RGC Joint Research Scheme
Joint Completion Report

(Please attach a copy of the completion report submitted to the NSFC by the Mainland researcher)

Part A: The Project and Investigator(s)

1. Project Title

Design and synthesis of advanced functional materials from microfluidic approaches

2. Investigator(s) and Academic Department/Units Involved

	Hong Kong Team	Mainland Team
Name of Principal Investigator *(with title)*	Weijia Wen	Jianhua Qin
Post	Professor	Professor
Unit / Department / Institution	Physics/HKUST	Dalian institute of chemical physics, CAS
Contact Information		
Co-investigator(s) *(with title and institution)*		

3. Project Duration

	Original	Revised	Date of RGC/ Institution Approval *(must be quoted)*
Project Start date	01/01/2012		
Project Completion date	31/12/2014		
Duration *(in month)*	36		
Deadline for Submission of Completion Report	31/12/2015		

Part B: The Completion Report

5. Project Objectives

5.1 Objectives as per original application

1. Design and fabricate microfluidic chips and control systems
2. Produce solid, hollow and core-shell microspheres and fabricate nano-materials using the microfluidic flow-focusing (MFF) and continuous flowing methodologies.
3. Characterize the properties of the produced materials and explore the applications in different fields.

5.2 Revised Objectives

Date of approval from the RGC: _____

Reasons for the change: _____

_____

1.
2.
3. ....

6. Research Outcome

Major findings and research outcome
(maximum 1 page; please make reference to Part C where necessary)

The important findings are described as following;

1) New design and fabrication of different types of microspheres by microfluidic methodology. The co-focusing microfluidic chips with multi-channels are successfully used for honeycomb and solid as well as porous microspheres productions and the sizes and components of microspheres could be easily adjusted via changing the multi-channel inputs as well as flow rate of input components. The microspheres can be functioned by doping of other materials and the bio-compatible properties can be realized.

2) We achieved the fabrication of PLGA nanofibers with arrayed structure and controllable structural cues on the surface, and further demonstrated the important applications of this new class of nanofiber scaffolds by characterizing MSCs stem cell behaviors on the 3D nanofiber scaffolds array and conducting anti-cancer drug testing in cancer cells on the micro-nanoscale hybridized platform.

3) With microfluidic approach, we have successfully grafted NIPAM onto PDMS surface with concentration gradients and photopolymerization process, leading to realization of surface roughness gradients in a highly controllable manner. The surface modification by microfluidic technique can be adopted to quickly generate substrates with a wide range of surface roughness in nanoscale. The magnitude of the average surface roughness in this work was well controlled within range up to $\sim 163.6 \pm 11.7$ nm. Via tuning the flow rate ratios between two injecting streams containing NIPAM monomer and DI water, five samples with different extents of roughness values were successfully prepared. Finally, sample G5 was adopted as the substrate for cell culture where the diverse degrees of surface roughness reveal to be playing an important role to define the cell behaviors. It was concluded that the number of attached cells and the areas of attached cell were both reduced with correspondence to the degree increase of surface roughness. It is believed that such a versatile approach of engineering surface roughness gradients can be broadly applied in various aspects from tissue engineering to cell investigations.

Potential for further development of the research and the proposed course of action *(maximum half a page)*

Functioned microspheres with different materials are the promising candidate for the drug delivery functionality, while the nano-porous structured one is able to enhance the drug release with "smart" capability. As we know that, with the conventional method, it is difficult to encapsulate the liquid into the core-shell microspheres purposely. However, this can be solved if the microfluidic chip is employed as we described above. Our results indicate that by controlling the flow rate of liquid and structure of chip, we are able to produce different types of microspheres and realize "smart" drug delivery under external magnetic field. We propose a new structure of the microfluidic chip, such as the joint T-Co-focusing structure to achieve simultaneous production of microspheres with different size, shape and composite carried out within an all-in-one chip. The preliminary experiment is carrying out recently.

7. The Layman's Summary

(describe in layman's language the nature, significance and value of the research project, in no more than 200 words)

What we have carried out in this project is to design microfluidic chip which can work for different experimental conditions by varying temperature, flow rate of liquid, various materials etc. The microfluidic chip can be fabricated with silicon wafer, plexiglass and PDMS by lithographic techniques. Different types of microspheres will be designed and fabricated by microfluidic approaches, the most interest structures of microspheres are nano-porous configuration. For the purpose of "smart" drug delivery, for example, the contained drug is designed as the liquid (liquid medicine/drug) can be stored in the porous microspheres. Under an external filed, the liquid drug through pores to the surroundings thus realize "smart' drug release purposely, where the release characteristics can be adjusted with temperature as well as structures of microspheres.

