The Effects of Electric Field on Jet Behavior and Fiber Properties in Melt Electrospinning

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Introduction

The electric field plays a key role in the formation of fibers during electrospinning process. The electric field strength and shape caused by the applied voltage between the spinneret and collector governs the electrospinning process.

In this work, to produce finer fibers in the melt electrospinning process, an auxiliary electrode was invited, and different electric filed were designed based on the three-dimensional electric field simulation. The experimental results confirm the simulation predictions.

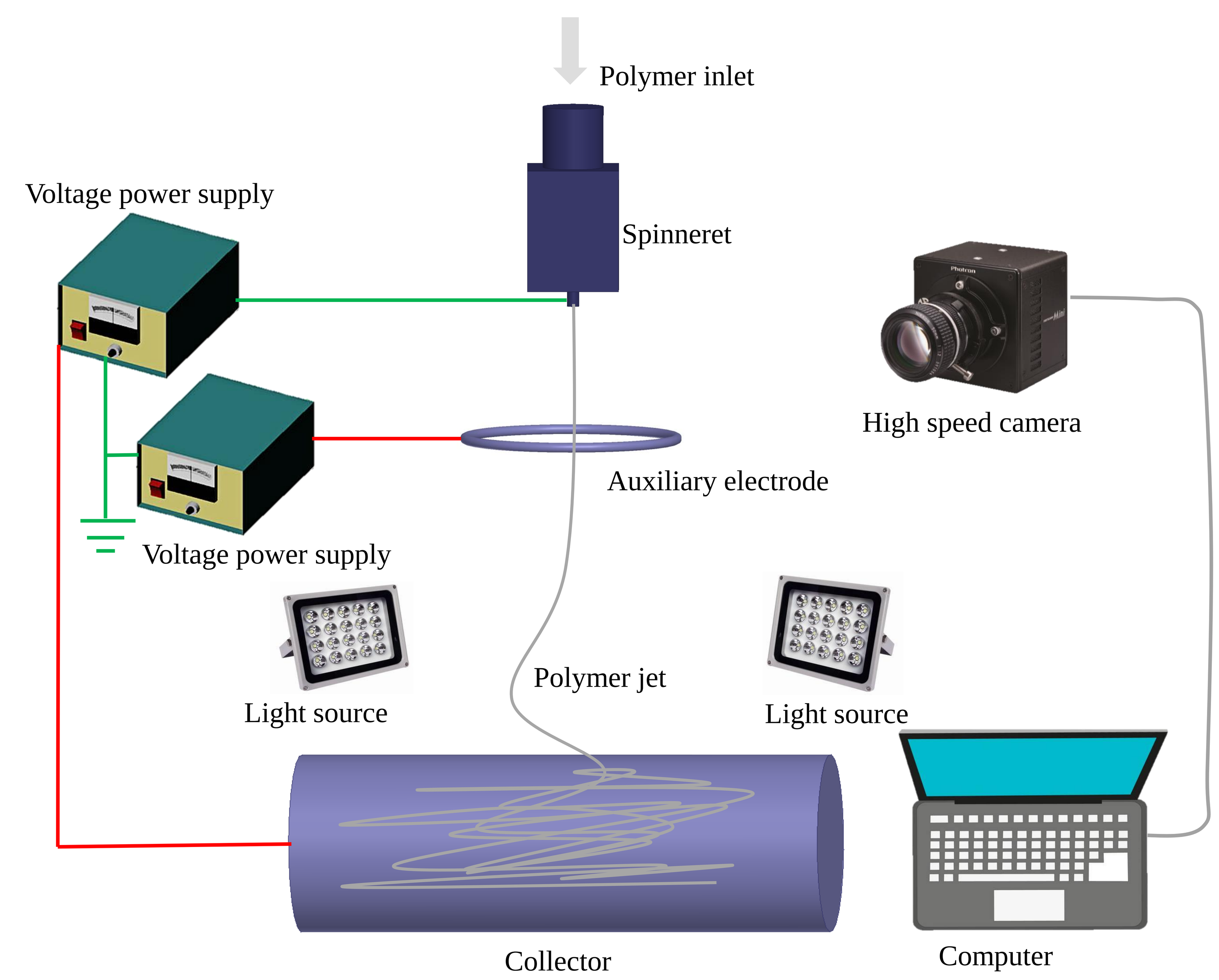

Figure 1. Schematics of experimental setups

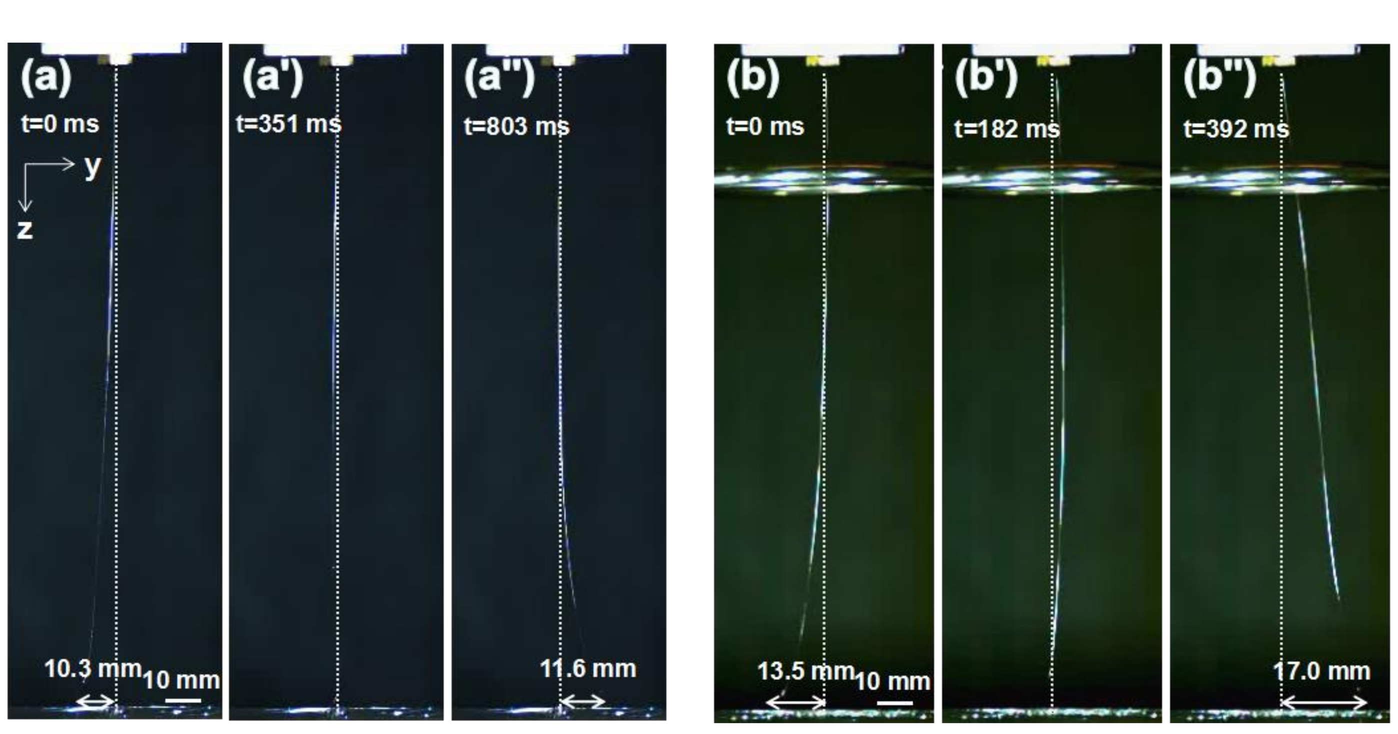

Figure 2. Jet trajectories captured by high-speed photography

Results

The greater electric field created by applying the auxiliary electrode leads to a larger whipping amplitude and a higher whipping frequency of the jet, and also produces the fiber with finer diameter. The simulation results and experimental results demonstrate that when the more uniform electric field along the spinning direction produces finer fibers and the better crystallinity and mechanical properties of fibers, because of more stable polymer jets.

