CHAPTER I
INTRODUCTION

Electrospinning is a process capable of fabricating fine fibers with diameters in submicrometer to nanometer range. In this process, a continuous filament is drawn from a polymer solution or polymer melt through a spinneret by electrostatic forces and then deposited on a conductive collector. When a high electrical potential is subjected to a polymer solution or polymer melt, charges are accumulated on a surface of a pendant droplet of polymer solution or polymer melt. When the electric field reaches a critical value at which the repulsive electric force overcomes surface tension, a charged polymer jet is ejected out of a spinneret and carried to the collector screen. As the jet travels in air, the solvent evaporates out, leaving polymeric fibers on the collector screen. Due to high surface area to volume ratio and small interfibrous pore size with high porosity of electrospun fiber mats, proposed applications for these materials are in areas such as filters, composite reinforcements, and scaffolds for tissue engineering.

Tissue engineering of bone regeneration has received much attention as an alternative approach in the treatment of bone tissue defects. In this approach a biocompatible scaffold is required to support seeded cells adhesion to guide and promote controlled cellular growth and differentiation in order to generate new bone tissue. The challenge in tissue engineering is the design of scaffolds that can mimic the structure and functions of the natural extracellular matrix (ECM). ECM plays an important role in mechanical supporting and controlling cell behavior. ECM is composed of a ground substance (i.e. proteoglycan) and fibrous protein (i.e. collagen, elastin). Scaffold should be designed to allow diffusion of nutrients to the transplanted cells and guide cell organization, attachment, and migration. By electrospinning process, the as-spun fibrous scaffolds meet the requirement due to their three dimensional structure with interconnected pores and high porosity that resembles the collagen fiber microstructure in natural ECM.

A variety of biocompatible materials have been investigated for their suitability in tissue engineering application. Almost all the biodegradable scaffolds used in tissue engineering have been made from biodegradable polymers. There are two kinds of biodegradable polymers : synthetic polymers and naturally derived polymers. Among these biodegradable polymers, polyesters are one of the most promising polymers that are often used as tissue scaffolding materials due to their biodegradability and biocompatibility. Polyester biodegradable materials such as polycaprolactone (PCL), poly(lactic acid) (PLA), poly(glycolic acid) (PGA), poly(3-hydroxybutyrate) (PHB), poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV), and poly(butylene succinate) (PBS) have attracted a great deal of attention. They can be used as bone scaffolding materials due to their potentially hydrolysable ester bonds and their slow degradation rate that are suitable for bone regeneration.

Poly(butylene succinate) (PBS) is one of biodegradable and biocompatible aliphatic polyesters produced through chemical synthesis based on polycondensation of 1,4-butanediol with succinic acid (Takiyama *et al.*,1994; Doi *et al.*,1996). Due to its excellent biodegradability, melt processability, and thermal and chemical resistance, proposed applications are in areas such as textiles, medical treatment, and environmental engineering. Jeong and co-workers (2005) studied the electrospinning of PBS for the first time. In this work, the thermal and structural properties of ultrafine PBS fibers were also investigated. Liu and co-workers (2007) investigated the morphology of PBS fibers fabricated by electrospinning under different weight concentration and needle-orifice diameters. Moreover, the thermal properties and crystallization of the electrospun PBS fibers were also characterized. Interestingly, PBS was first evaluated *in vitro* for its potential application as a novel material by Li and co-workers (2005). The *in vitro* biocompatibility of PBS was evaluated by monitoring proliferation and differentiation of osteoblasts cells cultured on PBS films for different period. The result revealed that PBS was biocompatible as the cells could proliferate and differentiate on the PBS films. The biocompatibility of PBS indicated that PBS can be used as a biomaterial for tissue repair. Several papers have reviewed the past and current researches on scaffold fabrication, However, none of those paper has studied the electrospinning of PBS for utilization as bone scaffolding materials.

In this research work, ultrafine fibers of poly(1,4-butylene succinate) extended with 1,6-diisocyanatohexane, ($C_{16}H_{32}N_2O_{10}$) were prepared by electrospinning technique. In the electrospinning experiment, the effect of processing parameters including applied electrical potential, polymer concentration, and collection distance on morphological appearance and size of the as-spun fiber mats were investigated. The mechanical integrity in terms of tensile strength, Young's modulus, and elongation at break of the scaffolds was investigated. In addition, thermal properties of the as-spun fibers in comparison with those of the as-received pellets and solution-cast films were also evaluated. Lastly, the potential use of the electrospun mats as scaffolding materials for bone regeneration was evaluated *in vitro* with human osteoblasts (SaOS-2) in terms of biocompatibility, attachment, proliferation, and alkaline phosphatase (ALP) activity of the cells that were cultured directly on the scaffolds. Comparisons were made with the cells that were cultured on tissue culturing polystyrene plate (TCPS) and solution-cast film scaffolds.