Design and Investigation of Functional Electrospun Bioactive-Nanofibers

CNF Project # 1811-09  
Principal Investigator(s): Margaret W. Frey  
User(s): Daehwan Cho  

Affiliation(s): Fiber Science and Apparel Design, Cornell University  
Primary Research Funding: National Science Foundation  
Contact: mfw24@cornell.edu, dc575@cornell.edu

Abstract:
A microfluidic device is fabricated to characterize the streaming electrokinetic potential on the surface of charged electrospun nanofibers. The electrodes are made of evaporating with Ti and Au on an insulator, Pyrex® wafer, and are covered by a PDMS microchannel to form a microfluidic channel. The cationic or anionic charges of the electrospun charged nanofibers on the electrodes are interacting with the counter ions in the buffer solution. A voltage changes are traced by a source meter during the flow of buffer solution into the channel and the electrokinetic potential of the charged nanofibers is calculated, which is brought about when pressure-driven flow in a microchannel forms double layer ions.

Summary of Research:
It has been commonly known that nanofiber surfaces are chemically and biologically modified to make functionality on them, in order to apply for bio-analysis; such as sample purification, and detection as acting on nano-guiding lines within the microfluidic channel [1]. The nanofibers can be electrospun, arranging them across the microchannels, or along the microchannels in order to create distinct immobilization strings within the channels, or to function as guiding structures for cell movement (see Figure 1). The preliminary studies of nanofiber applicability are provided to conduct the functional investigations as biofunctional guiding structures in microchannels, as biological separators in sample clean up and analyte concentration steps, and also for enhanced immobilization of biorecognition elements. The nanofiber density in the microchannels before and after fluid flow is quantified in order to determine the durability of nanofibers within the microchannels.

The nanoscale particles having carboxyl, sulfon, or amino groups have been incorporated into electrospun fibers to create the functional and bioactive sites on the fiber surface. These particles intrinsically have their own charge potentials according to the buffer solution. The extremely large specific surface area of nanofibers maximizes the availability of functional groups bound on the surface of the electrospun fibers. The particles are mixed into the mother polymer spinning dopes such as poly vinyl alcohol (PVA) or poly(lactic acid) (PLA), which are then jet to form the nano-scale fibers.

Figure 1: Schematic diagram for positioning electrospun fibers across a microchannel (a) and along the length of a microchannel (b). Arrows indicate the direction of buffer solution flow within the microchannel.

Figure 2: Positively charged nanofibers will be used as separators within a microchannel (a) and negatively charged ones as guiding structures (b).
by electric static force. All conditions of electrospinning, the concentration of base polymer in solution, and the ratio of base polymer to particles are optimized to form good morphology of electrospun fibers. Figure 2 shows the schematic diagram in which the fibers have functional groups on the surface. The functional groups on the fibers are characterized to verify that the groups are imbedded or bound into the fiber or the surface of the fiber; using FTIR, XPS and H-NMR, respectively.

Fibers with surface charges have been electrospun directly on the electrodes composed of microfluidic devices to measure the zeta potential on the fiber surface. A microchannel device is fabricated with the electrodes and PDMS channel. The nano-size fibers are electrospun between the two electrodes in order to characterize their charged potentials by measuring the streaming potential generated in the channels during the flow of buffer solution and then converted into zeta potential defined by Smoluchowski [2].

The dimensions of microchannel device are as followed; 2 mm in width, 5 mm in length, and 165 µm in height. In the case of electrodes evaporated by Ti and Au, the distance between two electrodes is 3 mm and the height is 100 nm. Figure 3 illustrates the overall system for the present study. The electrokinetic changes in the surface of the electrospun fibers are being studied by measuring the streaming potentials and the streaming resistance in the microfluidic while a micro pump is flowing the buffer solutions into the channel by varying the flow-rate. Figure 4 shows the results that the changes of voltage are traced during the flow of buffer solution.

The present research will be able to enlarge its initial work into the advancement of sensing fiber technology for advanced materials. As the fabrication of the charged potential electrospun fibers is achieved, the charged electrospun fibers have ability on the immobilization of biological molecules without additional chemical reactions and will progress the development of coordinated biosensing in which 3D biosensing structures have enhanced capability due to simulation of the 3D structure of the original biological system [3]. As the amount of charged potentials on the electrospun fibers is characterized by utilizing the streaming potential at the microfluidic channel, the charged potential of electrospun fibers will be designed by varying the contents of charged particles or types of charge for the final purpose of analysis.

**References:**

