A. Title Page

Design, construction and characterization of electrospinning apparatus for nanofibers

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B. Restatement of problem researched or creative activity

The global economic impact of nanotechnologies is projected to be $3.3 trillion by 2018 [1,2]. The need for nanoscience professionals is projected increase to 1 million employees by 2015 [2]. Electrospinning of nanofibers is one fabrication method that has gained popularity over the last decade. It is a simple approach that provides exceptional sample quality and flexibility at a relatively low cost.

In electrospinning, a polymer solution is dispensed from a hypodermic-like syringe where an intense electric field attracts the solution to a collector while drawing the polymer into a very thin fiber. The diameter of the fiber can be controlled by tuning the process parameters such as the voltage, solution flow rate, distance between syringe tip and collector, and the collector geometry. The techniques involved in producing electrospun fibers are described in further detail by Reneker [3] and Li [4].

An important component of our project is the construction of the electrospinning apparatus shown in Figure 1 [5]. The electrospinning apparatus consists of three components: the solution dispensing system, electric field, and collector. The solution dispensing unit consist of a syringe that contains the polymer solution, a pump that precisely controls the rate at which the solution is dispensed and a very fine hypodermic needle, known as the spinneret. The electric field is another critical component of the electrospinning apparatus, because the geometry of the polymer cone (known as the Taylor Cone) is controlled by the ratio of the surface tension of the polymer solution to the applied electric field.

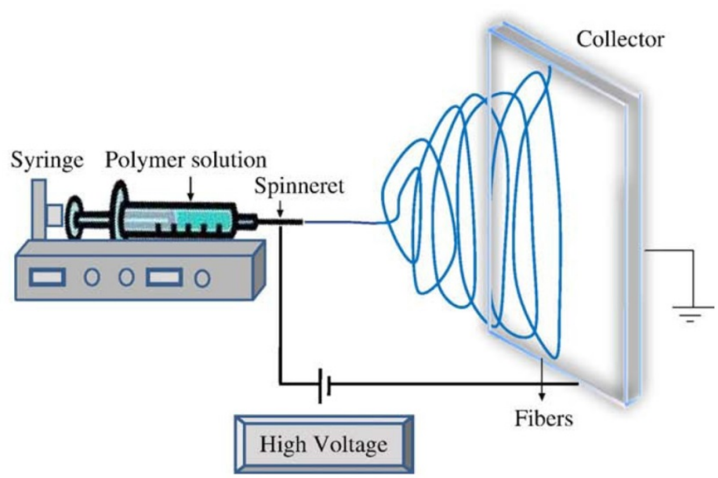


Figure 1 [5] Schematic of the proposed electrospinning apparatus that consists of three components: solution dispensing system (left), electric field (middle), and collector (right).

Typically the electric field is generated by a high voltage power supply. The final component is the collector. The collector impacts the orientation of the spun nanofibers. For instance, if a stationary collector is chosen, the fibers will be oriented randomly, however by using a spinning collector (such as a rotating wheel or drum) the spun fibers can be aligned.

BIBLIOGRAPHY

[1] http://jsnn.ncat.uncg.edu/outreach/

[2] http://theinstitute.ieee.org/career-and-education/career-guidance/big-opportunities-for-those-who-think-small

[3] Reneker, D., & Chun, I. (1996). Nanometre diameter fibres of polymer, produced by electrospinning. *Nanotechnology, 7*, 216-223.

[4] Li, D., & Xia, Y. (2004). Electrospinning of Nanofibers: Reinventing the Wheel? *Advanced Materials*, *16*(14), 1151-1170.

[5] Jain KK. Role of nanotechnology in developing new therapies for diseases of the nervous system. *Nanomedicine 2006 Jun;1(1)*:9-12.

C. Brief review of the research procedure utilized

Since one of the major goals of this project was the design and construction of an electrospinning apparatus we begun by performing a thorough review of the relevant literature to help us better understand the capabilities our system would need to produce high quality fibers. Additionally, we wanted the system to be flexible enough to allow us to explore several different material systems. From our literature review it was clear that one of the most important parameters that drives the formation of the nanofibers is the ratio of the surface tension of the polymer solution to the applied electric field. It is difficult to substantially adjust the surface tension of the solution without adding additional chemicals (e.g. surfactants) that would affect the properties of the produced nanofibers however, it is relatively easy to precisely control the electric field strength. The electric field can be tuned by adjusting the applied voltage, changing the distance from the spinneret to the collector, or some combination of both. Therefore, we decided for maximum flexibility, that the design of our system should incorporate both a highly adjustable power supply and an adjustable spinneret to collector distance. Figure 2 is a 3D rendered CAD drawing of our system design that is currently being machined. More detailed drawings of some of the subcomponents are attached in Appendix A of this report. The system is currently being machined at J.L.S machine shop and we expect it to be completed in two weeks.

