



**HAL**  
open science

## Development of electrospun composite as substitutive diaphragm membrane

Elham Mohsenzadeh, Nabyl Khenoussi, Laurence Schacher, Dominique Adolphe, Joseph Hemmerlé, Anne A. Schneider, Nadia Bahlouli, Christiane Wagner-Kocher

### ► To cite this version:

Elham Mohsenzadeh, Nabyl Khenoussi, Laurence Schacher, Dominique Adolphe, Joseph Hemmerlé, et al.. Development of electrospun composite as substitutive diaphragm membrane. Autex 2017, May 2017, Corfu, Greece. hal-01553655

**HAL Id: hal-01553655**

**<https://hal.science/hal-01553655>**

Submitted on 3 Jul 2017

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Development of Electrospun Composite as Substitutive Diaphragm Membrane

E Mohsenzadeh<sup>1</sup>, N Khenoussi<sup>1</sup>, L Schacher<sup>1</sup>, D Adolphe<sup>1</sup>, J Hemmerlé<sup>2</sup>, A Schneider<sup>2,3</sup>, N Bahlouli<sup>4</sup>, C Wagner-Kocher<sup>1,5</sup>

<sup>1</sup>Laboratory of Physics and Textile Mechanics, EA 4365 - UHA, Mulhouse, France

<sup>2</sup>National Institute of Health and Medical Research, UMR S 1121- INSERM, Strasbourg, France

<sup>3</sup>Pediatric Surgery Department, University Hospital of Strasbourg, Strasbourg, France

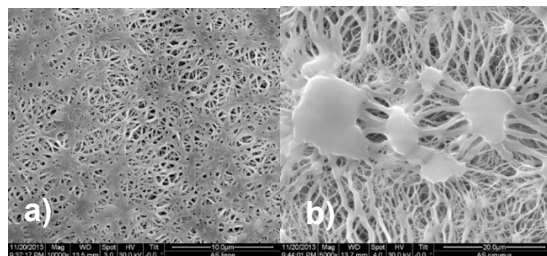
<sup>4</sup>Laboratory of Engineering Science, data processing and imaging, UMR 7357 - ICUBE, Strasbourg, France

<sup>5</sup>Mechanical and Civil Engineering Laboratory, Montpellier university, LMGC, Montpellier, France

[dominique.adolphe@uha.fr](mailto:dominique.adolphe@uha.fr)

## Introduction

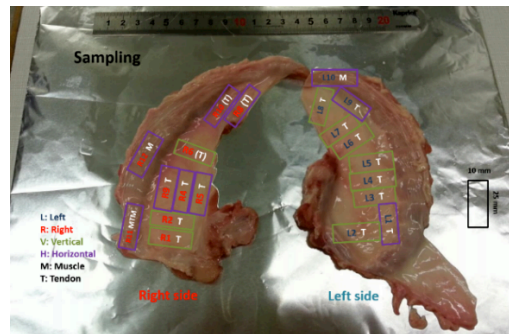
The diaphragm is a layer of muscle and tendon that serve as the main muscle of respiration and plays a vital role in the breathing process. Diaphragmatic hernia that occurs in about 1 in 5,000 live births, are defined as congenital or acquired defect. If the opening in the diaphragm is small, the hole can be sewn closed. If the opening is large, the surgeon will require additional tissue or material to close it. Often, a synthetic biocompatible material is used to patch the opening. Gore-Tex® (PTFE) prosthetic membrane is chosen for that purpose in University Hospital in Strasbourg/France (figure 1).



**Figure 1.** SEM images of double-faced implanted Gore-Tex; a) Smooth surface b) Rough surface

This patch will usually require replacement later as the child grows.

In our study, we aimed to design a substitution membrane by electrospun nanofibers web [1]. Mechanical properties of substitutive membrane have to be close to the human diaphragm that have been represented by pork's diaphragm. Pork's samples were excised from different parts of diaphragm from the left and right side, vertically and horizontally based on the tendon fiber orientation (figure 2). samples have been placed between special frames before being tested. Uniaxial tensile test (ISO 527-3 conditions) have been done using pneumatic grips. Tests were performed in climatic chamber to keep the samples humid during the tests.



**Figure 2:** Sampling from the fresh pig's diaphragm from left to right part

PA-6 was chosen as polymer to produce electrospun nanoweb because of its biocompatibility and expected adequate mechanical properties. Different electrospinning conditions have been tested to obtain optimal conditions of producing PA-6 nanofibers and optimal mechanical properties. 20 wt. % solution of PA-6/Formic acid with 0.1 mL/h feed rate was injected to the needle by applying 30 kV of voltage between needle and collector with a distance of 15 cm. To improve the strain properties of electrospun PA-6 nanofibers, a thin layer of elastomer material (1mm) was used while electrospinning of PA-6 solution. Electrospinning time was varied: 15, 30, 60, 90 minutes. Electrospun nanofibers were observed via SEM micrographs and diameters were measured thanks to ImageJ software.

## Results

The mechanical tests confirmed that regardless of the sampling region the pork's diaphragm presented isotropic properties. For the optimum electrospinning conditions an average diameter of 184 nm was obtained, without defects. It has been also observed that by increasing the time of electrospinning, the rupture force of the sample increases but the strain decreases. Moreover, an too important increase of the electrospinning time, leads to a total loss of the elasticity of elastomer material and delamination has been occurred.

## References

- [1] Aderhold J, Davydov V Yu, Fedler F, Klausning H, Mistele D, Rotter T, Semchinova O, Stemmer J and Graul J 2001 *J. Cryst. Growth* **222** 701
- [2] Rehan, V. K., Laiprasert, J., Wallach, M., Rubin, L. P., & McCool, F. D. (2001). Diaphragm dimensions of the healthy preterm infant. *Pediatrics*
- [3] Schneider, A., Koob, M., Sananes, N., Senger, B., Hemmerlé, J., & Becmeur, F. (2016). Computed Tomographic Study of the Pediatric Diaphragmatic Growth: Application to the Treatment of Congenital Diaphragmatic Hernia. *European Journal of Pediatric Surgery*.

## Corresponding author:

Dominique ADOLPHE

Université de Haute Alsace/Laboratoire de Physique et Mécanique Textiles/Ecole Nationale d'Ingénieurs Sud-Alsace

E-mail: dominique.adolphe@uha.fr

## Options indication

1. Oral
2. **Topic** : Medical Textiles, Tissue Engineering, Implants