FABRIC FOR BIOMEDICAL APPLICATION

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A thesis submitted in fulfillment of the
requirements for the award of the degree of
Master of Engineering (Biomedical)

Faculty of Biosciences and Medical Engineering
Universiti Teknologi Malaysia

AUGUST 2014

Specially dedicated to my beloved;

To my late father Haji Abdul Jamil Bin Selamat,

To my late mother Zaiton binti Mohd Yusoff,

My beloved husband Mohd Firdhaus Bin Samah,

My beloved sister Zuriyal Hanim Binti Haji Abdul Jamil,

My beloved sister Nurzahirah Binti Haji Abdul Jamil,

My beloved brother Mohd Asyraf Bin Haji Abdul Jamil,

My beloved brother Mohd Haziq Bin Haji Abdul Jamil,

My beloved sister Zarifah Binti Haji Abdul Jamil

ACKNOWLEDGEMENT

Bismillahhirrahmannirrahim. Alhamdulillah. I am very grateful to ALLAH, The Most Compassionate, The Most Gracious and The Most Merciful for granting me a strong heart and soul throughout this project.

I would like to express my deepest and sincere gratitude to my project supervisors, Dr. Dedy Hermawan Bagus Wicaksono and PM Dr Fadzilah Adibah Abdul Majid, whose encouragement, guidance and support from the initial to the final level enabled me to develop an understanding of the project.

I would like to thank our Ministry of Sciences, Technology and Innovations, Malaysia for funding this project through an eScience Funds Grant (Vot 01H65). My thanks and gratitude also goes to MEDITEG group members for all their support and valuable discussion that hold great value during this project.

I am grateful to my beloved husband, Mohd Firdhaus Bin Samah who stood beside me and encouraged me constantly and continuously, my thanks also goes to my beloved brothers and sisters for giving me happiness and joy. I would also fond to offer my gratitude to all my friends and relatives that had assist me in one way or another in completing this project.

Lastly, I would like to offer my regards and blessings to all of those who had supported me in any aspect during the completion of this study.

ABSTRACT

In this study, cotton fabric was used as a main material in creating two devices designed for cell proliferation and cell based assay application. The first device, low cost wax-impregnated cotton fabric platform was created to resemble a commercially available 96 well plates. The usage of cotton fabric platform was investigated through the proliferation of cell HSF 1184 on the designed platform. Surface property of cotton fabric platform was analyzed through FTIR (Fourier Transform Infrared) whereas biocompatibility of the platform was investigated through MTT (3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) assay. HSF 1184 proliferation on cotton fabric platform was observed through LVSEM (Low Vacuum Scanning Electron Microscope) and Confocal Microscope. Second device, known as cotton fabric based cell assay device are comprise of a microfluidic pattern surrounded by a hydrophobic background on the surface of cotton fabric. Capillary force exerting on the interstitial spaces between woven threads and spun fibers on the surface of cotton fabric are utilize as a natural pump to draw media bearing a suspended cell. Two types of suspended cells are used in this study; (HSF Fibroblast 1184; size: >5µm) and (Hybridoma; size: 2-5µm). Weave structures of cotton fabric are utilized as a natural filter to isolate cells based on size difference. Suspended cell were stained and wicking movement of cells drawn by the capillary wicking of the media in the hydrophilic channel was observed. To conclude, in this study, the usage of cotton fabric as a raw material for biomedical application was described in device designed for cell culture and cell based assay application.

