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Fabrication and characterization of melt electrowritten poly(D, L-lactic acid) scaffolds

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Introduction:

Melt electrowriting (MEW) is an advanced manufacturing technique capable of creating finely porous structures with precisely defined microarchitecture scaffolds for tissue engineering and regenerative medicine. Presently, poly(caprolactone) (PCL) is highly favored as the ideal material for MEW, because of its low melting temperature and fast solidification. Nonetheless, the printing of various biobased materials using MEW remains a challenge, primarily because of their thermal degradation characteristics. Poly(D, L-lactic acid) (PDLLA) has gained significant attention in tissue engineering and regenerative medicine due to its biocompatibility and biodegradability. Within this context, we approach to examine both the fabrication and the characterization of PDLLA scaffolds.

Experimental:

A custom-built MEW device is used to print medical-grade PDLLA with a D/L ratio of 50/50 and molecular weight of 240 kDa (Musashino, Japan). Critical translation speed (CTS), refers to the collector's speed when it aligns with the jet speed and creates a straight line. To determine the CTS, a range of collector speeds was adjusted within the range of 1 to 30 mm/s, with increments of 0.2 mm/s. The printing parameters are 1.75 mm nozzle-to-collector distance, 3.5 kV applied voltage, 100 kPa air pressure, printing temperature from 185 to 155 °C, and 75 °C collector temperature. The average temperature of the printing cabinet is 27~29 °C and the average relative humidity is 26~28 %. Before printing, the PDLLA raw material is dried in a vacuum oven at 110 °C for 12 hours.

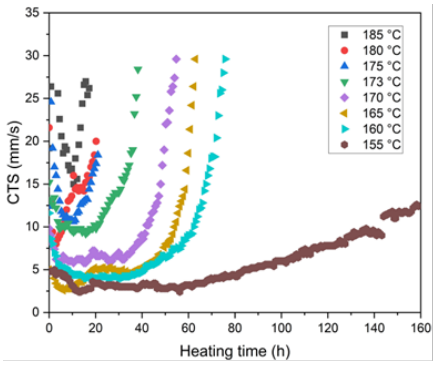

Fig.1 CTS versus heating time.

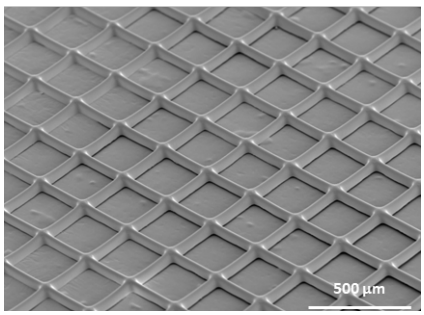

Fig.2 Melt electrowritten PDLLA scaffold.

Results and Discussion:

The PDLLA exhibits a progressively stable CTS as the heating temperature decreases from 185 to 155°C, as shown in Figure 1. At 155°C, it can maintain continuous printing for over 40 hours without requiring any specific procedures. Figure 2 shows the PDLLA scaffold with an interfiber spacing of 300 µm. With an air pressure of 40 kPa, the fibers can be neatly stacked into 50 layers, and they seamlessly fuse together, even though the collector temperature used is only 6 °C higher than the glass transition temperature (59 °C).

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