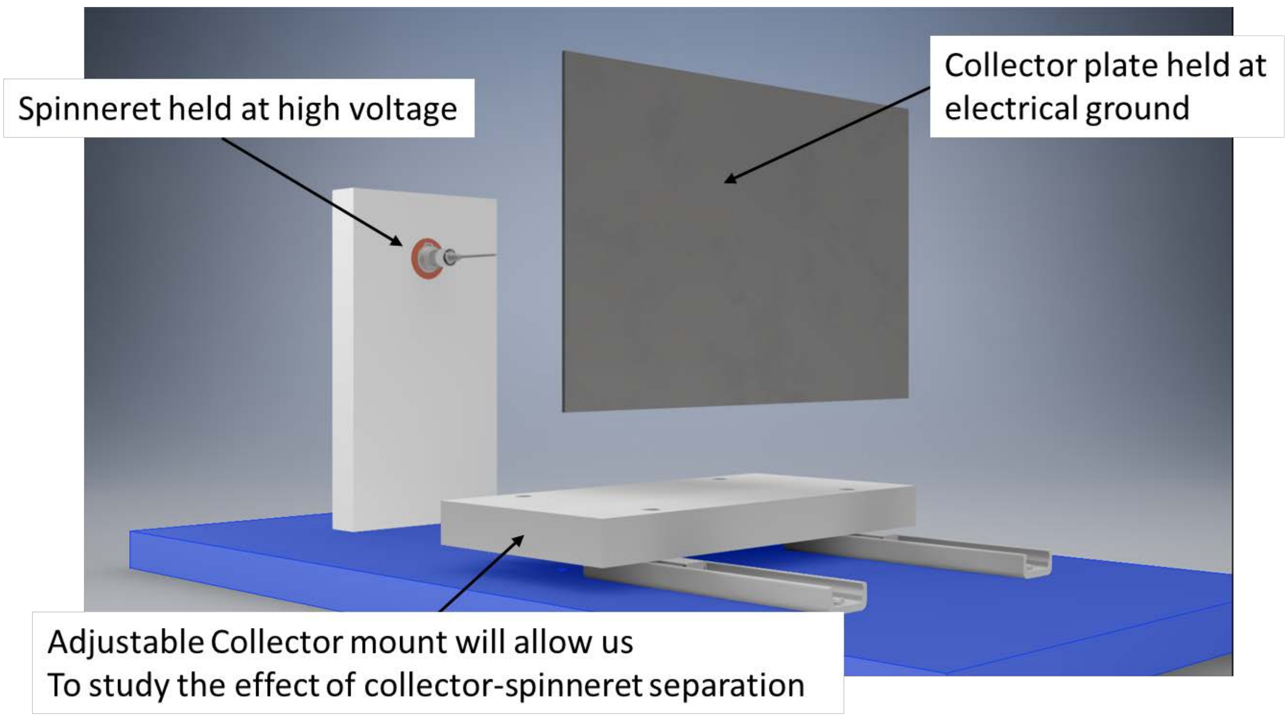


Figure 2 3D CAD Drawing of our system design. In this design there is an adjustable collector mount that will allow us to study the effect of the collector-spinneret separation on the spun nanofibers.

In addition to designing the system we have also purchased all of the supplies we needed for the project and we plan to run our first samples when the system is back from the machine shop. Table 1 list all the supplies and their current status. Our first fibers will be made from polyethylene oxide (PEO) and polyvinylpyrrolidone (PVP). These fibers were chosen because the solutions are easy to prepare and they are relatively easy to electrospin.

Description	Vendor	Model	QTY	Price ($)	Status
Dual – Single syringe pump	New Era Pump Systems	DUAL-NE-1010	1	1670.00	Received
Luer needles	Linaribiomedical	NEL-0815-12PC	12	30.00	Received
Glass syringe	Linaribiomedical	SOC10_3pcs	1	60.00	Received
Analytical balance	Cole-Parmer	EW-10000-15	1	1650.00	Received
Pyrex beaker	Cole-Parmer	EW-34502-02	1	60.00	Received
Silicone tubing	Cole-Parmer	EW-96410-15	1	86.50	Received
PEO (powder)	Sigma Aldrich	181986-500G	1	159.50	Received
PVP (powder)	Sigma Aldrich	PVP40-500G	1	139.00	Received
Fabrication	J.L.S. Machine Shop	N/A	1	500.00	Currently under construction

Table 1List of budgetary items and their current status. At this time we have ordered and received all necessary supplies for the project.

