Electrospinner Upgrades for Nanofiber Production

Niko Black, SULI 2024 | Target Systems Department
Supervisor: Sujit Bidhar

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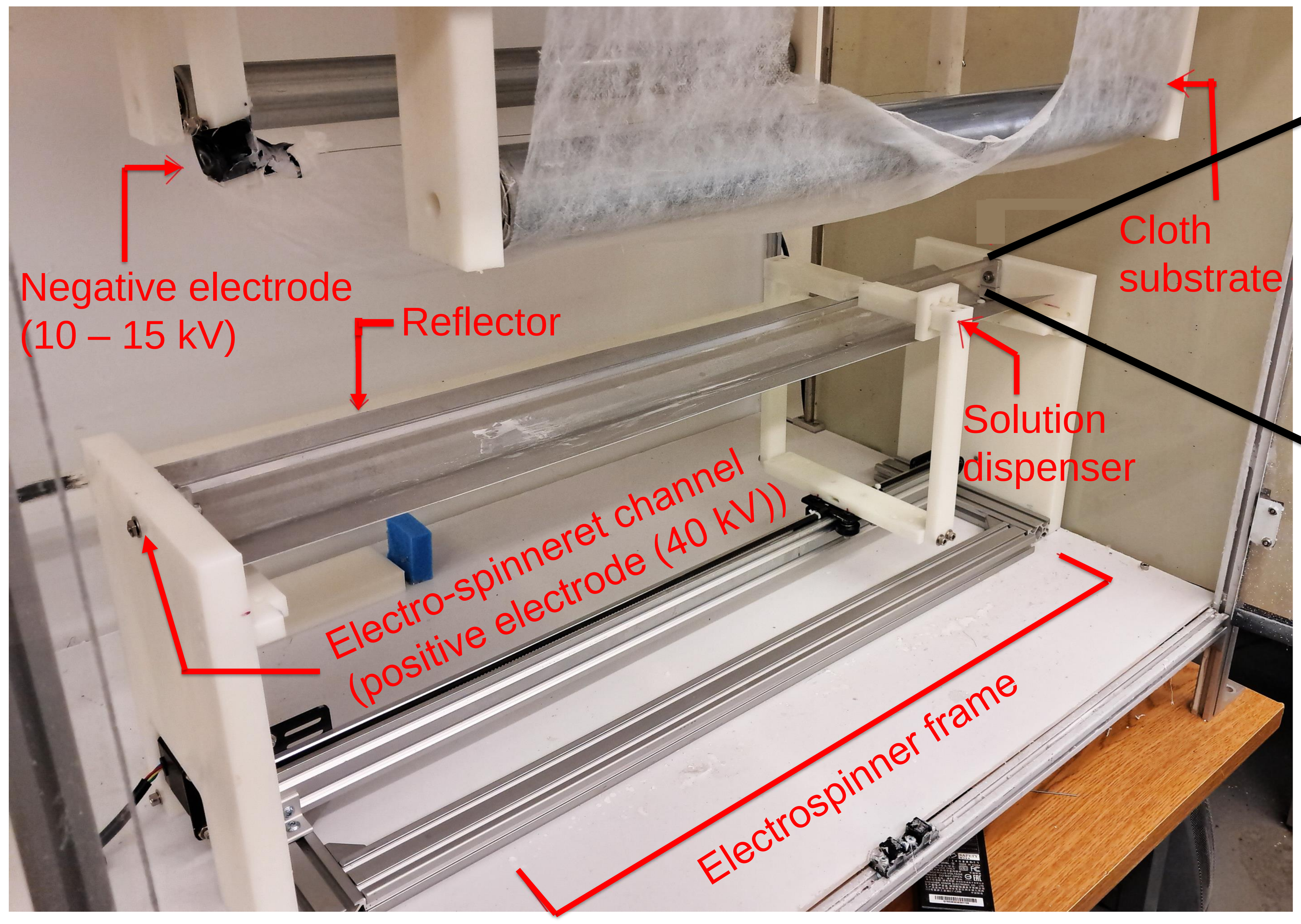
Background & Motivation

