Supporting Information

Simultaneous enhancements in the strength, modulus and toughness of electrospun polymeric membranes

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Fig. (S1-S4)

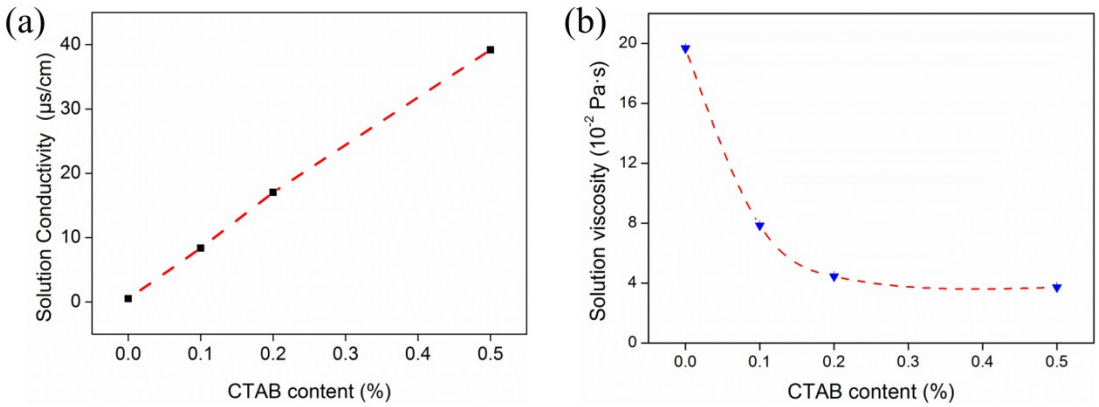

Fig. S1. (a) Conductivity and (b) viscosity of PC solution with different content of CTAB.

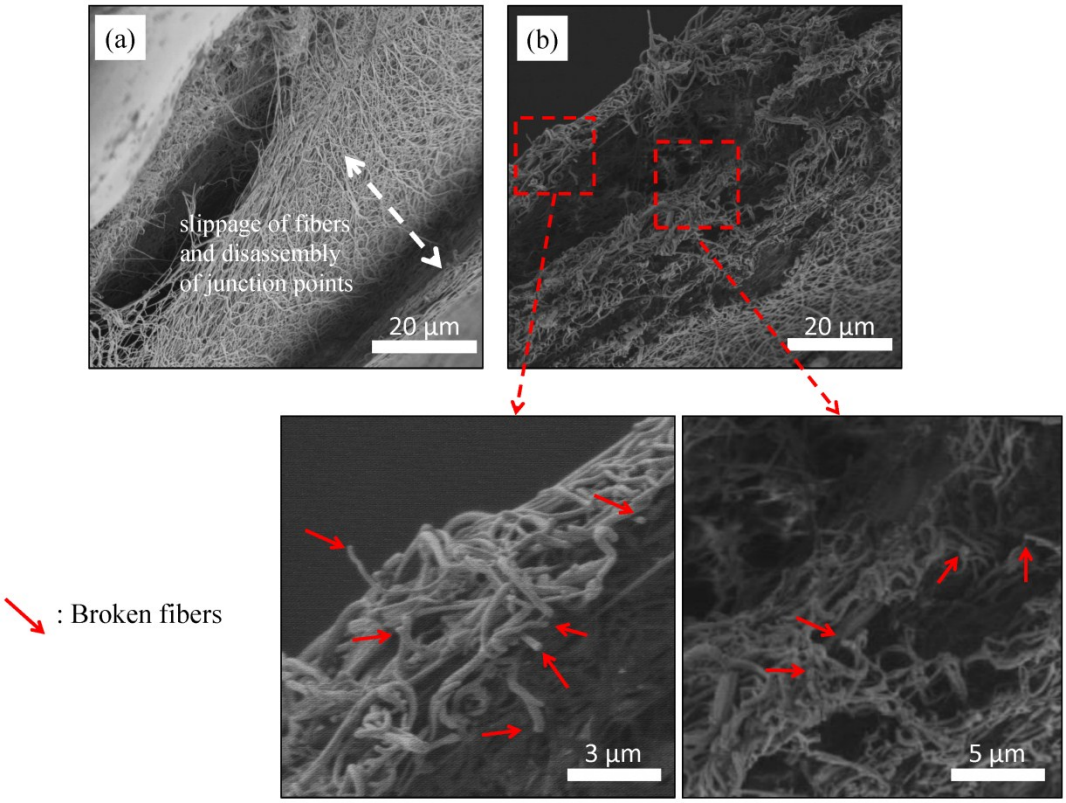

Fig. S2. Micro fracture appearance of (a) origin PC membrane and (b) post-treated PC membrane by the mixed solvents with 30% THF. There were clear signs of fiber slippage and disassembly of junction points of fibers in Fig. S3a. After treatment there were large amount of broken fibers at the fracture (shown in Fig. S3b), which demonstrated that the slippage and disassembly were greatly confined by the fusion of junction points.

