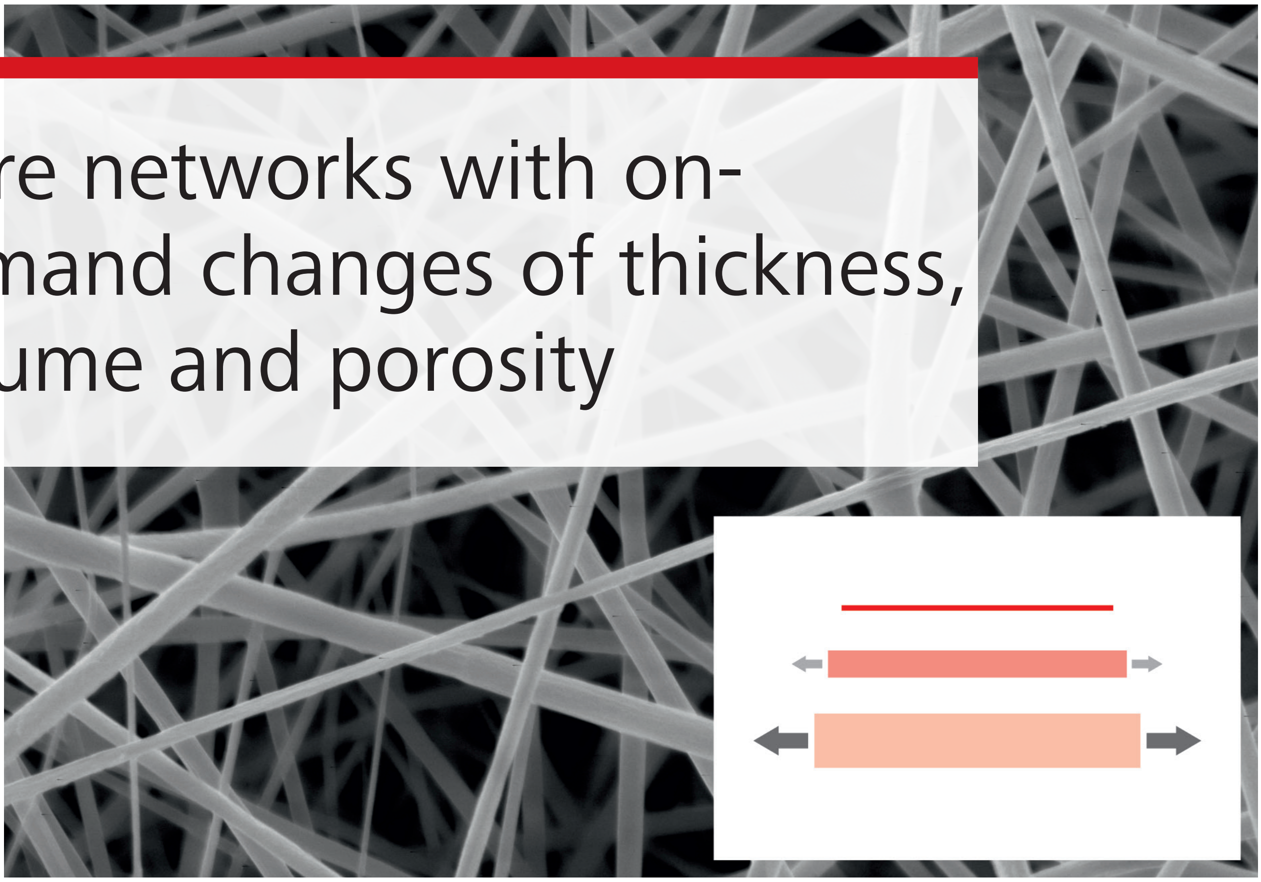
Licensing Opportunity

TT-Ref. 2017-013

Empa
Materials Science and Technology

Fibre networks with on-demand changes of thickness, volume and porosity



Invention

We present auxetic fibre networks with particular micro-structure: they counter-intuitively *increase* their thickness on *demand* when stretched along a certain direction and thereby multiply their volume. The volume gain entails a change of dimensions, porosity, pore size and pore shape, all of which affect the transport properties through the network. Electrospinning can be used to produce such a network from a wide range of base materials.

Background

Fibrous network materials are ubiquitous in nature and used in a wide range of industrial, engineering and medical applications [1]. The many reasons for this broad use include their light-weight properties and their porous structure which allows fluids and particles to enter, interact, pass or be retained. A major limitation of these materials is that once they have been produced, their structure is typically static so that porosity and pore size, and thus all the associated physical properties, can hardly be altered on-demand at a later stage. Another limitation, that applies, e.g., to classic electrospinning, is that the production process itself limits the achievable pore sizes so that either complex process modifications or secondary treatments are required to generate larger pores [2].