- Electrospinning is an inexpensive method for producing nanofibers with applications in accelerator targets, air filtration, and biomedicine
- Nanofiber diameter (varies functional properties) is determined by spinneret to substrate separation distance and polymer solution viscosity
- Current setup is incapable of adjusting spinneret displacement
- Polymer solution viscosity has not been quantified and can be applied to channel design once measured



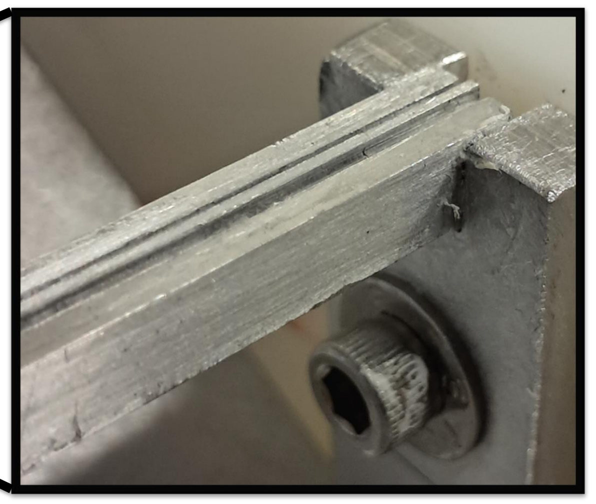


Fig 1: Free surface electrospinner unit
Inset: Electro-spinneret channel (grooved aluminum bar)

Objectives

- Research and develop a vertical lift system for the electro-spinneret channel (positive electrode)
- Redesign the solution delivery system for enhanced reliability and precision
- Calibrate viscometer and measure the viscosities of various polymer solutions

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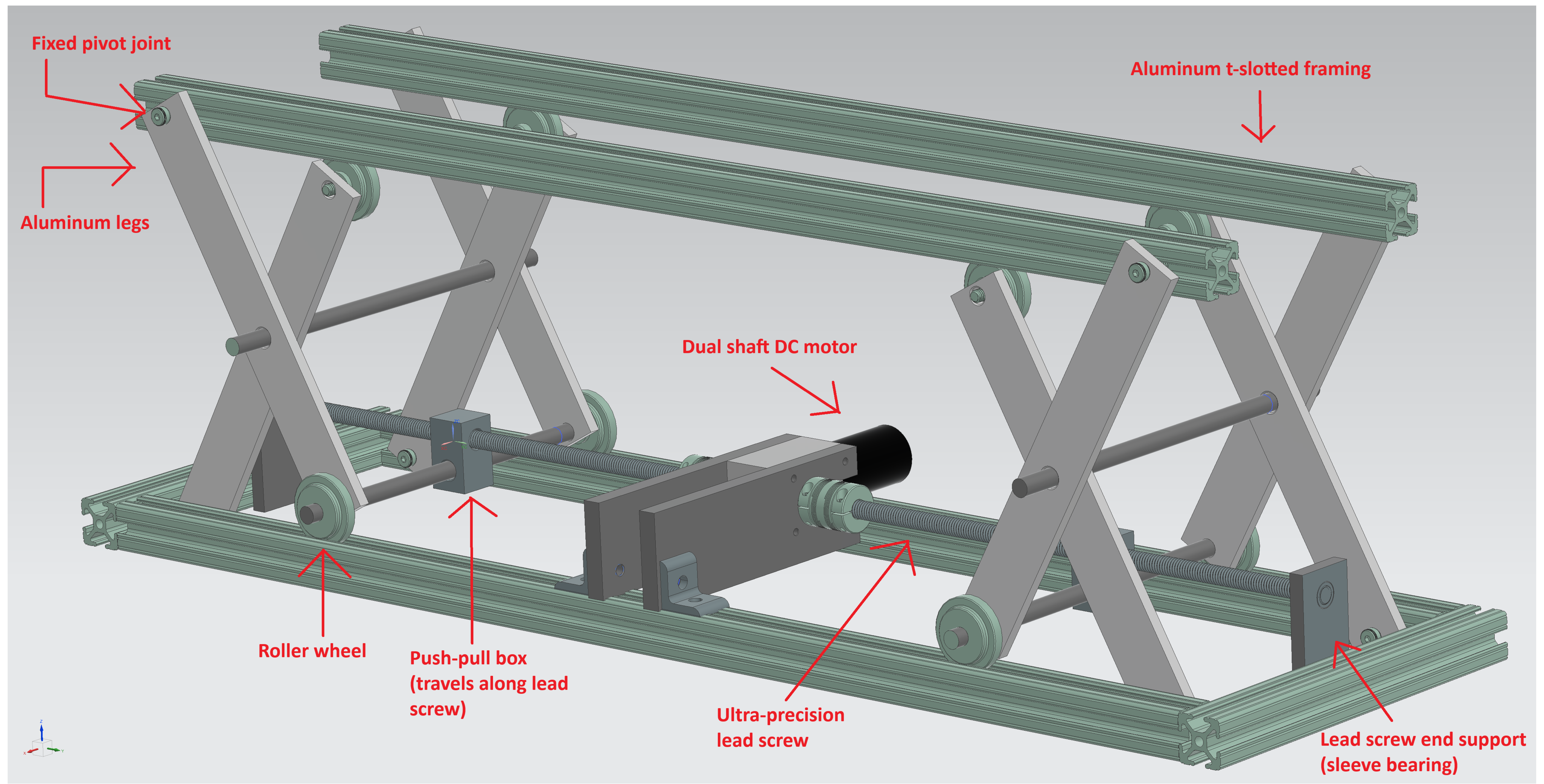

