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MACRO-MECHANICAL PROPERTIES OF NANOTEXTILES ON PLGA BASE – TENSILE STRENGTH

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Abstract: *The paper presents the results measured during the macro-mechanical study of properties of nanotextiles based on poly-(lactide-co-glycolite) acid (PLGA). These nanotextiles are extensively used in biomedicine and many other applications, and therefore it is important to reach a certain level of mechanical properties so that they can be used properly. Very easy and cheap method, so called passportization, can be utilized for investigation of nanotextile microscopic properties. For the testing of macro-mechanical properties it is possible to use common testing methods like in case of textiles and membranes (e.g. water vapor barriers). The results of tensile strength related to the width of tested sample are presented in this paper. Finally, certain aspects limiting the use of common testing methods (especially nanotextile weight per unit area) are discussed.*

Keywords: ***nanotextiles, nanofibers, mechanical properties, tensile strength, PLGA.***

1. Introduction

Macro-mechanical properties are lately investigated even in case of nano-materials. The following text is specifically focused on nanofibre materials based on polymers and their macro-mechanical properties. The tested nanotextiles were spun using "NanoSpider" technology (Elmarco Ltd.) that works on principle of needleless electrospinning where the cylinder (cathode) is connected to a high voltage source covering itself with a thin film of polymer solution. The anode is created by a slab on which are the nanofibres formed. The electric field pulls out, elongates and thins the fibers that are finally collected on the slab. The resulting fibers have typical thickness from tens to hundreds of nanometers.

The process of electrospinning itself is dependent on many parameters: choice of polymer type and viscosity of its water solution, or different solvent solution. The NanoSpider technology enables setting of electrode distance, setting of spinning voltage, setting of substrate fabric speed and spin speed of cylinder cathode. Environmental parameters like temperature and humidity of the air are also of a great importance.

Extremely fine nanofibres can't exist independently and they need a kind of support (at least during the electrospinning), i.e. material that would assure sufficient mechanical resistance. There exist several possibilities, which supporting the material: it can be a polymeric support textile (spunbond), a sheet based on cellulose, or certain types of "classical" textiles. Except the price there is important the adhesion of nanofibres to the supporting surface (by manipulation the support and the nanofibres mustn't separate). The electrospinning technology enables production of nanotextiles

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within a certain range of weight per unit area. Using this technology it is possible to produce nanotextiles with the width of up to 4 meters (Li et al., 2002). The produced nanotextiles, depending on the weight per unit area, can be applied with or without supporting material (spunbond). The nanofibres are macroscopically hardly accessible and so just the reproducibility of the same nanostructure in repeatable production procedure is a very delicate problem.

The above mentioned facts tend to the need for investigation of macro-mechanical properties. Besides there are other mainly macroscopic properties (especially the weight per unit area) that can specifically describe the micro structure of nanotextiles. Such properties are subsequently used for passportiazation of nanotextiles (Krňanský et al., 2010), i.e. an easy and cheap method how to check the microscopic properties of produced nanotextiles based on measured macroscopic properties. The mechanical test of nanotextiles can be performed using conventional testing techniques (Huang el al., 2001).

For the macro-mechanical testing there were used nanotextiles based on Poly-(lactide-co-glycolite) acid (PLGA). Such nanotextiles are largely used, for instance, in biomedicine (Paipitak et al, 2010).

2. Experimental methods and samples

The PLGA based nanotextiles were spun in the Center for Nanotechnology in Civil Engineering, at the Faculty of Civil Engineering, Czech Technical University (CTU) in Prague. This center uses the Elmarco NS Lab 500 S, the laboratory device for electrospinning of nanofibres with spinning electrode width of 500 mm. The PLGA solution (ration 50:50) for electrospinning were prepared as 2.3% solution where 0.23 g of PLGA were stirred with 4 ml of dimethyl chloride (DMC, Sigma Aldrich) and subsequently 6 ml of dimethylformamide (DMF) were added.

The nanotextile samples with the length of 40 mm and width between 21 and 25 mm were cut out from the PLGA based nanotextile. The nanotextile layer was subsequently carefully separated from the spunbond. The samples' weights per square meter were determined from their dimensions (micrometric set) and measured with the accuracy of 0.0005 g.

The ends of tested samples were strengthened by a paper tape to prevent damage of the PLGA nanotextile before testing, respectively during preparation of a tensile test. The tensile strength tests were carried out on LabTest 4.100SP1 device at the Faculty of Civil Engineering of CTU in Prague. The measuring range was set to 50 N maximum where the accuracy exceeds 0.1 % (at 2 N force). The samples were loaded with constant speed until failure. The resulting forces were determined from the testing device software.

The arrangement of the tensile strength test is showed on Fig. 1 and 2.