D. Summary of findings

To summarize our findings our design:

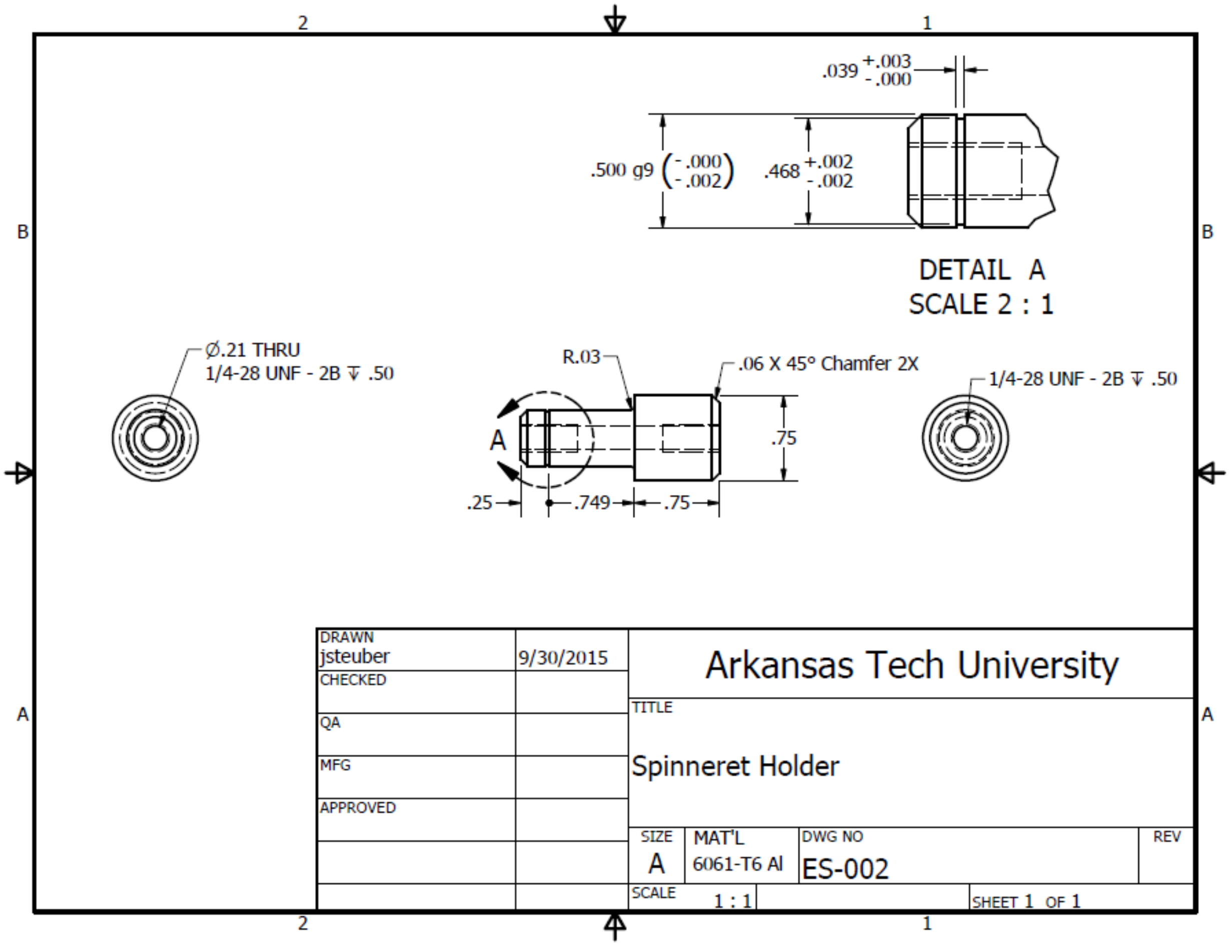
1. Is flexible enough to allow us to explore numerous material systems.
2. Will allow us to produce simple and more complex fiber geometries (coaxial, triaxial, etc.).
3. Because we are building the system using high-precision CNC techniques, we should be able to reliably and consistently reproduce results.
4. Our system is inexpensive.

