Mechanical properties of "pseudo-woven" electrospun nanofiber mats

Nanofibers have shown great potential for use in filtration applications, separators in batteries, sensors in tissue engineering, and functional textiles. Electrospinning is the most controlled method to generate extremely small diameter polymer fibers. However, the classical electrospinning method deposits fibers on a flat surface in the form of a virtually 2D non-woven mat, whose inherent disadvantage lies in its poor mechanical properties. Specifically, such thin assemblies provide low abrasion resistance, low ultimate tensile stress, as well as high internal contractile stress. A possibility to increase the mechanical stability is to introduce fiber-to-fiber interactions, for example by generating "woven" fiber mats, analogous to the classical textile weaving, where mechanical stability originates from the functional interaction between the single fibers ordered perpendicular to each other. While the high mechanical strength of yarns allows the process of weaving, thin electrospun fibers are not stable enough to be used by this fabrication technique to generate nanofiber wovens.

In order to control the deposition and alignment of electrospun nanofibers, specially designed counter-electrodes are used. For example, two electrode plates with a gap between them allow for selective attraction and uni-directional alignment of the nanofibers. The fibers are then deposited only between the two plates and an array of parallel-aligned and stretched nanofibers is formed over the gap. In this way, alternating alignment of nanofibers in a perpendicular way has been achieved, resulting in the generation of so-called "pseudo-wovens". However, the mechanical properties of these pseudo-wovens have never been sufficiently investigated. By introducing fiber-to-fiber interactions, which is known to cause increased mechanical strength in analogy to classical wovens, into electrospun nanofiber mats would open the possibility to generate tougher electrospun membranes for use in more demanding applications, such as gas sensors or bioengineering.

The project includes the following tasks/experiments:

- Generation of nano- and microfibers of poly-lactic acid (PLA) by the electrospinning method.
- Generation of different fiber diameters, between 100 nm to 5 µm.
- Generation of pseudo-wovens by using a matrix electrode setup, potentially testing different geometries.
- Fiber characterization by scanning electron microscopy (SEM).
- Characterization of mechanical properties of pseudo-wovens by tensile testing.

We are looking for a Master student with an interest in Materials Science, who is eager to work in a multidisciplinary research group. Please contact Fabian Itel (fabian.itel@empa.ch, https://www.empa.ch/web/s401) for information and application. If you are interested, please briefly state your scientific background and interests.