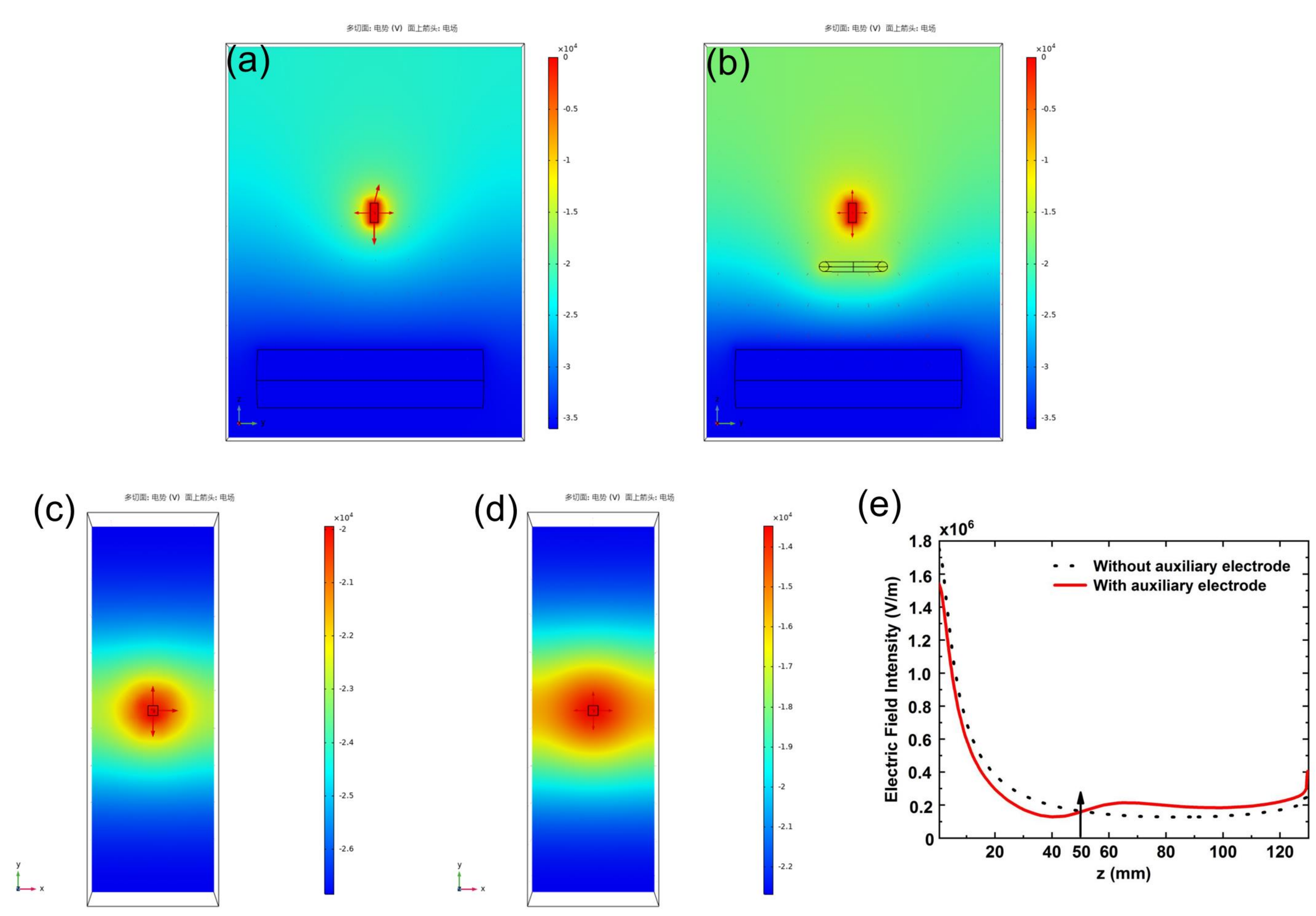

Figure3. Comparison between electric field distributions of melt electrospinning setups with and without an auxiliary electrode: (a) (c) center plane along z-axis and xy-plane at z = 50 mm of melt electrospinning setup without an auxiliary electrode, (b)(d) center plane along z-axis and xy-plane at z = 50 mm of melt electrospinning setup with an auxiliary electrode, and (e) comparation of the electric field intensity from the spinneret to the collector along z-axis in the melt electrospinning system with and without an auxiliary electrode.