ABSTRAK

Dalam kajian ini, kain kapas telah digunakan sebagai bahan utam dalam membuat dua alat yang digunakan untuk tujuan proliferasi sel dan alat kajian berasaskan sel. Alat yang pertama, platform kain kapas berlapikkan lilin yang berkos rendah telah direka untuk menyerupai 96 mikrowel yang boleh didapati secara komersial. Kegunaan kain kapas telah dikaji melalui proliferasi sel HSF 1184 di atas alat. Sifat permukaan kain kapas telah dikaji melalui ujian *FTIR (Fourier Transform Infrared)* manakala kesesuaian platform telah dikaji melalui ujian *MTT (3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide)*. Proliferasi HSF 1184 di atas platform kain kapas telah dilihat melalui *LVSEM (Low Vacuum Scanning Electron Microscope)* dan *Confocal* Microscope. Alat yang kedua, dikenali sebagai alat kajian berasaskan sel adalah terdiri daripada corak mikrofluidik yang dikelilingi latar belakang hidropobik di atas permukaan kain kapas.Daya kapilari di antara ruang celahan antara benang tenunan dan serat yang diputar di atas permukaan kain kapas telah digunakan sebagai pam semula jadi untuk menarik media yang mengandungi sel yang terapung. Dua jenis sel terapund telah digunakan dalam kajian ini; HSF 1184; saiz>5 µm dan Hybridoma; saiz 2-5 µm. Struktur tenunan kain kapas telah digunakan sebagai penapis semula jadi untuk mengasingkan sel berasaskan perbezaan saiz sel. Sel terapung telah di ditanda dan pergerakan sel melalui penyerapan media di dalam saluran hidropilik telah dilihat.Sebagai kesimpulan, di dalam kajian ini, kegunaan kain kapas dalam aplikasi biomedikal telah dihuraikan melalui alat yang dicipta untuk proliferasi sel dan juga alat kajian berasaskan sel.

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LIST OF ABBREVIATIONS

ELISA	Enzyme-linked immunosorbent assay
PDMS	Poly (dimethylsiloxane)
HSF	Human Skin Fibroblast
FACS	Fluorescence activated cell sorter
DEP	Dielectrophoresis
WBC	White blood cell
DLD	Deterministic Lateral Displacement
µFACS	Microfabricated fluorescence activated cell sorter

Chapter 1

Introduction

1.1 Preface

Fabric is referring to any material that has been processed through weaving, knitting, spreading, crocheting or bonding. Cotton is considered as one of the textile material that is commonly used, especially for daily clothes. Cotton has also been a major focus for researchers around the world, especially in the low-cost analysis tools [39]. In addition, a number of advantages such as low cost, widely available and lightweight are among the reason of cotton fabrics usage in this study.

Microwell has recently been recognized as a tool that is often used in cell culture, particularly in 2D cell culture to replace a conventional Petri dish. The ability to perform high-throughput screening has made microwell as a standard tool in analytical research and clinical diagnostic test laboratories. Enzyme linked immunosorbent assay (ELISA), which is known as the basis of modern diagnostic testing in human and animals is commonly performed using microwell [15]. Fabrication processes of microwell such as photolithography, soft lithography and etching were effective in a large-scale production; however these fabrication procedures require an additional equipment to be implemented. As a result, additional costs are required during fabrication process and thus are not favorable especially in a limited resource region. Therefore, a simpler and low cost fabrication process to create microwell was formulated in this study.

Cell based-assay is recently applicable to a wider range of biological research topic especially relating to a cellular response of a various physiological and pathological stimuli [11]. This is cause by the capability of cell based-assay of monitoring the biochemical activity of a target bimolecular in a cellular context. Over the year, microfluidic has been seen to be integrating into a cell-based assay application due to several advantages such as a high surface area to volume ratio and a slow diffusion of secreted molecules necessary in a normal function. Generally, cell-based screening is often automated in order to reduce the time and the cost of fabrication. Most of these automation systems are thus expensive to be developed especially in a developing country [11].

To perform real biological sample detection, the cell must be sorted and separated in order to obtain a single cell from a complex sample. Since then, numerous approaches are developed to create a miniaturized particle-sorting on the microfluidic platform [52]. Generally, cell sorting on microfluidic platform is performed using optical, magnetic, electrical and mechanical manipulation [27]. Cell sorting based on size is the most commonly approach in a microfluidic sorting methods. In this study, a simpler and low cost fabrication process was investigated to create a cell based-assay to separate cells based on size differences.

