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A Study of the Printability of a High Melting-temperature Polymer via Melt Electrowriting

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Introduction:

Melt electrowriting (MEW), an advanced additive manufacturing (or 3D printing) technology for producing high-fidelity scaffolds, has been widely applied in tissue engineering and regenerative medicine. Current MEW can easily print polycaprolactone with a melting temperature (T_m) of approximately 60 °C, while its printability extremely decreases for printing polymers with high melting temperatures. In this context, ethylene vinyl alcohol (EVOH) (T_m = 174 °C) was chosen as a model polymer to unfold the principles of printing high melting temperature polymers by MEW to some extent.

Experimental:

Initially, EVOH pellets (K3850B, MITSUBISHI CHEMICAL GROUP) were dried in a vacuum oven at 80 °C for 2 hours and then at 110 °C for 6 hours. A home-built MEW device was used throughout. The printing parameters include print temperatures of 160 ~ 265 °C, collector temperatures of 60 ~ 100 °C, applied voltages of 2 ~ 3 kV, nozzle-to-collector distance of 1.75 mm, air pressure of 100 kPa, and collector speed of 8 mm/s. The room temperature was kept in the range of 25 to 27 °C and the relative humidity was kept in the range of 33 to 35%.

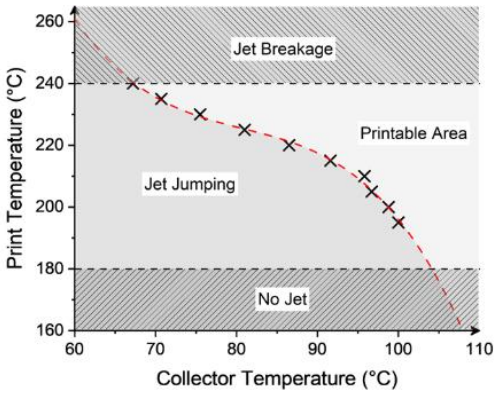

Fig.1 A phase image of EVOH in MEW system.

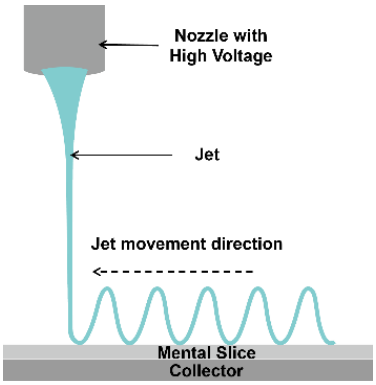

Fig.2 Schematic image of jet jumping.

Results and Discussion:

Fig.1 reflects the jet states under different collector and print temperatures. Specially speaking, the jet cannot be extruded out when the print temperature is lower than 180 °C, or the jet breaks up when the print temperature is higher than 240 °C. A continuous and homogenous jet is formed for the print temperatures set between 180 to 240 °C. A red dashed line further divides the phase image into jet jumping (Fig. 2) and printable regimes. Under an insufficient heating atmosphere, the jet partially solidifies before reaching the collector; once the jet attaches to the collector, the surface of the jet soon attracts negative charges that carry the jet moving upwards, resulting in the jet jumping.

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