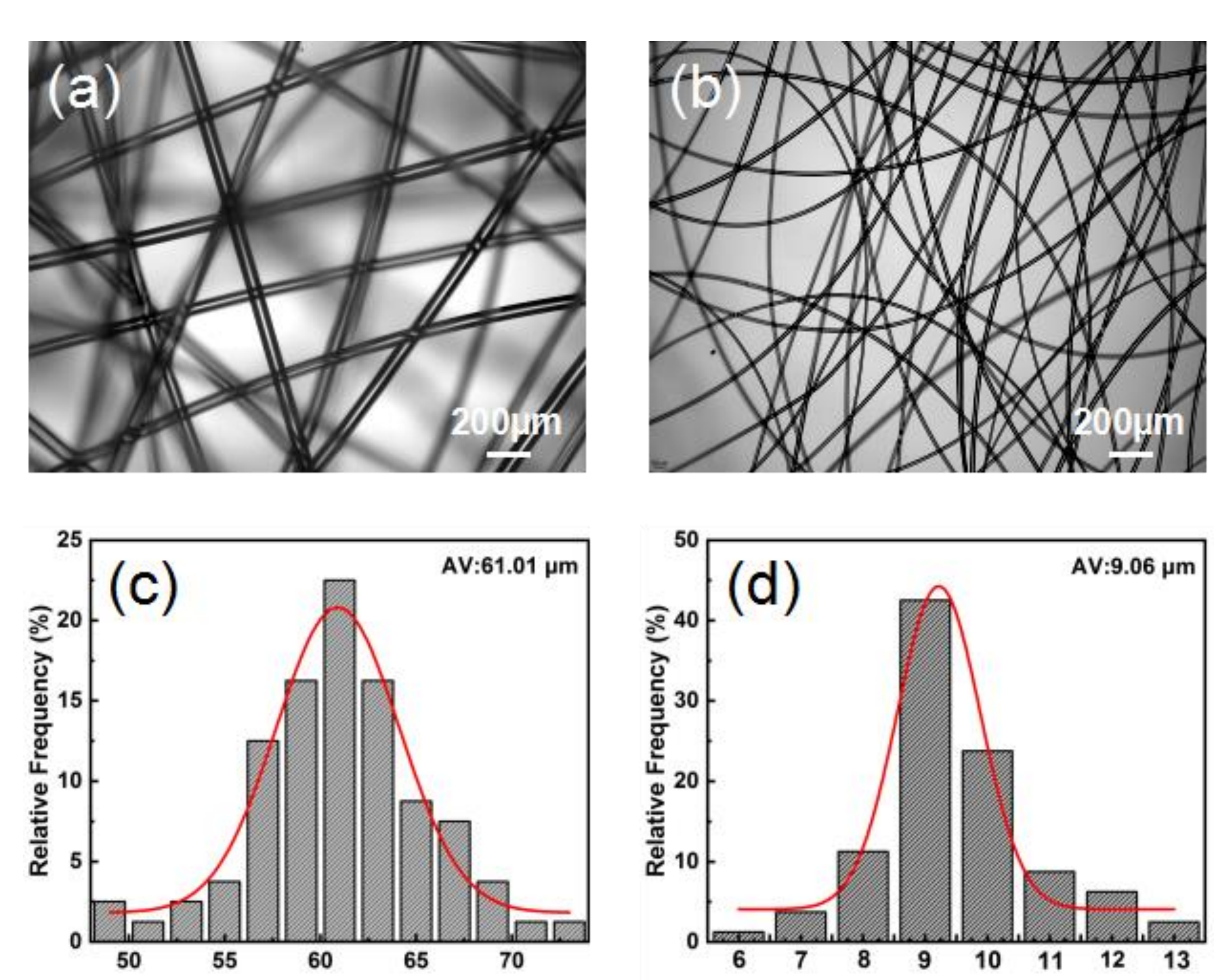

Figure 4. Images and diameters of melt electrospun fibers with and without an auxiliary electrode.(a) image of melt electrospun fibers without an auxiliary electrode, (b) image of melt electrospun fibers with an auxiliary electrode, (c) fiber diameters of melt electrospun fibers without an auxiliary electrode, (d) fiber diameters of melt electrospun fibers with an auxiliary electrode.

Conclusions:

This work describes investigations on the effects of electric field on jet behavior and resultant fiber morphology during the electrospinning process, using both experimental and simulation methods. The simulation results show that the more uniform electric field along the spinning direction produces finer fibers and the better crystallinity and mechanical properties of fibers.

References:

Mayadeo, N; Morikawa, K; Naraghi, M; Green, MJ. Modeling of Downstream Heating in Melt Electrospinning of Polymers. Journal of Polymer Science Part B-Polymer. 2017; 55:1393-1405