CHAPTER VI
CONCLUSIONS AND RECOMMENDATIONS

In this research work, the electrospinning technique was used to produce ultrafine polyamide-6 fibers. The effects of some of the solution and process parameters on morphological appearance and average diameter of the as-spun polyamide-6 (PA-6) fibers were thoroughly investigated using optical scanning (OS) and scanning electron microscopy (SEM) techniques. For the solution parameters, these influencing parameters were investigated: solution concentration, molecular weight of polyamide-6, solution temperature, addition of salts, and solvent systems. Whereas the influencing of either positive or negative polarity of the emitting electrode and the electric field strength were the process parameters that were investigated in this work.

An increase in the solution concentration caused an increase in the solution viscosity and the relationship between the solution viscosity and the solution concentration could be approximated by an exponential growth equation. At low solution viscosities, only small droplets were present. At slightly higher viscosities, a combination of small droplets and smooth fibers was obtained. At some critical viscosities, droplets disappeared altogether, leaving only beaded and smooth fibers on the collective target. Further increasing the solution viscosity resulted in the reduced number of beads and the increased fiber diameters. At high enough solution viscosities, only smooth fibers were present. It was found that solutions with high enough viscosity values were necessary to result in electrospun polyamide-6 fibers having uniform diameters.

At a given concentration, fibers obtained from PA-6 of higher molecular weights appeared to be larger in diameter, but it was observed that the average diameters of the fibers obtained from PA-6 of different molecular weights exhibited a common relationship with the viscosities of the solutions which could be approximated by an exponential growth equation. An increase in the temperature of the solution during electrospinning resulted in a decrease in the fiber diameters, but resulted in an increase in the deposition rate. Addition of some inorganic salts to the solution resulted in an increase in the conductivity values, which, in turn, caused the fiber diameters to increase due to the large increase in the mass flow.

PA-6 solutions were prepared in both single solvent systems and mixed solvent systems to investigate the influencing of solvents. For single solvent systems, only the solution of PA-6 in 85 wt.% formic acid gave uniform electrospun fibers, with the average diameters being about 83.5 nm, while the solutions of PA-6 in *m*-cresol and 20 and 40 wt.% sulfuric acid did not form ultra-fine fibers. For mixed solvent systems, the solvent mixtures were prepared by mixing 85 wt.% formic acid with *m*-cresol, 20 and 40 wt.% sulfuric acid, acetic acid, ethanol, DMF, and DMSO in the compositional ratios of 10 to 40% (v/v). In general, the average fiber diameters of the as-spun fibers were found to increase with increasing content of the second solvent, with the exception of the mixtures containing DMF and DMSO that the average fiber diameters were, instead, found to decrease. In mixed solvents of high compositional ratios of *m*-cresol and sulfuric acids (i.e. greater than 20%), fibers of rough surface and fused fibers were observed.

Regardless of the emitting electrode polarity, the onset for the formation of smooth fibers from negative polarity occurred at a lower concentration or viscosity, with the as-spun fibers from negative polarity being larger for at a given concentration of the solutions. Interestingly, under negative polarity, solutions of high concentrations or high viscosity values produced flat fibers. The average diameter (or average width) of the as-spun PA-6 fibers of different average molecular weights exhibited a common relationship with the solution viscosity, with such the relationship for as-spun fibers from positive polarity being best described by an exponential growth equation, while that for as-spun fibers from negative polarity being a power-law equation. An increase in the applied electrostatic field strength resulted in as-spun webs of decreasing diameter, but resulted in an increase in the diameters of the as-spun fibers. Interestingly, the fiber density of the as-spun fiber webs from negative polarity was much lower than that of as-spun fibers from positive polarity. Under negative polarity, as-spun fibers from the salt-containing solution were flat and the average width increased with increasing salt content.

The fundamental aspects of the influencing solution and process parameters in other polymer-solvent systems are still interested. The collection of a number of data in different systems may be helpful to predict the morphological appearance and also the fiber diameter size. However, the applications of these electrospun fibers products in several proposed, for example; in biomedical, in filter device are interested as well.