# CHAPTER I
# INTRODUCTION

In recent years, much interest has been paid on fabricating ultra-fine fibers by a process commonly known as electrospinning. Electrospinning process involves the application of a strong electric filed across a conductive capillary attaching to a polymer liquid-containing reservoir and a collector (Reneker, 1996; Doshi, 1995). When the electric field exceeds a critical value where the Coulombic repulsion of the accumulated charges overcomes the surface tension of the polymer droplet at the tip of the capillary, a charged jet is ejected. During its flight to the collector, the charged jet thins down and, simultaneously, dries out or solidifies, leaving ultra-fine fibers on the collector (Deitzel, 2001). Ultra-fine fibers obtained from this process exhibit various interesting characteristics (e.g., high surface area to mass or volume ratio, high density of micro- or nanometer-sized pores of the non-woven mat, and vast possibilities for surface functionalization). These unique properties render electrospun fibers as excellent candidates for various biomedical applications, e.g., scaffolding materials for cell/tissue culture (Yoshimoto, 2003; Wutticharoenmongkol, 2006; Suwantong, 2007), wound-dressing materials (Min, 2004; Noh, 2006), and carriers for topical/transdermal delivery of drugs (Kenawy, 2002; Taepaiboon, 2006; Taepaiboon, 2007; Tungprapa, 2007; Suwantong, 2007).

One of the advantages of the electrospinning process over the conventional film-casting technique is the highly porous nature of the electrospun fiber mats which exhibit much greater surface area that assumingly could allow drug molecules to diffuse out from the matrix much more conveniently (Kenawy, 2002; Zong, 2002), when these materials are used as carriers for delivery of drugs. A wide variety of polymeric materials, either biodegradable or non-biodegradable with biocompible properties, can be used as delivery matrices. Poly(lactic acid) (PLA) and poly(ethylene-co-vinyl acetate) (PEVA) were successfully electrospun in the presence of tetracycline hydrochloride (an antibiotic drug) as a model drug by Kenawy *et al.* (2002). The total percentage of tetracycline released from the as-cast films was lower than that from the electrospun fiber mats due to the much lower surface area. For poorly water-soluble drug, such as itraconazole (an anti-fungal drug) and ketanserin (a

drug for ischemic acute renal failure), polyurethane, a non-biodegradable polymer, was used as the matrix (Verreck, 2003). They concluded that the release of poorly water-soluble drugs could be achieved using a water-insoluble polymer and the rate of release could be tailored by varying the drug to polymer ratio.

Wound dressing with electrospun fiber mats can meet the requirement such as higher gas permeation and protection of wound from infection and dehydration. A collagen nanofibrous matrix produced by electrospinning process was introduced for application of wound dressing by Rho *et at.* (2006). They found that Collagen nanofibrous matrices were very effective as wound-healing accelerators in early-stage wound healing. The cross-linked collagen nanofibers coated with ECM protein, particularly type I collagen, may be a good candidate for biomedical application such as wound dressing and scaffolds for tissue engineering. The best biomaterials for wound dressing should be biocompatible and promote the growth of dermis and epidermis layers. Chen *et al.* (2008) have successfully produced a composite nanofibrous membrane composed of collagen and chitosan, which are known for their beneficial effects on wound healing. The membrane was found to promote wound healing and induce cell migration and proliferation. From animal studies, the nanofibrous membrane was better than gauze and commercial collagen sponge in wound healing.

Cellulose acetate (CA) is the acetate ester of cellulose, the primary structural component of the cell wall of green plants and is one of the most common biopolymers on earth (Anonymous, 2006). CA has been fabricated as semi-permeable membranes for separation processes and fibers and films for biomedical applications. Electrospinning of 5 and 8 wt.% CA solutions in acetone produced short and beaded fibers with diameters being ~1 μm (Jaeger, 1998). An improvement in the electrospinning of CA was achieved when 2:1 v/v acetone/dimethylacetamide (DMAc) was used as the solvent system (Liu and Hsieh, 2002). This mixture allowed the resulting 12.5-20 wt.% CA solutions to be continuously spun into fibers with diameters ranging between ~100 nm and ~1 μm. A new solvent system for the electrospinning of cellulose acetate (CA) nanofibers was studied by Han *et al.* (2007). The CA solutions were electrospun at a positive voltage of 25 kV, a tip-to-collector distance of 10 cm, and a solution flow rate of 3 mL/h. Long uniform CA nanofibers

with an average diameter of 180 nm were electrospun from a 17 wt.% CA solution in mixed solvent containing acetic acid/water at a ratio of 75:25 by weight. The average diameters of the CA nanofibers could be controlled from 160 nm to 1280 nm by changing the composition of the mixed solvent.

The aim of this work was to investigate the potential for use of ultra-fine fiber cellulose acetate fiber mats containing either curcumin (CM; from the plant *Curcuma longa* L.) or asiaticoside (AC; from the plant *Centella asiatica* L. either in the form of pure substance (PAC) or a crude extract (CACE)) as topical/transdermal patches or wound dressings. Various properties (i.e., morphological, mechanical, swelling, and weight loss) of both the neat and the herb-loaded electrospun CA fiber mats as well as the release characteristic of herbal substances from the herb-loaded electrospun CA fiber mats were investigated. The chemical integrity of the as-loaded herbs in the herb-loaded electrospun CA fiber mats was also investigated. For the biological study of herb-loaded electrospun CA fiber mats with normal human fibroblast (NHDF) cells were evaluated in terms of the indirect cytotoxicity, the antioxidant activity, the cell attachment, the cell proliferation, and the collagen quantification. The morphological observation of cultured cells was also investigated by scanning electron microscopy (SEM). Comparisons were made against the corresponding solvent-cast CA films.