Method of Forming Gradient Coating Based on the Hybrid -Jetting and E-Spray 3D Desktop Bio-Printing Platform

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Industry Problem

Tendon injury is one of the most common injury in human body, which has been reported to account for about half of all musculoskeletal injuries in the United States, with more than 100,000 patients undergoing reparative surgery. Tendon, being a soft tissue, is able to transmit the force and movement from muscle to bone. Tendon-to-bone interface is a complex gradient structure, and gradually changes from soft tissue to hard tissue. This interface is critical since it enables the transfer of loads between tendon and bone, minimizes the formation of stress concentrations. Recently, some researchers have reported different manufacturing methods for tissue-engineered tendon-to-bone interface scaffolds. Scaffolds based on current techniques are still unfulfilling the requirements for obtaining effective tendon-bone interface in a simple pathway.

Solution

In this invention, a hybrid process which combined electrohydrodynamic jet printing (E-jet) and electrospraying (E-spray) was successfully applied to fabricate scaffolds with functionally gradient structure to bio-mimic the tendon-bone interface, which connects and gradually changes from soft tissue to hard tissue.

E-jetting technique is applied to generate nano-/micro-scale bio-polymeric fibers, and E-spray is applied to generate nano-scale particles for coating using a bio-ceramic material. In this invention, these two techniques are combined together with a specially designed setup to achieve fabrication of composite gradient coating. This E-jetting and E-spray dual-nozzle setup is incorporated in the 3D desktop printing platform to continuously create customized functional gradient coatings. Also, the dual-nozzle setup is flexible enough to work independently for either bio-polymer coating or bio-ceramic coating with diverse structure and porosity.

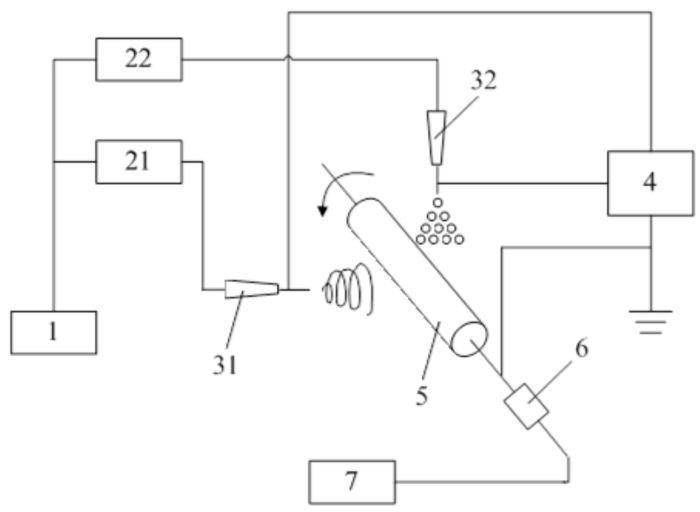

Figure 1: Schematic overview of the hybrid E-spinning and E-spraying system.

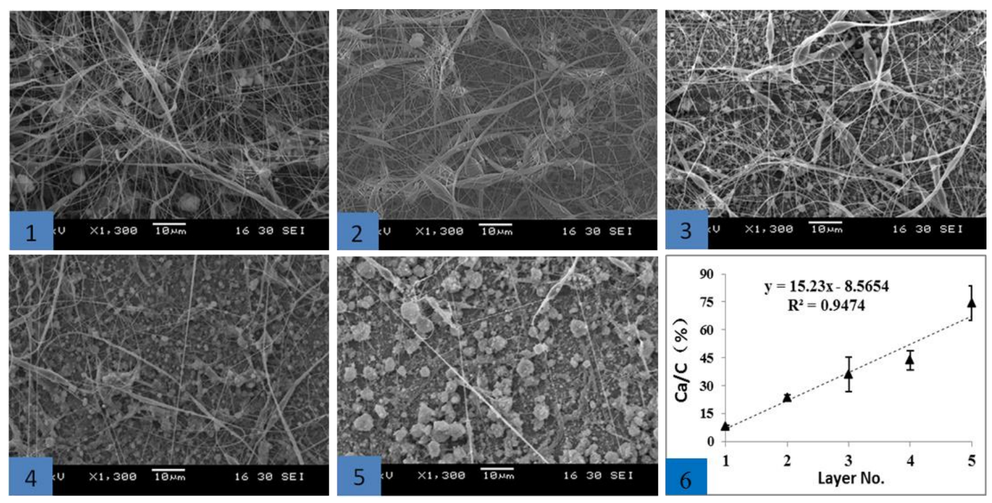

Figure 2: (1-5) Morphology of different layers of the scaffold; (6) The C/Ca ratio of different layers of the scaffolds.

Value Proposition

Currently, some researchers have reported different manufacturing methods (e.g. co-electrospinng, hybrid twin screw extrusion/electrospinning and soaking the electrospun mat in a highly concentrated solution with calcium phosphate content) for tissue-engineered tendon-to-bone interface scaffolds. Those scaffolds based on current techniques are still unfulfilling the requirements for obtaining effective tendon-bone interface in a simple pathway.

Compared with the current technologies, the advantage of the hybrid process was that it had the capability to fabricate the gradient construct without manual operation and material changing during printing. The technique was designed to distribute polycaprolectone to hydroxyapatite in a gradient way.

Other Potential Application

The potential applications of this invention include soft tissue printing in regenerative medicine, customized scaffolding for drug testing, uniform functionally-gradient coating with combination of multiple materials for implant coating, etc.

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