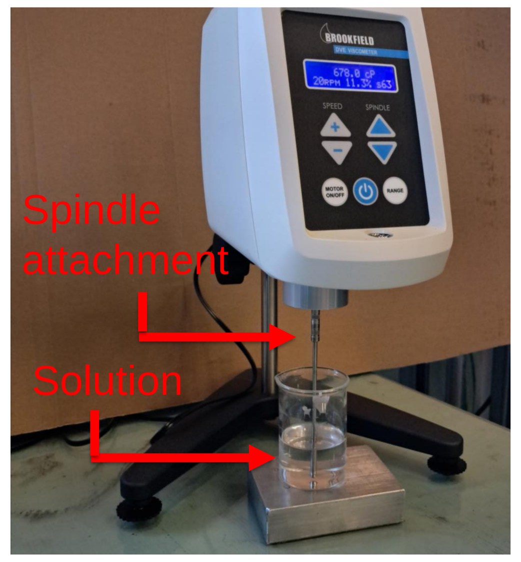

Fig 2 (above): Scissor lift model in NX CAD
Fig 3 (right): Brookfield DVE-LV Viscometer
Figure 4 (below): Disc spindle

Vertical Lift System

- Designed a dual scissor jack lifting mechanism connected directly to the electrospinner frame
- Lift is powered by a dual shaft DC motor coupled to lead screws and a potentiometer (controls speed)
- Roller wheels and aluminum t-slotted framing enable smooth and robust actuation

Viscometer Tests

- Viscosity is calculated from the torque required to rotate a spindle (Figs 3-4) in a solution at fixed speed
- Disk spindles give apparent viscosity, while cylindrical spindles give more accurate viscosity & shear values
- ω = spindle ang. velocity (rad/sec), R_c = beaker radius (cm), R_b = spindle radius (cm), x = radius of calculation (cm), M = torque (dyne-cm), L = effective spindle length (cm)

Shear rate (sec^{-1}): Shear stress ($\frac{dynes}{cm^2}$): Viscosity (Poise):

$$\gamma = \frac{2\omega R_c^2 R_b^2}{x^2(R_c^2 - R_b^2)} \qquad \tau = \frac{M}{2\pi R_b^{2L}} \qquad \eta = \frac{\tau}{\gamma}$$

