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Numerical simulation of electrospinning using PAK and ANSYS software

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Abstract:
During the process of electrospinning, polymer solution is accelerated from a capillary orifice of the syringe under the influence of electric field, and the liquid jet is injected in the air that travels towards the grounded plate. Consequently, it is crucial to simulate the electrospinning process including the interaction of electric field and polymer. The motivation for this research was to analyze the effects of different solution, process and ambient parameters without the necessity to perform the experiments each time. Additionally, validated simulations in PAK software, developed at the University of Kragujevac, would create possibilities to include additional modifications and parameters that influence the process of electrospinning.

The simulations were performed using the Finite Element Method (FEM) based on geometry values obtained from commercially available EC-CLI device (IME Technologies, Geldrop, The Netherlands). Electrospinning parameters used in the experiment were adopted for simulation - 21G needle type; voltage pairs 15kV applied on the nozzle and 0kV on the collector; 0.8 ml/h flow rate. Material properties for 10wt% PVA solution were adopted from the literature values, as they could not be determined experimentally at this point. Laminar flow was assumed and simulation included flow field and electric field interaction.

The simulation results in PAK software show good agreement with commercially available software ANSYS and similar jet shapes were obtained during the simulations. Initial results also confirm the hypothesis that the jet shape during electrospinning can indicate whether setting of the chosen electrospinning parameters would result in good quality fibers. Future studies would include parameter modifications in order to examine jet shapes when optimal and non-optimal parameters are used. The ultimate goal is to provide users with stand-alone application for finding optimal parameters in electrospinning, which would reduce time-consuming process of performing experiments until relevant parameters are determined. The beneficial effect of such simulations could also be seen in reduced solution material consumption, maintenance costs etc.

Keywords:
electrospinning, PAK software, computational simulation, finite element method (FEM)

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