

**ELECTROSPUN POLYCAPROLACTONE FIBERS FOR BONE  
SCAFFOLDING APPLICATION**

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## ABSTRACT

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Electrospun (e-spun) fiber mats of polycaprolactone (PCL;  $M_n = 80,000$ ) with or without calcium carbonate ( $\text{CaCO}_3$ ) or hydroxyapatite (HAp) nanoparticles (i.e. E-PCL, E-PCL/ $\text{CaCO}_3$ , and E-PCL/HAp) were successfully fabricated. Indirect cytotoxicity evaluation of these e-spun mats revealed that these mats posed no threats to the cells. The potential use of the e-spun fiber mats as bone scaffolds was evaluated *in vitro* with human osteosarcoma cells (SaOS2) and mouse calvaria-derived, pre-osteoblastic cells (MC3T3-E1). For SaOS2 cells, E-PCL, E-PCL/ $\text{CaCO}_3$ , and E-PCL/HAp were evaluated in terms of attachment, proliferation, and alkaline phosphatase (ALP) activity of the cells that were cultured on the scaffolds. The results were compared with those on corresponding solution-cast film scaffolds and tissue-culture polystyrene plate (TCPS). All of the e-spun fiber mats promoted much better adhesion and proliferation of cells than the corresponding film scaffolds and TCPS. E-PCL/HAp (1.0% w/v HAp) showed the highest ALP activity. For MC3T3-E1 cells, E-PCL and E-PCL/HAp were evaluated in terms of attachment, proliferation, differentiation, and mineralization of the cells that were cultured on the scaffolds. The results were compared with those of TCPS. The greater expression for both the osteocalcin (OC) gene and the OC protein on days 14 and 21, respectively, of MC3T3-E1 after being cultured on E-PCL/HAp than that on E-PCL and TCPS was apparent, as this leads to the greatest amount of mineralization observed on day 21 for the cells grown on E-PCL/HAp, followed by that for the cells grown on E-PCL and TCPS, respectively.

## บทคัดย่อ

พัชรภรณ์ วุฒิเจริญมงคล : เส้นใยพอลิคาโพรแลคโตนจากกระบวนการปั่นเส้นใยด้วยไฟฟ้าสถิตเพื่อใช้เป็นวัสดุโครงสร้างสำหรับกระดูก (Electrospun Polycaprolactone Fibers for Bone Scaffolding Application) อ. ที่ปรึกษา : รศ. ดร. พิชญ์ ศุภผล 165 หน้า

แผ่นเส้นใยพอลิคาโพรแลคโตน (น้ำหนักโมเลกุลเฉลี่ยโดยจำนวน 80,000 กรัม/โมล) แผ่นเส้นใยพอลิคาโพรแลคโตนที่เติมผงแคลเซียมคาร์บอเนตขนาดนาโน และแผ่นเส้นใยพอลิคาโพรแลคโตนที่เติมผงไฮดรอกซีเอปาทาइटขนาดนาโน (E-PCL, E-PCL/CaCO<sub>3</sub> และ E-PCL/HAp) สามารถเตรียมได้จากกระบวนการปั่นเส้นใยด้วยไฟฟ้าสถิต จากการทดสอบความเป็นพิษต่อเซลล์โดยวิธีอ้อม พบว่าแผ่นเส้นใยทุกชนิดไม่มีความเป็นพิษต่อเซลล์ และได้ศึกษาคุณสมบัติในการใช้เป็นวัสดุโครงสร้างสำหรับกระดูกในสภาวะนอกร่างกาย ด้วยเซลล์สร้างกระดูกชนิด SaOS2 และ MC3T3-E1 ในกรณีของเซลล์สร้างกระดูก SaOS2 ได้ทำการศึกษการยึดเกาะ การเจริญเติบโต และอัลคาไลน์ฟอสฟาเตสแอกติวิตีของเซลล์ที่เพาะเลี้ยงบนแผ่นเส้นใยทุกชนิด เปรียบเทียบกับแผ่นฟิล์มจากกระบวนการหล่อที่มีส่วนประกอบเหมือนกันกับแผ่นเส้นใยและงานเพาะเลี้ยงเซลล์พอลิสไตรีน (TCPS) พบว่าเซลล์ยึดเกาะและเจริญเติบโตบนแผ่นเส้นใยทุกชนิดได้ดีกว่าบนแผ่นฟิล์มและงานเพาะเลี้ยงเซลล์พอลิสไตรีน นอกจากนี้เซลล์ที่เพาะเลี้ยงบนแผ่นเส้นใยพอลิคาโพรแลคโตนที่เติมผงไฮดรอกซีเอปาทาइट (ไฮดรอกซีเอปาทาइट 1% โดยน้ำหนัก/ปริมาตร) ให้ค่าอัลคาไลน์ฟอสฟาเตสแอกติวิตีมากที่สุด ส่วนในกรณีของเซลล์สร้างกระดูก MC3T3-E1 ได้ทำการศึกษการยึดเกาะ การเจริญเติบโต การแปรสภาพ และการพอกแร่ธาตุของเซลล์ที่เพาะเลี้ยงบนแผ่นเส้นใยพอลิคาโพรแลคโตน และแผ่นเส้นใยพอลิคาโพรแลคโตนที่เติมผงไฮดรอกซีเอปาทาइट เปรียบเทียบกับงานเพาะเลี้ยงเซลล์พอลิสไตรีน พบว่าเซลล์ที่เพาะเลี้ยงบนแผ่นเส้นใยพอลิคาโพรแลคโตนที่เติมผงไฮดรอกซีเอปาทาइट สร้างขึ้นออสติโอแคลซินในวันที่ 14 ของการเพาะเลี้ยง และสร้างโปรตีนออสติโอแคลซินในวันที่ 21 ของการเพาะเลี้ยง ได้มากกว่าเซลล์ที่เพาะเลี้ยงบนแผ่นเส้นใยพอลิคาโพรแลคโตนและงานเพาะเลี้ยงเซลล์พอลิสไตรีน ซึ่งทำให้พบว่าปริมาณการพอกแร่ธาตุมากที่สุดบนแผ่นเส้นใยพอลิคาโพรแลคโตนที่เติมผงไฮดรอกซีเอปาทาइट รองลงมาคือแผ่นเส้นใยพอลิคาโพรแลคโตน และงานเพาะเลี้ยงเซลล์พอลิสไตรีนตามลำดับ

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