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Editors

Jiri Orava

University of Cambridge
Department of Materials Science and Metallurgy
27 Charles Babbage Road
CB3 0FS Cambridge
United Kingdom

Tohoku University
WPI-Advanced Institute for Materials Research
(WPI-AIMR)
2-1-1 Katahira, Aoba-ku
980-8577 Sendai
Japan

Tomas Kohoutek

Involved Ltd.
Siroka 1
537 01 Chrudim
Czech Republic

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INTRODUCTION OF NEW LABORATORY DEVICE 4SPIN® FOR NANOTECHNOLOGIES

4SPIN®
make nano friendly

Pokorny M.*, Rebicek J., Klemes J., Velebny V.
Contipro Biotech s.r.o., R&D Department, 561 02 Dolni Dobrouc, Czech Republic
web: www.4spin.info, phone: +420 467 070 339, e-mail: marek.pokorny@contipro.com

INTRODUCTION

4SPIN, a new desktop laboratory apparatus, has been developed for the deposition of nanomaterials for medical applications. The apparatus integrates different methods to enable the preparation of nanostructured scaffolds according to specific research requirements. These methods are Electrospinning, Electrospraying and Electroblowing.
A variety of materials (including hyaluronic acid and its derivates) have already been processes. Precisely aligned nanofibers with anisotropic properties have been collected by advanced Electrospinning. Small spherical structures have been prepared from low concentrated solutions in the Electrospraying mode. Morphological properties can be well controlled by Electroblowing process parameters.
The device is designed to be run in a clean room (a variety of accessories can be sterilized). The stability and accuracy of the production processes lead to the preparation of materials with highly repeatable and reproducible properties. Thanks to safety components, easy handling, intuitive device control and other benefits the apparatus significantly contributes to the acceleration of research progress in the field of medical application.

MATERIALS

The set of presented polymers are studied for medical purposes and therefore are biocompatible and biodegradable. However, only HA derivates, PLLA and PCL have the slow degradation rate suitable for cell culture.

- HYALURONIC ACID: H_2O/AcOH, 0.5% HA
- POLYLACTIC ACID: DMF/chloroform, 12% PLLA
- POLYVINYLPYRROLIDONE: H_2O/ethanol, 5% PVP
- POLYLACTIC-GLYCOLIC ACID: DMF/THF, 15% PLGA
- POLYETHYLENOXIDE: H_2O, 8% PEO
- POLYURETHANE: DMF, 15% PU
- POLYCAPROLACTONE: DMF/THF, 12% PCL
- POLYVINYL ALCOHOL: H_2O, 16% PVA

EMITTERS

The system of emitters have been developed to fulfil the requirements of the spinability the prepared mixture and the very high process throughput. Dead-volume is from 500 µl.

Emitters are made of stainless steel, POM (alt. PP or PEEK) and with Luer-Lock fittings.

Legend: 1) Deposition chamber, 2) Collector, 3) Emitter with integrated dosing system, 4) Exhaust pipe, 5) 10.4" touch screen, 6) Multifunctional knob, 7) Central stop, 8) Terminals.

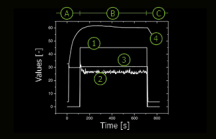
METHODS

The electrospinning is a technique for production of fibers with diameters ranging from tens of nanometres to several micrometres from variety of solutions. The electrospraying technology results in the deposition of materials in the form of small beads. The electroblowing adds to the previous ones airflow at elevated temperature around the emitter.

PROCESSING PARAMETERS

The complete software solution has been designed specifically for this application in order to provide accurate and stable processes and easy-to-grasp intuitive control.