1.2 Problem Statement

Low cost wax-impregnated cotton fabric platform:

Common fabrication process for microwell fabrication such photolithography, soft lithography and etching was proven effective but still require an extensive equipment to be implemented. These fabrication processes was costly especially in a limited resource region. A simpler fabrication method utilizing a low cost cotton fabric as raw material for cotton fabric platform was investigated in this study.

Cotton fabric based-cell assay device:

Cell based-assay device is capable of monitoring the biochemical activity of target bimolecular in the context of the cell without purification steps such as antibody-based enzyme assay or conventional enzyme-or antibody-based assay. However, most of the applied cell based screening was automated to reduce bearing cost and time which is still costly especially in a developing country. A low cost cotton fabric is used to fabricate a simpler cell based-assay device using a simpler fabrication process was investigated in this study.

1.3 Hyphothesis

In order to fulfil the aforementioned problems statement, hypotheses are proposed;

Low cost wax-impregnated cotton fabric platform:

i. Wax ratios were used to improve the surface biocompatibility of cotton fabric for the proliferation of HSF Fibroblast 1184.

i. Cotton fabrics are used as main material in cotton fabric platform fabrication process due to its advantages such as low cost, lightweight and commercially available.

ii. Wax patterning method was used as a fabrication process in order to create a low cost cotton fabric platform resembling a commercially available 96 microwell.

Cotton fabric based-cell assay device:

i. Cotton fabric and wax patterning method are used to create a low cost and simpler cell based assay by forming a microfluidic pattern on the surface of cotton fabrics-based cell assay.

ii. Cell isolation are perform based on size differences by utilizing cotton fabric woven structure as a filter.

iii. Capillary forces between interstitial spaces of fiber and spun yarn were used as a natural pump to draw media containing suspended cells.

1.4 Objectives

The objectives of this research project are stated as follow:

Low cost wax-impregnated cotton fabric platform:

i. To create cotton fabric platform resembling a commercially available 96 microwell for the proliferation of HSF Fibroblast 1184.

ii. To formulate wax ratios required for the development of a low cost wax-impregnated cotton fabric platform for the proliferation of HSF Fibroblast 1184.

iii. To assess the proliferation of HSF Fibroblast 1184 (cells) on a low cost wax-impregnated cotton fabric for 24 hour.

iv. To discuss the future possibility of cotton fabric platform resembling a commercially available 96 microwell in a cell culture application.

Cotton fabric based-cell assay device:

i. To fabricate a simpler and low cost cotton fabrics-based cell assay device by utilizing a low cost cotton fabric as a main material and a simple wax patterning method as a fabrication method.

ii. To observe wicking movement of suspension cell (HSF Fibroblast 1184, Hybridoma) on cotton fabrics-based cell assay device.

iii. To assess the wicking movement of suspension cell (HSF Fibroblast 1184, Hybridoma) on cotton fabrics-based cell assay device.

iv. To discuss the future possibility of cotton fabric-based cell assay device in isolating suspended cells based on size differences.

1.5 Research scopes

The scopes for this research were:

Low cost wax-impregnated cotton fabric platform:

i. Draft a design (ACAD) for the fabrication of a low cost wax-impregnated cotton fabric platform
ii. Formulate a wax ratios used in layering cotton fabric for the fabrication of a low cost wax-impregnated cotton fabric platform
iii. Analyze the proliferation of cell (HSF Fibroblast 1184) on low cost wax-impregnated cotton fabric platform.

Cotton fabric based-cell assay device:

i. Draft a design (ACAD) for the fabrication of a cotton fabric based-cell assay device.
ii. Manipulating the length of hydrophilic pattern on the surface of cotton fabric based on limitation occur in fabrication method.
iii. Analyze the wicking movement of suspended cell (HSF Fibroblast 1184, Hybridoma) through capillarity on the hydrophilic pattern on the surface of cotton fabric based-assay device.
iv. Accessing the future possibility of cotton fabric based-cell assay device by suspended cells isolation based on size differences.

