Microstructured Biomaterials with a Tunable Negative Poisson's Ratio

Tech ID: 21758 / UC Case 2011-095-0

BACKGROUND

The elastic properties of a biomaterial tissue scaffold reflect its ability to handle external loading conditions and must be tailored to match the attributes of the native tissue that it aims to repair. A scaffold's elastic modulus and Poisson's ratio describe how it supports and transmits external stresses to the host tissue site. (The Poisson ratio is positive/negative when the material contracts/expands transversally with axial expansion; "auxetic" materials are materials that exhibit negative Poisson ratio.) While the elastic modulus is tunable in scaffolds, the Poisson's ratio of virtually every porous tissue construct is positive. There have been no reports of solid-phase micro-cellular biomaterials synthesized with a precisely-tuned negative Poisson's ratio. Others have formed auxetic polyurethane foams by compressing the foams and annealing them while compressed; however, the annealing process renders little practical control over the cellular microstructure comprising the foams, making it very difficult to tune the strain-dependent behavior of Poisson's ratio. Additionally, the foams have little to no use in biological applications involving the interactions between biomaterials and living tissue (e.g., tissue engineering applications) and other biological applications.

TECHNOLOGY DESCRIPTION

UC San Diego researchers have developed microstructured biomaterials that are auxetic, i.e., exhibit a negative Poisson ratio (expand rather than contract transversally when stretched axially). Importantly, said negative Poisson ratio is tunable in the invention. The auxetic behavior is obtained by patterning traditional non-auxetic biomaterial with an artificial lattice of rib-containing unit-cells or pores, and the Poisson's ratio tuning is achieved by altering the pore shape and deformation mechanisms. The patterning is done using digital micromirror device projection printing (DMD-pp) and the auxetic biomaterials are fabricated from traditional polyethylene glycol (PEG) and other traditional photocurable biocompatible materials. For example, three-dimensional PEG tissue scaffolds with tunable negative Poisson's ratios have been fabricated by stacking single-layer constructs composed of cellular structures with special geometries. Such scaffolds may be more suitable for emulating the behavior of native tissues.

RELATED MATERIALS

- "Three-Dimensional Polymer Constructs Exhibiting a Tunable Negative Poisson's Ratio," Advanced Functional Materials, 11 May 2011, DOI: 10.1002/adfm.201002022.
- "Nanoengineers Invent New Biomaterial That More Closely Mimics Human Tissue" in *UC San Diego News* at http://ucsdnews.ucsd.edu/newsrel/science/05-26-11NewBiomaterial.asp and *Science Daily* at http://www.sciencedaily.com/releases/2011/05/110526091806.htm.
- *New Biomaterial More Closely Mimics Human Tissue* in PhysOrg.com.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	9,631,171	04/25/2017	2011-095

CONTACT
University of California, San Diego
Office of Innovation and Commercialization
innovation@ucsd.edu
tel: 858.534.5815.

OTHER INFORMATION

KEYWORDS
Poisson's ratio, auxetic, scaffold, polyethylene glycol, tissue engineering

CATEGORIZED AS
- **Materials & Chemicals**
  - Biological
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- **Nanotechnology**
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9500 Gilman Drive, MC 0910, ,
La Jolla,CA 92093-0910

https://innovation.ucsd.edu
Fax: 858.534.7345