PARAMETER	AVAILABLE RANGE	TOL. ±	UNIT
High voltage	0 - 60	0.2	kV
Electrodes distance	50 - 250	2.5	mm
Collector revolutions	10 - 5000	10.0	rpm
Airflow	0 - 100	1.0	l·min^{-1}
Air temperature	25 - 80	2.0	°C
Needle diameter	15 - 26		gauge
Solution volume	10, 20 or 30		ml

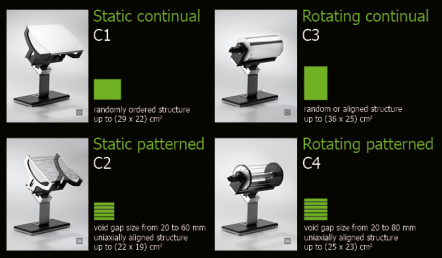


A Process initiation
B Running deposition
C Process termination

#	Parameter	Average	Max/Min	Unit
1	High voltage	44.99	±0.01	kV
2	Current	28.4	±2.0	µA
3	Airflow	30.7	±0.3	l·min^{-1}
4	Air temperature	60.7	±1.7	°C

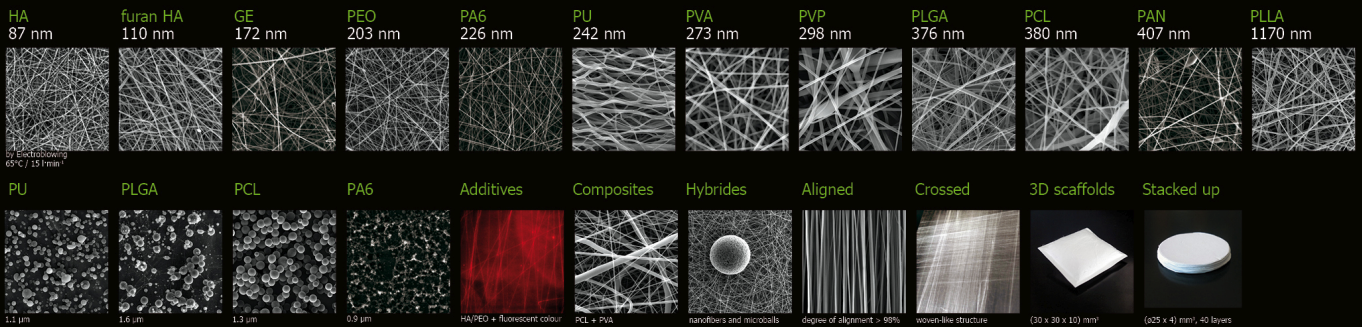
COLLECTORS

The collector design is adapted to the product requirements in terms of the size and internal morphology (random or regular) of the nanomaterial.



RESULTS

The emitters of the 4SPIN® apparatus allow different types of polymers to be spun, from synthetic to natural polymers and their blends. For example electroblowing is the only way in which high-molecular-weight hyaluronic acid can be spun in its native form. Moreover, simultaneous solutions dosing allow composite and hybrids material formation. Different types of collectors can be used to generate aligned nanofiber layers with varying degrees of organization. By means of applying advanced collecting procedures, nanofiber layers can be created with controlled morphology (i.e. crossed woven-like structure) and with different macroscopic dimensions (e.g. 3D scaffolds).



CONCLUSIONS

Nanofibers prepared by electrostatic spinning have several advantages over bulk materials, in particular the huge surface-to-volume ratio, very high porosity and improved physico-chemical properties. Of the various processing methods (drawing, phase separation, self-alignment, etc.), electrospinning is the only viable method that can be further developed for the mass production of nanofibers from various polymers. Compared to the conventional methods, electroblowing has the following advantages: 1) a combination of the forces of the electric field applied and the air flow increases the efficiency of the ES process, 2) the increased air flow temperature reduces the viscosity of the solution spun, 3) the air flow accelerates the evaporation of the solvent from the solution, 4) the speed and temperature of airflow affect the morphology of the nanofibers. The 4SPIN® laboratory device is the only such device that offers this technology. All of these processes are a major focus of attention because of their versatility and ability to prepare materials on a scale of micro- and nanometres, which are highly suitable for Tissue Engineering and Regenerative Medicine applications.

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