Development of electrospun composite as substitutive diaphragm membrane

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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).

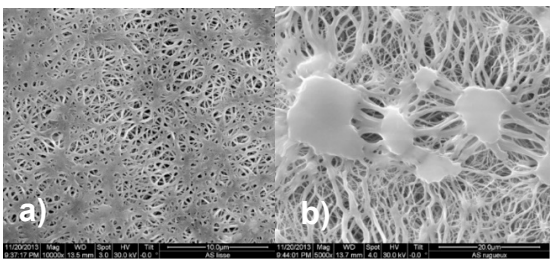

Figure 1. SEM images of double-faced implanted Gore-Tex; a) Smooth surface b) Rough surface

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 gripes. Tests were performed in climatic chamber to keep the samples humid during the tests.

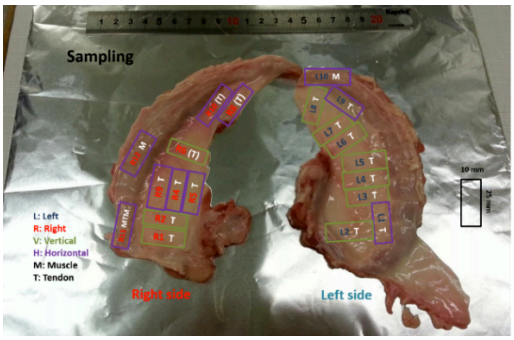

Figure 2: Sampling from the fresh pig's diaphragm from left to right part

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 prese ted 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.

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Options indication

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