**Dataset on biomimetic hierarchically arranged nanofibrous structures resembling the architecture and the passive mechanical properties of skeletal muscles: a step forward towards artificial muscles**

**Carlo Gotti1, Alberto Sensini2, Gianmaria Fornaia3, Chiara Gualandi2,3, Maria Letizia Focarete3,4, Andrea Zucchelli1,2**

1Department of Industrial Engineering, Alma Mater Studiorum-Università di Bologna, Bologna, Italy

2Advanced Mechanics and Materials-Interdepartmental Center for Industrial Research (CIRI-MAM), Alma Mater Studiorum-Università di Bologna, Bologna, Italy

3Department of Chemistry ‘G. Ciamician’ and INSTM UdR of Bologna, Alma Mater Studiorum-Università di Bologna, Bologna, Italy

4Health Sciences and Technologies - Interdepartmental Center for Industrial Research (CIRI-HST), Alma Mater Studiorum-Università di Bologna, Bologna, Italy

Contact Person: Maria Letizia Focarete: marialetizia.focarete@unibo.it; Chiara Gualandi: c.gualandi@unibo.it

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**Data set Contents**

The data set consists of a .7z file containing the following folders, each containing the listed files:

- Thermal Analysis

2 tabular quantitative files saved in .ods format:

“TGA PU.ods”

“DSC PU.ods”

- Mechanical Data

6 tabular quantitative files saved in .ods format:

“Random Mats.ods”

“Random Bundles.ods”

“Aligned Mats.ods”

“Aligned Bundles.ods”

“HNES.ods”

“Results.ods”

- Samples Geometries

1 tabular quantitative file saved in .ods format:

 “Samples Geometries.ods”

- Nanofibers Alignment

1 tabular quantitative file saved in .ods format:

 “Nanofibers Alignment.ods”

- Statistical Analysis

 1 text file saved in .rtf format:

 “Statistical Analysis.rtf”

**Data set Documentation**

**Abstract**

The present database contains the data presented and discussed in the paper “Biomimetic hierarchically arranged nanofibrous structures resembling the architecture and the passive mechanical properties of skeletal muscles: a step forward towards artificial muscle” by Carlo Gotti, Alberto Sensini, Gianmaria Fornaia, Chiara Gualandi, Andrea Zucchelli and Maria Letizia Focarete, accepted for publication in the journal Frontiers in Bioengineering and Biotechnology (2020, doi 10.3389/fbioe.2020.00767). The paper describes an approach for the biomimetic design of engineered muscle, that makes use of an elastomeric polyurethane with suitable mechanical performances, processed with the electrospinning technology, to produce a hierarchically arranged nanofibrous structure resembling the architecture and passive biomechanical properties of skeletal muscles. Scaffolds morphology and physical properties are studied and a detailed analysis of material mechanical properties is performed, taking into account the different levels of increasing complexity, going from mats to bundles and finally the hierarchical nanofibrous electrospun structure (HNES). Data include the thermal characterization of the pristine PU pellets (thermogravimetric and differential scanning calorimetry analysis), force-displacement data obtained through mechanical tensile tests along with the different geometrical and physical characterization of the samples, the results of the mechanical characterization, data on the nanofibrous alignment and the outcome of a statistical analysis.