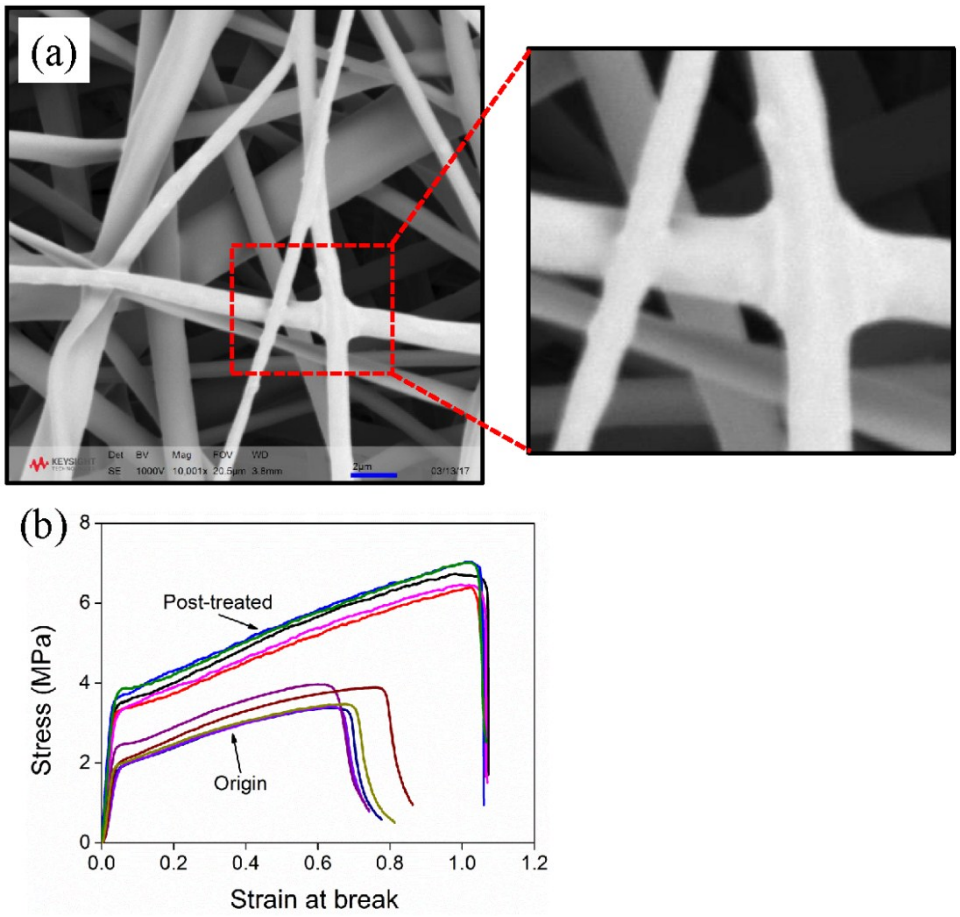

Fig. S3. (a) Morphology of ES PLA fibers after treatment and (b) Strain-stress curve of origin and post-treated PLA membrane. The PLA membrane was post-treated by a solvent composed of 90% ethanol and 10% dichloromethane (DCM). There was clear sign of fusion of junction points of fibers (shown in the amplified red dash rectangle), and after treatment the membrane exhibited enhanced modulus, strength and toughness. The scale bar measures 2 μm.

