

**GELATIN AND ALGINATE HYDROGELS  
AS BIO-INTERACTIVE DRESSINGS**

Panprung Sikareepaisan

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**By:** Panprung Sikareepaisan  
**Program:** Polymer Science  
**Thesis Advisor:** Prof. Pitt Supaphol  
Dr. Uracha Ruktaononchai

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..... College Dean  
(Asst. Prof. Pomthong Malakul)

**Thesis Committee:**

  
.....  
(Asst. Prof. Pomthong Malakul)

  
.....  
(Prof. Pitt Supaphol)

Uracha Ruktaononchai  
.....  
(Dr. Uracha Ruktaononchai)

Hathaikarn M.  
.....  
(Asst. Prof. Hathaikarn Manuspiya)

  
.....  
(Asst. Prof. Chidchanok Meechaisue)

## ABSTRACT

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To improve the wound healing, wound dressing can be developed from traditional passive materials that simply covered and concealed the wound to the active dressing that focused on moisture management and active ingredients delivery in the local wound environment. In this work, three types of active wound dressing are developed from gelatin and alginate hydrogels. They are nanofibrous gelatin mats containing an herbal *Centella asiatica* extract prepared by electrospinning technique, asiaticoside-loaded alginate films obtained by solvent casting process and gelatin hydrogel containing silver nanoparticles achieved by gamma irradiation synthesis. As-loaded *Centella asiatica* extract and asiaticoside are commonly known for wound healing activity, increasing collagen synthesis and reducing in keloid production, while as-loaded silver nanoparticles are an effective broad-spectrum antibacterial agent. Consequently these as-prepared wound dressings were expected to possess wound healing property or antibacterial activity satisfactory to use as bio-interactive dressing that can facilitate the healing process. Physical properties such as gel fraction, moisture retention, swelling and weight loss behaviour, mechanical properties of wound dressings and the release characteristic of the active substances from these wound dressing in buffer solutions were evaluated. The potential use of these wound dressings was further assessed in terms of the indirect cytotoxicity with normal human dermal fibroblast (NHDF) cells and the antibacterial activity evaluation.

## บทคัดย่อ

ปานปรุง สิขรีไพศาล : ไฮโดรเจลจากเจลาตินและอัลจินตที่มีสารสำคัญออกฤทธิ์ทางชีวภาพเพื่อการใช้งานเป็นวัสดุปิดแผล (Gelatin and alginate hydrogels as bio-interactive dressings)  
 อ. ที่ปรึกษา: ศาสตราจารย์ ดร. พิชญ์ ศุภผล และ ดร. อรุชา รักรัตนันทชัย 141 หน้า