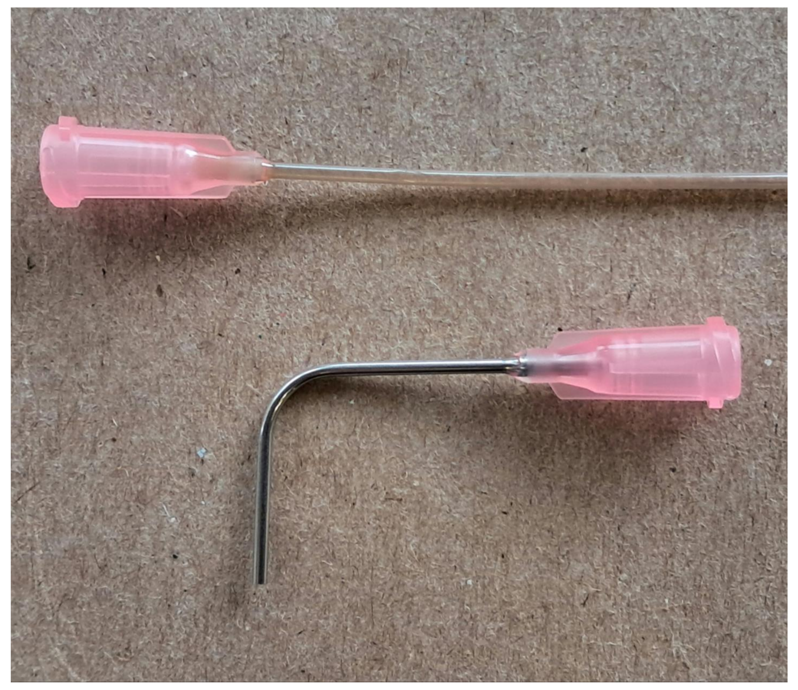

Fig 5: Upgraded solution delivery syringes (McMaster)

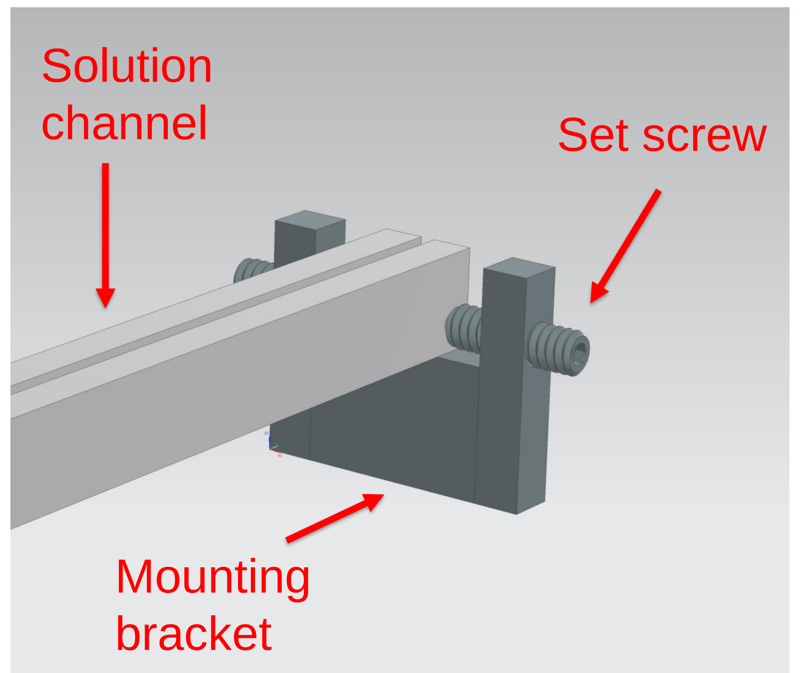

Fig 6: Channel adjustment model

Solution: PVDF, beaker diam. = 2”, disc spindle LV-2

PVDF Weight %	RPM	Torque %	Viscosity (cP)
10	30	1.9	19.00
10	50	3.5	21.00
10	60	4.5	22.50
20	30	26.5	265.0
20	50	47.2	283.2
20	60	58.0	290.0

Results & Future Work

- Acquired funding and ordered components for the scissor lift design
- Procured new solution delivery syringe (Fig 5)
- Redesigned spinneret channel to include alignment adjustment set screws (Fig 6)
- Build the scissor lift and integrate it with the electrospinner
- Complete viscometer calibration and redo measurements of polymer solutions
- Incorporate new delivery syringe and channel adjusters