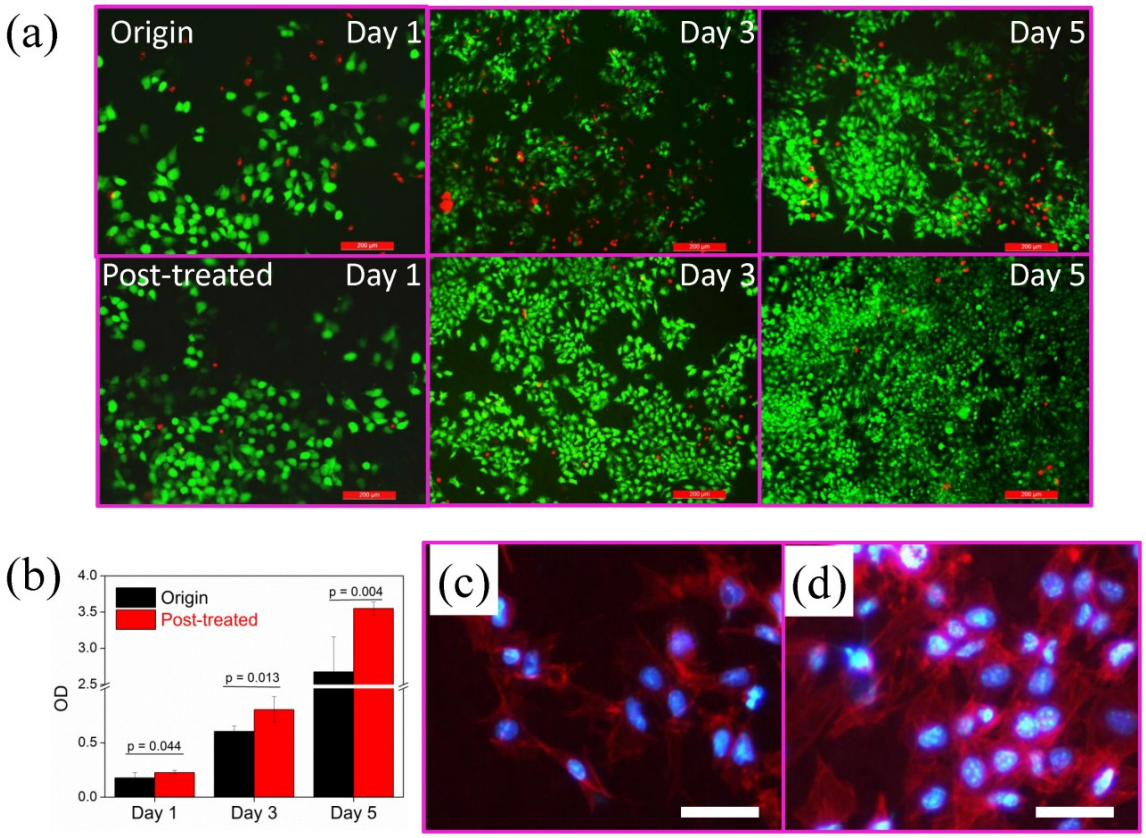

Fig. S4. (a) Live/dead viability results of HUVECs, (b) quantitative analysis of cell proliferation, and cytoskeleton of cells grown on (c) origin and (d) post-treated scaffold. HUVECS survived very well on the post-treated scaffold (green fluorescence indicates live cells) and fewer dead cells were seen (red fluorescence indicates dead cells). The quantitative cell proliferation also demonstrated that after treatment PLA membrane exhibited better biocompatibility, and the $p < 0.05$ denoted the compared data was significantly different. Seeing form (c) and (d), cells grown on the post-treated scaffold showed superior spreadability and solid cytoskeleton, which was probably because scaffold with better mechanical property supported the cell well and promote cell adhesion. The scale bar measures 200 μm in (a) and 60 μm in (c) and (d).

Experimental

Materials

PC 2720 (Mw = 42,000 g/mol) was from Sabic (USA) and PLA 4032D (Mw = 100,000 g/mol) was from Nature Works (USA). Tetrahydrofuran (THF), Dimethyl Formamide (DMF), ethanol, dichloromethane (DCM) and Hexadecyl trimethyl ammonium bromide (CTAB) were from Kermal Co (Tianjin, China). All the materials were used directly without any advance purification.

Electrospinning

A high voltage supplier was purchased from Gamma (USA). PC nanofibers were fabricated from the solution containing 16 wt. % of PC which was dissolved in THF/DMF in the ratio of 7 : 3 (v/v). CTAB was added into the solution to increase the conductivity of the solution with the content of 0.2 wt. % of PC. PLA membrane was electrospun from the solution with 10 wt. % of PLA which was dissolved in DCM/DMF in the ratio of 7 : 3 (v/v). All the nanofibers were electrospun at room temperature, ambient humidity, with a solution feed rate of 0.6 ml/h and applied voltage of 18 kV. All the electrospun fibers were collected using 2D metal plate.

Posttreatment

As-spun PC membranes were immersed in water/THF with ratio ranging from 5:5 to 9:1 for 0.5 h. PLA membranes were immersed in ethanol/DCM in the ratio of 9 : 1 for 0.5 h. Then the membranes were transferred to a ventilated area to allow the mixed solvent to evaporate at room temperature for 24 hours.