Advantages

Most materials *contract* laterally when stretched along one direction. Strikingly, the here described sheet-like network structures feature the unique characteristic of *expanding* out-of-plane to an enormous extent when moderately stretched along an in-plane direction [3]. The effect is very pronounced and can lead to a multiplication of thickness and volume, with according changes of pore size and overall porosity. While this pronounced auxetic effect is due to the network structure, and little affected by the fibre material properties, the latter have a strong impact on the reversibility of the stretch expansion, i.e., on the extent of expansion that remains after load removal. Electrospinning, being simple and cost-efficient, is the preferred process for producing a wide range of such fibre networks as large sheets of non-wovens from a variety of materials.

Applications

The pronounced changes in dimension and volume on-demand, that rapidly generate a bulky piece out of a thin strip of material, call for many fields of application (Fig. 1).

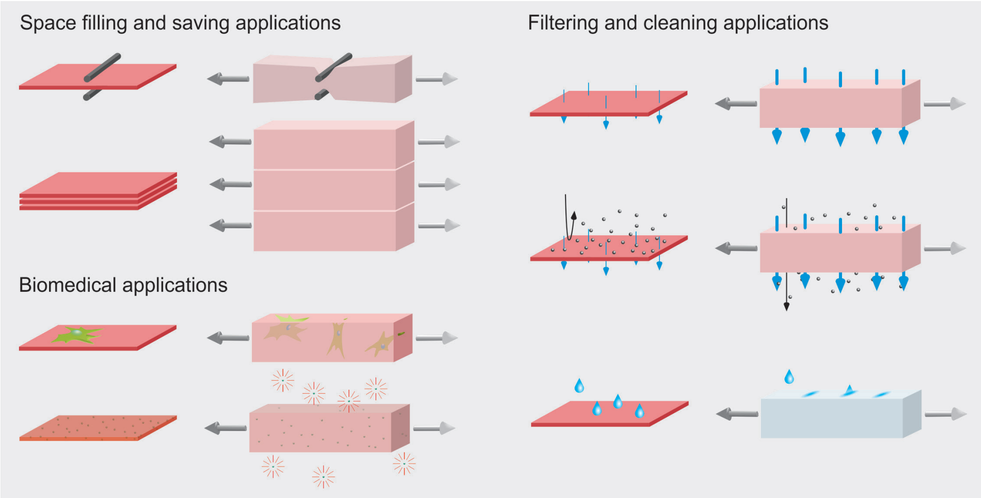


Fig. 1: Potential applications of stretch-expanding fibre networks

Potential medical and filtration applications include
– tissue engineering scaffolds with enhanced infiltration of cells
– space-saving absorbent materials activated by stretching
– materials with on-demand release of entrapped particles or embedded drugs
– filter materials insertable into small or poorly accessible lumina
– adjustable filters with changeable permeability

Ownership

Empa, Swiss Federal Laboratories for Materials Science and Technology, Überlandstrasse 129, CH-8600 Dübendorf

References

[1] Picu RC. Mechanics of random fiber networks – a review. *Soft Matter* 7(2011):6768 – 6785.
[2] Feltz KP, Growney Kalaf EA, Chen C, Martin RS, Sell SA. A review of electrospinning manipulation techniques to direct fiber deposition and maximize pore size. *Electrospinning* 1(2017):46–61.
[3] Domaschke S, Morel A, Fortunato G, Ehret AE, Random auxetic from buckling fibre networks. *Nat. Commun.* 10(2019):4863.

Keywords

Stretch expansion, fibrous materials, deployable filter, electrospinning, auxetic behaviour, on-demand change of porosity, pore-size control

Contact

Empa, Technology Transfer
Dr Markus Kasper, markus.kasper@empa.ch
Phone +41 58 765 44 38, Fax +41 58 765 69 08

Technical Information

Dr Alexander Ehret, Group Leader, alexander.ehret@empa.ch
Empa, Experimental Continuum Mechanics
Phone +41 58 765 48 42

Empa
Materials Science and Technology

Empa

CH-8600 Dübendorf
Überlandstrasse 129

Telefon +41 58 765 11 11
Telefax +41 58 765 11 22

CH-9014 St. Gallen
Lerchenfeldstrasse 5

Telefon +41 58 765 74 74
Telefax +41 58 765 74 99

CH-3602 Thun
Feuerwerkerstrasse 39

Telefon +41 58 765 11 33
Telefax +41 58 765 69 90

www.empa.ch

Empa is an interdisciplinary research and service institution within the ETH Domain covering selected fields of materials science and technology development including important environmental issues. Empa's R&D activities focus on the requirements of industry and the needs of society, thus linking research to engineering, and science to industry and society. As a result, Empa is capable of providing its partners with customized services and solutions that not only enhance their innovative edge, but also help to improve the quality of life for the public at large. Safety, reliability and sustainability of materials and systems are cross-sectional topics and a hallmark of all Empa activities. As such, Empa plays a key role in Switzerland's research and innovation landscape.