1.6 Research Methodology

The summary of overall research approaches in this study was illustrated in figure 1.1 and figure 1.2

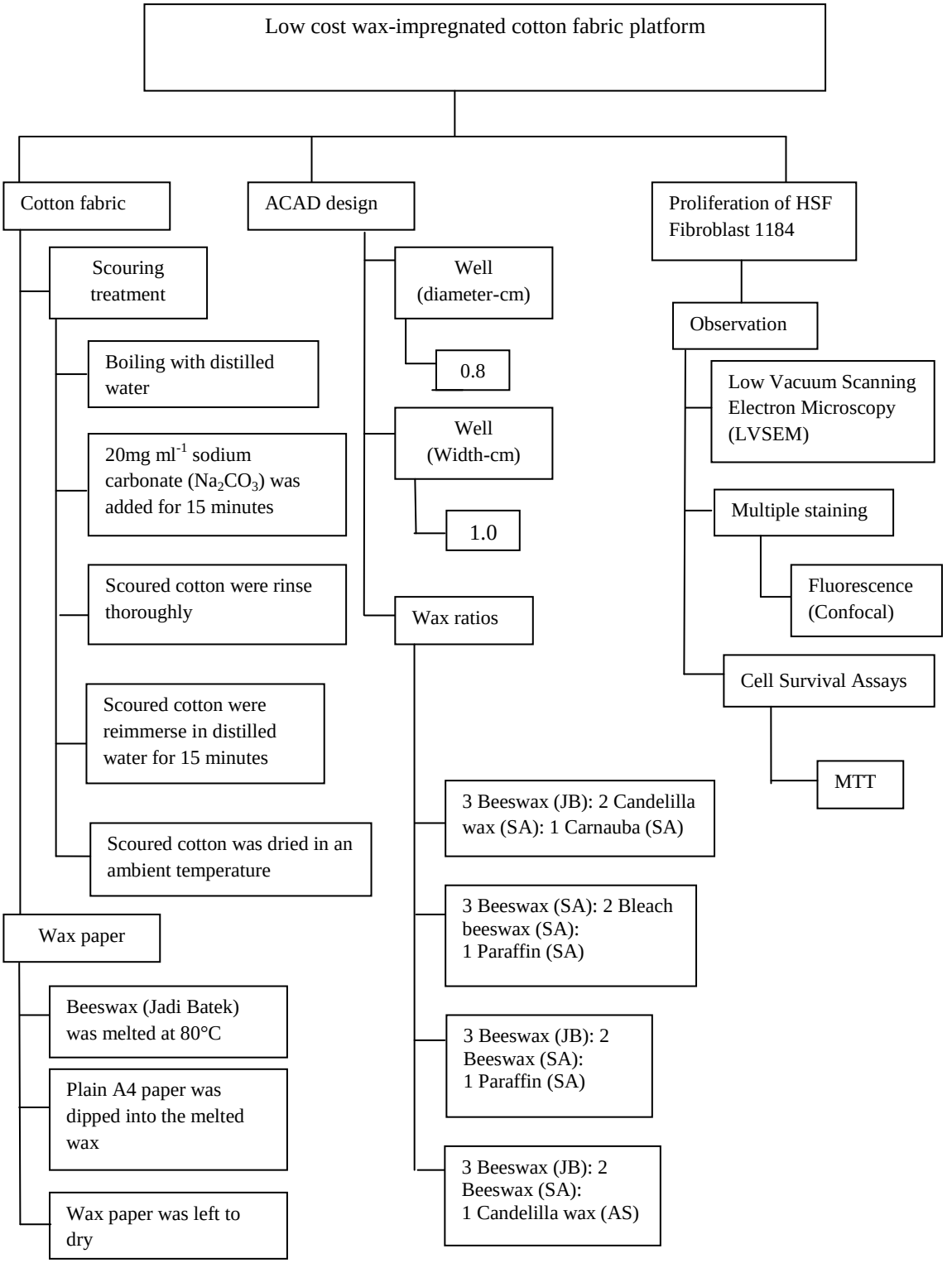

Figure 1.1: Research design