SEM characterization

As-spun nanofibers were observed using scanning electron microscope (SEM, Keysight 8500 FE, USA) after gold coating. Distribution of fiber diameter were analyzed using ImageJ software from a population of more than 200.

TEM characterization

Internal morphology of fibers was characterized using transmission electron microscope (JEM-2100, Japan).

AFM characterization

PC nanofibers for AFM (Keysight 7500, USA) characterization were received using silicon slice. Topography and phase diagram of PC nanofibers were imaged using tapping mode.

Tensile test

Tensile tests were carried out using a tester with 20 N load range and 0.01 N load resolution. All the specimens were stretched to failure at a strain rate of 5 mm/min with gauge length of 50 mm and width of 5 mm. Each test was repeated for 5 times and averaged.

Biocompatibility Evaluations

- **Cell Culture and Seeding**

Human umbilical vein endothelium cells (HUVECs, Oligobio, Beijing, China) were used for cell culture studies on the prepared scaffolds. The cells were cultured in RPMI1640 (BI) supplemented with 10% fetal bovine serum (BI), and incubated at 5% CO_2 and 37 ^oC. Cells were routinely subcultured in a 1:4 ratio before reaching ~80–90% confluence, and media was replaced every day.

Scaffolds were tailored into circle and placed on the bottom of a sterile standard 24-well plate. Before cell seeding, scaffolds were soaked in 75% medicinal alcohol overnight, and then washed with PBS for three times, after that soaked in PBS overnight, then washed with PBS for three times and sterilized by UV sterilization for 30 minutes on each side. HUVECs cells were washed with PBS for second times and then dissociated for 3 min in trypsin-EDTA and then washed with complete medium (RPMI1640 supplemented with 10% fetal bovine serum). Cells were counted and seeded at a density of 10,000 cells/cm^2 onto each membrane. The utilization of these plates ensured that the only cells being assayed were those that were bound to the material under examination. The culture plates with electrospun membranes were then placed in an incubator at 5% CO_2 and 37 ^oC. Media was replaced every day and assays were

performed at days 1, 3, and 5 to characterize cell viability and proliferation. All tests were done with at least three replicates.

- **Cell Viability (Live/Dead Assay)**

The cell viability of the scaffolds was characterized using a Live/Dead Viability/Cytotoxicity Kit (KeyGEN BioTECH) to determine how many cells were living and dead on days 1, 3, and 5. This kit contained green fluorescent Calcein AM to image the cytoplasm of living cells, and red fluorescent Propidium Iodide (PI) to image cell death by penetrating broken cellular membranes. The staining solution was prepared following the manufacturer's instructions. For the live/dead assay, the medium was first removed from the scaffold and cells. Then Dulbecco's phos-phate-buffered saline (DPBS) was used to gently wash the scaffold and cells. Following this, an appropriate amount of the staining solution was added directly to the scaffold with cells and incubated 30 minutes at room temperature. The cells were observed using a Fluorescent inverted microscope (DMI3000, Leica).

- **Cell Proliferation (CCK8 Assay)**

The number of cells living on days 1, 3, and 5 was determined using a CCK8 assay (Japanese colleagues). 20 µL of CCK8 dissolved in 200 µL media were put onto six samples of each type. After incubating for 2 hours at 5% CO_2 and 37 ^{o}C, 100 µL the media containing CCK8 was added to a 96-well plate. The number of cells was calculated by measuring the absorbance at 450 nm.

- **Cell Morphology/Adhesion (Cytoskeleton Assay)**

Cell morphology on days 4 was determined by CF™ 568 phalloidin (red F-actin) staining. Cells were gently rinsed with DPBS three times and then fixed by Fix cells incubating scaffolds on ice with 3.75% formaldehyde solution in PBS for 15 minutes. Following this, they were washed three times, again with DPBS, and then permeabilized by incubating the scaffolds in 0.5% Triton-X in PBS for 10 minutes at room temperature. Washed cells three

times, and blocked by BSA for 30 minutes at room temperature. The cells were then washed with DPBS and incubated in 5 μL fluorescent phalloidin stock solution in 200 μL DPBS for 20 minutes at room temperature. The cells were washed with DPBS three times, and incubated in 200 μL 4', 6-diamidino-2- phenylindole (DAPI) for 10 minutes at room temperature. Then the cells were washed again with DPBS and imaged using the same microscope used for the live/dead assay.