ในปัจจุบันวัสดุปิดแผลโดยทั่วไปทำหน้าที่ปิดแผลไว้เพียงเพื่อป้องกันบาดแผลไม่สัมผัสกับสิ่งแวดล้อมภายนอกเท่านั้นไม่ได้มีส่วนร่วมในกระบวนการหายของแผล เพื่อให้แผ่นปิดแผลมีส่วนช่วยส่งเสริมให้การหายของแผลเป็นไปอย่างรวดเร็ว การพัฒนาวัสดุปิดแผลจึงได้เปลี่ยนจากวัสดุแบบเก่าไปเป็นวัสดุที่มีหน้าที่จัดการความชื้นและปลดปล่อยสารสำคัญออกมาสู่บริเวณแผลได้ งานวิจัยนี้ได้ศึกษาการเตรียมวัสดุปิดแผล 3 ประเภท จากเจลาตินและอัลจินต ไฮโดรเจล วัสดุปิดแผลดังกล่าวได้แก่ แผ่นเส้นใยนาโนจากเจลาตินที่ผสมสารสกัดจากใบบัวบกซึ่งเตรียมด้วยวิธีการปั่นเส้นใยด้วยไฟฟ้าสถิต, แผ่นฟิล์มอัลจินตที่ผสมสารเอเซียติโคไซด์ซึ่งเตรียมด้วยวิธีการระเหยตัวทำละลาย, และแผ่นเจลาตินไฮโดรเจลที่มีอนุภาคเงินนาโนผสมอยู่ซึ่งเตรียมด้วยวิธีการฉายรังสีแกมมา สารสกัดจากใบบัวบกและสารเอเซียติโคไซด์ที่มีอยู่ในวัสดุปิดแผลเหล่านี้มีคุณสมบัติในการสมานแผล เร่งการสร้างเนื้อเยื่อและช่วยลดรอยแผลเป็น ส่วนอนุภาคเงินนาโนก็มีฤทธิ์ในการยับยั้งเชื้อแบคทีเรีย ดังนั้นวัสดุปิดแผลที่มีสารเหล่านี้จึงมีคุณสมบัติช่วยให้แผลหายเร็วขึ้นหรือช่วยต่อต้านเชื้อแบคทีเรียซึ่งเหมาะสมอย่างยิ่งในการนำไปประยุกต์ใช้เป็นวัสดุปิดแผลชนิดใหม่ที่มีส่วนร่วมอย่างมากในการช่วยส่งเสริมการหายของแผล ในงานวิจัยนี้ได้ศึกษาลักษณะพื้นฐานวิทยาของวัสดุปิดแผลที่เตรียมได้โดยใช้กล้องจุลทรรศน์อิเล็กตรอนแบบส่องกราด คุณสมบัติทางกายภาพ ความสามารถในการบวมน้ำและการสูญเสียมวล คุณสมบัติเชิงกล และการปลดปล่อยสารสำคัญออกจากวัสดุปิดแผล โดยใช้วิธีการทดลองแบบจุ่มในสารละลายบัฟเฟอร์ และได้ประเมินความเป็นไปได้ในการนำวัสดุดังกล่าวไปใช้งานทางการแพทย์ โดยทำการทดสอบความเป็นพิษต่อเซลล์ผิวหนังมนุษย์ รวมถึงความสามารถในการยับยั้งเชื้อแบคทีเรียของวัสดุปิดแผลดังกล่าวอีกด้วย

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**ABBREVIATIONS**

AAS	Atomic absorption spectroscopy
DMEM	Dulbecco's modified Eagle's medium
DMF	Dimethyl formamide
DMSO	Dimethyl sulfoxide
e-spinning	Electrospinning
e-spun	Electrospun
FBS	Fetal bovine serum
G	$\alpha$ -L-guluronic acid
GTA	Glutaraldehyde
HPLC	High pressure liquid chromatography
M	$\beta$ -D-mannuronic acid
mCA	Methanolic crude extract of <i>Centella asiatica</i>
MTT	3-(4,5-Dimethyl-2-thiazolyl)-2, 5-diphenyl-tetrazolium bromide
nAg	Silver nanoparticles
NHDF	Normal human dermal fibroblast cell
PAC	Pure asiaticoside
PBS	Phosphate buffer saline
Rf	Retention factor
RH	Relative humidity
SBF	Simulated body fluid
SEM	Scanning electron microscopy
SFM	Serum-free medium
SM	Stereo microscope
TCPS	Tissue-culture polystyrene plate
TLC	Thin-layer chromatography
TEM	Transmission electron microscope
UV-vis	UV-visible spectrophotometer

## LIST OF SYMBOLS

$W_i$	Initial weight of the sample in its dry state
$W_s$	Weight of the sample in its wet, swollen state
$W_d$	Weight of the dried sample after immersing in buffer
$M_c$	The number-average molecular weight of the chain segments between cross-linking points
$\rho_G$	Density of gelatin
$\rho_w$	Density of water
$V_1$	Molar volume of water
$\chi$	Flory-Huggins interaction parameter between water and gelatin
$\nu_G$	Volume fraction of gelatin in hydrogel specimens in their equilibrium swollen state
$W_0$	Initial dry weight of the specimens
$W$	Weight of the specimens in their equilibrium swollen state
$N_A$	Avogadro's number
$V_e$	The cross-link density in terms of the number of elastically effective chains per unit volume of the gelatin hydrogel network
$A$	Numbers of bacterial colonies for the plates that had been smeared with washing solutions from the nAg-loaded gelatin hydrogel specimens
$B$	Numbers of bacterial colonies for the plates that had been smeared with washing solutions from the neat gelatin hydrogel specimens
$\gamma$ -rays	Gamma rays