Low cost wax-impregnated cotton fabric platform

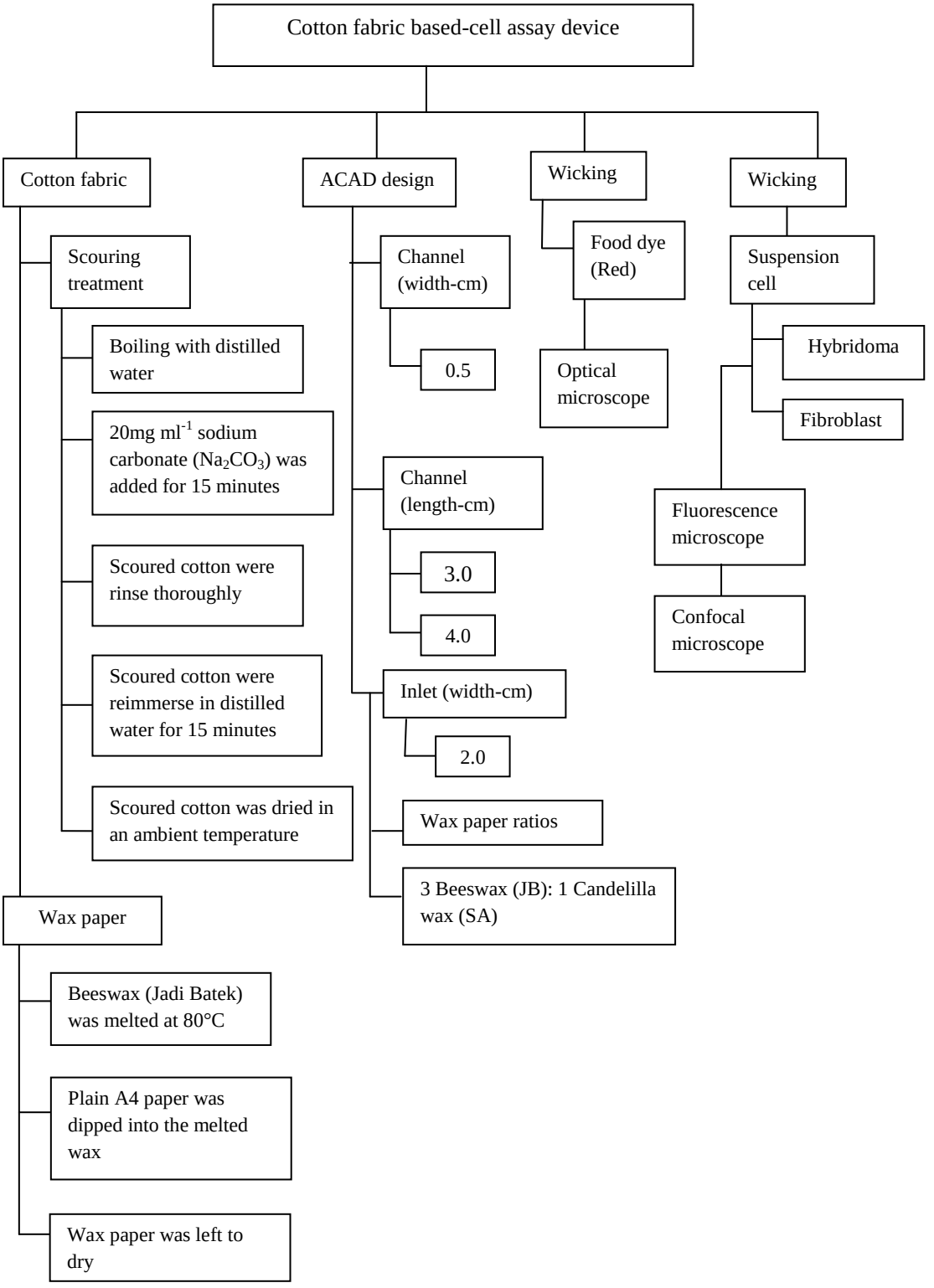

Figure 1.2: Research design

Cotton fabric based-cell assay device

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