**Content of the files**

* file “TGA PU.ods” contains data of thermogravimetric analysis (TGA) performed on the polyurethane pellets used in the work to produce the electrospun nanofibers. Analysis was carried out with a TGA 2590 (TA Instruments) under nitrogen atmosphere at 10°C/min.
* file “DSC PU.ods”contains data of differential scanning analysis (DSC) performed with a DSC q100 (TA Instruments) on the polyurethane pellets used in the work to produce the electrospun nanofibers. Two spreadsheets are reported: one is referred to the 1st DSC heating scan carried out at 20°C/min, the second one is referred to the 2nd heating scan carried out at 20°C/min after a controlled cooling scan performed at 10°C/min.
* file “Random Mats.ods” contains data of mechanical analysis performed on polyurethane electrospun mats made of randomly aligned nanofibers. This analysis was carried on with a tensile test on a Mod. 4465 Instron (Norwood, USA) with a ±100 N load cell (Instron, Norwood, USA). The test machine worked under displacement control to obtain an average strain rate of 0.33 % s−1. Each tab in the file represents a specimen.
* file “Random Bundles.ods” contains data of mechanical analysis performed on polyurethane electrospun bundles obtained by rolling up mats of randomly aligned nanofibers. This analysis was carried on with a tensile test on a Mod. 4465 Instron (Norwood, USA) with a ±100 N load cell (Instron, Norwood, USA). The test machine worked under displacement control to obtain an average strain rate of 0.33 % s−1. Each tab in the file represents a specimen.
* file “Aligned Mats.ods” contains data of mechanical analysis performed on polyurethane electrospun mats made of aligned nanofibers. This analysis was carried on with a tensile test on a Mod. 4465 Instron (Norwood, USA) with a ±100 N load cell (Instron, Norwood, USA). The test machine worked under displacement control to obtain an average strain rate of 0.33 % s−1. Each tab in the file represents a specimen.
* file “Aligned Bundles.ods” contains data of mechanical analysis performed on polyurethane electrospun bundles obtained by rolling up mats of aligned nanofibers. This analysis was carried on with a tensile test on a Mod. 4465 Instron (Norwood, USA) with a ±100 N load cell (Instron, Norwood, USA). The test machine worked under displacement control to obtain an average strain rate of 0.33 % s−1. Each tab in the file represents a specimen.
* file “HNES.ods” contains data of mechanical analysis performed on polyurethane electrospun hierarchical muscle-like structures that were produced by grouping several bundles of aligned fibers tighten together by an external membrane of electrospun random fibers. This analysis was carried on with a tensile test on a Mod. 4465 Instron (Norwood, USA) with a ±100 N load cell (Instron, Norwood, USA). The test machine worked under displacement control to obtain an average strain rate of 0.33 % s−1. Each tab in the file represents a specimen.
* file “Results.ods” contains the data output of the mechanical analysis on the samples. The force-displacement curves were converted to stress-strain graphs using two different approaches. In the first one, the apparent stress, calculated by dividing the force by the cross-sectional area of the specimen measured before the test, was plotted against strain, whereas in the second approach, the net stress was used, in order to determine the mechanical properties of the specimen independently from its porosity. The net stress was calculated by dividing the apparent stress by the volume fraction (*v*) of the specimens. The volume fraction (*v*) was calculated by using the equation:

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| --- | --- |
| $$v=\frac{w}{\left(L∙A∙ρ\right)}$$ | (1) |

Where w is the weight of the specimen, L is length of the specimen, A is the cross-sectional area of the specimen, ρ is the density of the raw material (PU = 1.18 g/cm3). Each line of the sheet represents a different specimen repetition and each tab of the file is dedicated to a different family of samples.

* file “Nanofibers Alignment.ods” contains data concerning the analysis of the alignment of the nanofibers of the samples. The nanofibers orientation analysis was carried out by using the opensource plugin of ImageJ Directionality with the Local Gradient Orientation method. For each sample category (i.e. random mats, random bundles, aligned mats, aligned bundles and HNES sheaths), 5 SEM images were collected with a magnification of 8000x, aligning the cam to the longitudinal axis of the specimen. Each of the 5 SEM images (for each sample category) were analyzed by the software that registered the amount of nanofibers oriented in each interval of angles, of six degrees, from 0° up to 174°. The results for each interval of angles were mediated with the same interval of the other 5 images and converted in percentage. Then the data were added with the specular intervals to obtain a final representation from 0° (axial orientation) up to 90° (circumferential orientation) to obtain the final result showed in the paper and showed as mean and standard deviation.
* file “Sample geometries.ods” contains data about the physical and geometrical characteristics of each sample of the different families. For the mats, weight, thickness, length, and width are reported. For bundles and HNES, presenting a cylindrical structure, weight, diameter, and length are reported.
* file “Statistical Analysis.rtf” contains data obtained calculating with a ratio paired parametric t-test the significance of differences between the apparent mechanical properties for the mats (n = 10) and bundles (n = 10) with the same nanofibers orientation (i.e. random or aligned), and for the aligned bundles and the HNES (n = 3). With the same procedure, the net mechanical properties were compared. Instead, the comparison between the apparent and net mechanical properties of the same sample families (i.e. random mats, aligned mats, random bundles, aligned bundles, and HNES) were assessed with an unpaired parametric t-test with Welch’s correction.