ME 450 Fall 2014

Team 6 Electro-Jet: Executive Summary

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We were tasked by our sponsor, Professor Joerg Lahann and the researchers in his lab, to design and manufacture a new electrojetting station for Janus particle fabrication. Janus particles are multi-compartmental nanoparticles that have different properties in each compartment. They have applications in biological sciences, imaging and magnetolytic therapy, electronic displays, drug delivery, and many more applications. The current system used in the laboratory to fabricate these particles has numerous shortcomings. First, the station requires the frequent removal of particles collected on a plate from the collection stage, and the removal of the plates is a time consuming process. Second, the current design has no method of applying a layer of OCT to be jetted into, a capability the researchers desire. Third, the enclosure can build up enough charge to deliver an electric shock to users and equipment and has many cracks that allow external air to disrupt jetting. Fourth, the acrylic walls on the current system are degraded every cleaning cycle by the Lab's current cleaning process, using acetone or chloroform. Fifth, the current system requires makeshift measures to accommodate experiments involving multiple syringe pumps. Additionally, the needle to collector distance has no metric to accurately adjust it to a specific value. This distance is an important variable that affects the electric field and particle formation. Finally, cleaning of the needle required the case to be opened, fully exposing the jet to lab atmosphere. Professor Lahann has requested that we resolve all of these issues with a station that can fit inside of their fume hoods.

We created a list of specifications that improves upon the shortcomings of the current system. Our sponsor, the Lahann Lab, specified that the most important shortcoming to be addressed from the current system is the time interval between removing particles from the collection stage. Our design decreases the frequency of particle removal from 45 minutes to once every three hours, thus allowing the researchers to collect a larger volume of sample more efficiently. Additionally, our design incorporates a method for evenly applying OCT to the jetting surface. We have designed the entire enclosure frame material using acrylic to eliminate the buildup of electric charge and have designed the enclosure to be lined with a PVDF film to eliminate degradation. The needle to collector plate distance is now adjustable between 10-50 cm and accurate to 1 cm, and the system includes a feature that shows the collector plate height for repeatability.

The main features of the final design are an enclosure, a particle collection and protection system, height control, and a viscous medium distribution system. Each of the final design parameters required a unique analysis to determine the most efficacious way to meet the engineering specifications. The enclosure is constructed primarily from acrylic, the collection system is driven by an electric motor, and an air compressor powers the viscous medium distributor. We ran FEA with many iterations on the enclosure to optimize the strength of and rigidity without adding excess cost or metal components. Our final FEA model showed that the enclosure has a large safety factor against yield and less than a millimeter of deflection under load. We also created a fluid model for the viscous medium distributor, and we evaluated the necessary torques for the collection and protection system. After finalizing our design and receiving approval from our sponsor we created manufacturing plans and built and tested our enclosure. We delivered our validated final design to our sponsor before the deadline.