Supporting information

Stable Single Device Multi-Pore Electrospraying of Polymeric Microparticles *Via* Controlled Electrostatic Interactions

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Experimental

Poly (ε-caprolactone) (PCL; M_w = 45000 g/mol) was purchased from Sigma-Aldrich, USA. Dichloromethane (DCM) was obtained from Sinopharm Chemical Reagent, China, and was used without further purification. To prepare electrosprayed (ES) PCL particles, polymeric solutions with concentrations of 1, 3, 5, 7, 9, 12 wt. % were prepared by dissolving appropriate quantities of PCL in DCM solvent. The polymer solutions were mechanically stirred for 1h at the ambient temperature.

A schematic illustration of the ES setup is shown in **Fig. 1**. The flute-like multi-pore emitter was manufactured using a 1mL plastic syringe (Sentansha Medical Co., Ltd, CN). The three pores (A, B and C) of each multi-pore emitter had diameters of 400 μm and were fabricated in a straight line at the bottom of the syringe. Two flute-like multi-pore emitters were engineered possessing pore intervals of 1.2 mm and 2.4 mm using hot-melt adhesives, respectively. The solution flow rate was controlled by a syringe pump (KDS100, USA). A high voltage generator (Glassman, USA) was used to provide a static electric field between the multi-pore emitter and the rectangular iron coil. The distance between the multi-pore emitter and the rectangular iron coil

was set at a distance of 10 mm. A high speed camera (Baumer, TXG02c, Germany) equipped with an optical light source was used to observe and record jetting behavior of the ES and orifice/pore region.

Polymeric solutions were transferred into 5 ml plastic syringes and were (individually) continuously perfused into the multi-pore ES emitter at a series of flow rates. A selection of positive voltages were applied to the multi-pore emitter to initiate the atomization process resulting in PCL microparticles (MPs), A rectangular iron coil was used as the grounded electrode. Glass slides (substrate) were placed on a raising platform to collect PCL MPs under the grounded electrode at different deposition distances. All ES processes and experimentation was carried out at ambient temperature (22 ± 2℃).

The surface morphology and size of generated PCL MPs was characterized using Optical (Phenix MCD310, China) and scanning electron microscopy (SEM, Hitachi SU-70, Japan). Prior to SEM scanning, samples were sputter-coated with gold for 60 s in a vacuum after mounting the sample on metallic studs with double-sided conductive tape. Samples were examined at an accelerated voltage of 3 kV. The average diameter of the generated particles was obtained from optical micrographs using Image J software (National Institute of health, USA) (sample size n>100).

To confirm interactions between the adjacent electrojets and the theoretical solution velocity distribution into a tri-pore flute-like emitter, Comsol Multiphysics 5.0 (*via* finite element method) was deployed. The use of Comsol Multiphysics 5.0 includes: (1) creating geometries of the flute-like ES emitter according to the real device (pipe diameter=4.70 mm, pore diameter=400 um, pore interval=1.2 mm and 2.4 mm), (2) setting physical properties and boundary conditions, (3) solving and post-processing the related data.

The repulsion of electrojets was equivalent to the interactions between three beams of charged particles which are released at regular time intervals. The effect of the pore (orifice) interval was simulated by comparing the tendency of repulsion between adjacent charged particle beams at the same applied voltage (18kV).

The solution velocity at the three pores and its movement throughout the whole volume of the flute-like ES emitter was simulated by setting a theoretical model which incorporated the same dimensions (3D) and also utilised the same flow rate at 10ml/h with no electric field. The exact flow rates at the orifice of the three pores was calculated.

Figures

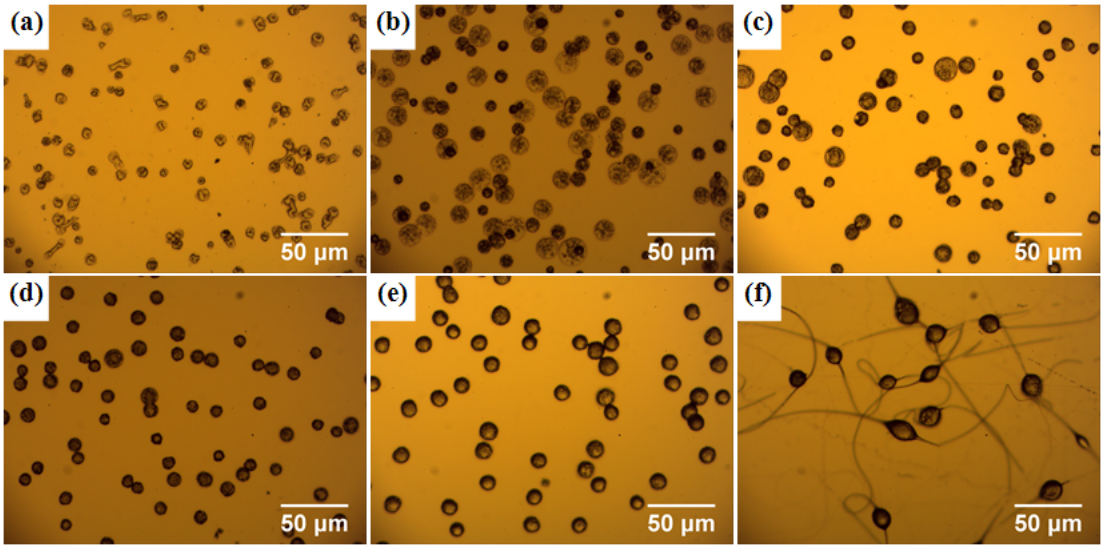

Fig. s1 Optical micrographs of generated particles by a tri-pore emitter using PCL solutions with concentration of 1, 3, 5, 7, 9, 12 wt.%, (a)-(f) respectively.

Tables

Table. 1 Simulation results of individual solution flow rates from each pore at varying total inflow rates. According to the data in the table, all three pores demonstrate very similar flow rates (range from 9 to 10.5 ml/h). Furthermore, when the total flow rate is increased within the range, the difference between individual pore flow rates is reduced.

Table. s1 Flow rate of 3 pores

unit: ml/h

Total Flow Rate	Pore A	Pore B	Pore C
9.0	3.0029	2.9996	2.9975
9.5	3.1697	3.1662	3.1641
10.0	3.3364	3.3328	3.3308

10.5	3.5032	3.4994	3.4974

Table. 1 flow rate from pore A, pore B and pore C when the total flow rate varies from 9.0 ml/h to 10.5 ml/h.