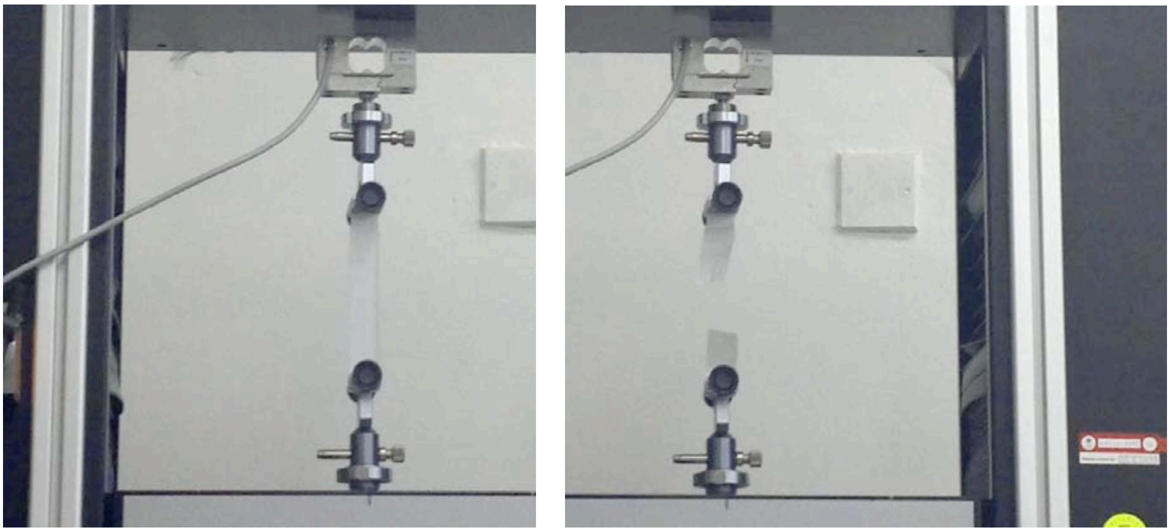

Fig. 1, 2: Arrangement of tensile strength test – during testing (left), after failure (right)

3. Experimental results

The resulting forces were unified by dividing them by the width of the sample (N/m). For the weight per square meter of 3.1 (± 10 %) g/m^2 the resultant force reaches 7.4 E-5 (± 10 %) N/m. The results were determined as the arithmetic mean of 6 measurements.

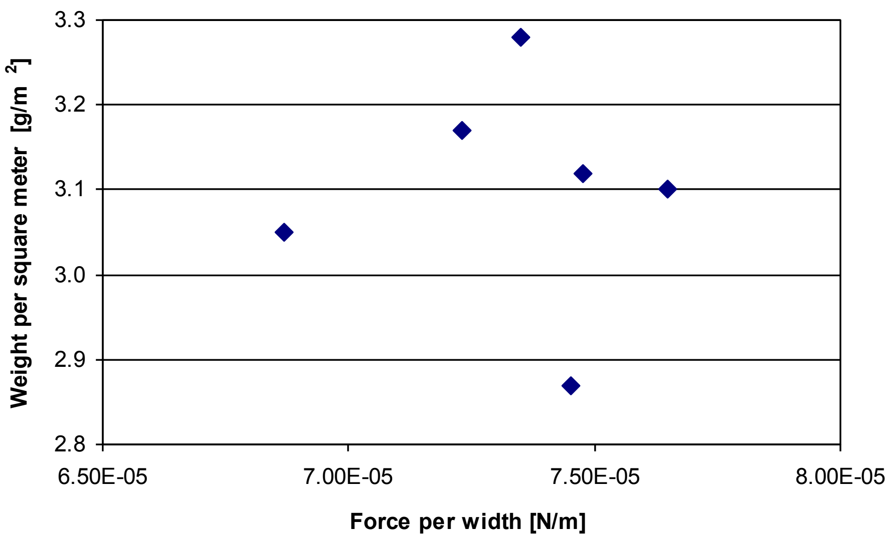

Fig. 3: Measured results of tested PLGA nanotextile samples

4. Conclusions

The nanotextile tensile strength testing showed the feasibility of such a testing. There are certain critical aspects limiting the testing of nanotextiles on common equipment (pull test devices). From the practical point of view it is possible to work with polymeric nanotextiles that have weight per unit area more than 1 g/m^2 (Krňanský et al., 2011). Working with nanotextiles with lower weight per unit area is very complicated because of the nanofibre surface tension when the nanotextiles tend to wrap up. Other aspect is a treatment of the nanotextile sample ends that must be strengthened before fastening in the clips (Andrady, 2008).

In a similar way like the nanotextile weight per unit area correlates with water vapor diffusion permeability (Krňanský et al., 2010) it is presumable that the tensile strength (in combination with e.g. weight per unit area) is related to certain macroscopic and/or microscopic properties that can be efficiently used for the passportization.

In the next step, it is proposed to move the nanotextile testing into micro-level, e.g. using AFM (Atomic Force Microscopy) and nanoindentation devices (Tesárek & Němeček, 2011), and finally compare the results obtained in macro a micro level.

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