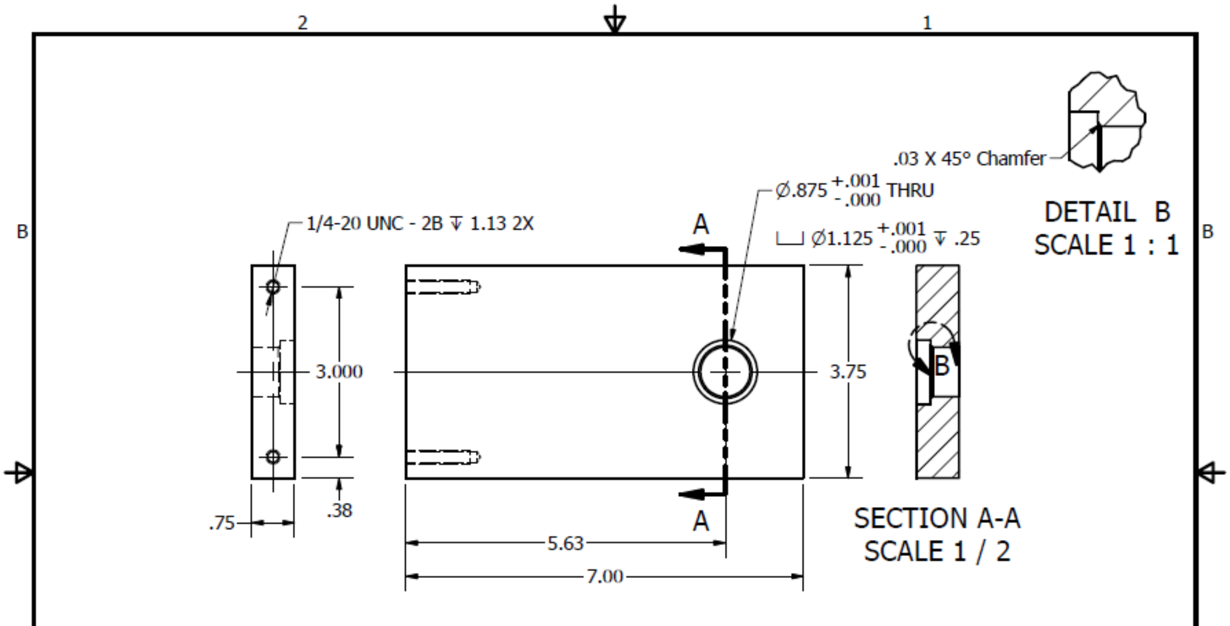
E. Conclusions and recommendations

In conclusion, a system has been designed and is currently being built that will allow us to produce nanoscale fibers. The system is designed to be flexible enough to allow the researchers to explore numerous material systems. We hope to be producing our first samples in the coming weeks of the Fall 2015 semester. Furthermore, this seed funding has allowed us to submit two follow-up proposals to explore more exotic material systems. Specifically, one proposal was submitted to the Arkansas Center for Energy, Natural Resources, and Environmental Studies to produce piezoelectric nanofibers that can be used as energy harvesters. Also, we have prepared and submitted a proposal to the Arkansas Tech University Undergraduate research office to produced TiO_2 nanofibers that can be used as a water splitting catalyst. In both proposals we requested funds to support undergraduate students.

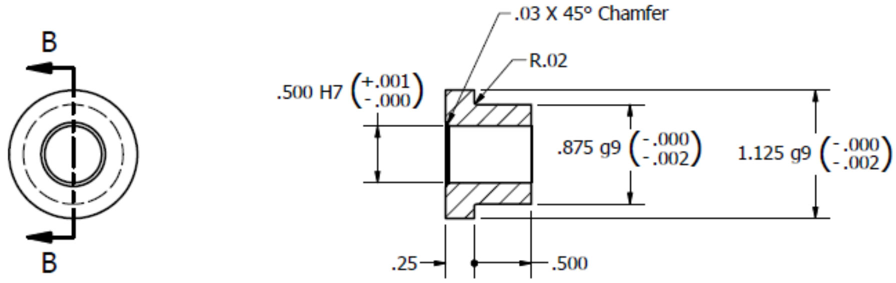
Appendix A

Mechanical Drawings for Electrospinning System





DRAWN jsteuber	9/30/2015	Arkansas Tech University			
CHECKED		TITLE Spinneret Plate			
QA					
MFG					
APPROVED		SIZE A	MAT'L 6061-T6 Al	DWG NO ES-001	REV
		SCALE 1 / 2		SHEET 1 OF 1	



SECTION B-B
SCALE 1 : 1

MAT'L
High Temperature Phenolic (G11)

DRAWN jsteuber	9/30/2015	Arkansas Tech University
CHECKED		TITLE
QA		Spinneret Isolator
MFG		
APPROVED		
		SIZE A / DWG NO ES-003 / REV
		SCALE 1 : 1 / SHEET 1 OF 1