Part C: Research Output

8. Peer-reviewed journal publication(s) arising directly from this research project

(Please attach a copy of each publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				Author(s)	Title and Journal/ Book	Submitted to RGC	Attached to this report	Acknowledged the support of this Joint Research Scheme	Accessible from the institutional repository
Year of publication	Year of Acceptance *(For paper accepted but not yet published)*	Under Review	Under Preparation *(optional)*	***(bold** the authors belonging to the project teams and denote the corresponding author with an asterisk*)*	*(with the volume, pages and other necessary publishing details specified)*	*(indicate the year ending of the relevant progress report)*	*(Yes or No)*	*(Yes or No)*	*(Yes or No)*

2012				Lei Jiang , Min Zhang , Jiaxing Li , Weijia Wen and Jianhua Qin*	"Simple Localization of Nanofiber Scaffolds via SU-8 Photoresist and Their Use for Parallel 3D Cellular Assays", Advanced Materials, 24, 2191 (2012)	2013	No	Yes	Yes
2013				Jingyun Ma , Yu Sanna Hui , Min Zhang , Yue Yu , Weijia Wen , and Jianhua Qin*	"Facile Synthesis of Biomimetic Honeycomb Material with Biological Functionality" Small, 9, 497(2013)	2013	No	Yes	Yes
2014				Xiping Zeng, Bingpu Zhou, Yibo Gao, Cong Wang, Shunbo Li, Chau Yeung Yeung and WeiJia Wen	Structural dependence of silver nanowires on polyvinyl pyrrolidone (PVP) chain length, Nanotechnology 25, 495601 (2014)	2014	Yes	Yes	Yes
2015				C. Wang, B. P. Zhou, X. P. Zeng, Y. Y. Hong, Y. B. Gao and W. J. Wen*	Enhanced photochromic efficiency of transparent and flexible nanocomposite films based on PEO–PPO–PEO and tungstate hybridization, J. Mater. Chem. C, 3, 177–186 (2015)	2014	Yes	Yes	Yes
2015				Xinghua Gao, Yeung Yeung Chau, Jiao Xie, Jun Wan, Yanxiao Ren, Jianhua Qin and Weijia Wen*	Regulating cell behaviors on micropillar topographies affected by interfacial energy", RSC Adv.,, 5, 22916–22922 (2015)	2014	Yes	Yes	Yes

2015				Bingpu Zhou, Cong Wang, Xiao Xiao, Yu Sanna Hui, Yulin Cao and Weijia Wen*	"Controllable microdroplet splitting via additional lateral flow and its application in rapid synthesis of multi-scale microspheres", RSC Adv., 5, 10365–10371 (2015)	2014	Yes	Yes	Yes
2015				Bingpu Zhou, Xinghua Gao, Cong Wang, Ziran Ye, Yibo Gao, Jiao Xie, Xiaoxi ao Wu, and Weijia Wen,	"Functionalized PDMS with Versatile and Scalable Surface Roughness Gradients for Cell Culture", ACS Appl. Mater. Interfaces, 7, 17181−17187 (2015)	2014	Yes	Yes	Yes

9. Recognized international conference(s) in which paper(s) related to this research project was/were delivered *(Please attach a copy of each delivered paper. All listed papers must acknowledge RGC's funding support by quoting the specific grant reference.)*

Month/Year/ Place	Title	Conference Name	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this report *(Yes or No)*	Acknowledged the support of this Joint Research Scheme *(Yes or No)*	Accessible from the institutional repository *(Yes or No)*
August, 2014 Dalian, China	Studies of microfluidic and nanofluidic mixing	Lab on a chip industry workshop-Microfluidic application	2014	Yes	Yes	Yes

10. Student(s) trained *(Please attach a copy of the title page of the thesis.)*

Name	Degree registered for	Date of registration	Date of thesis submission/ graduation
Bingpu Zhou	Ph.D	09/2011	Graduated in 01/2015

11. Other impact *(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, etc.)*