## 7TH DRESDEN NANOANALYSIS SYMPOSIUM

## "NANO-SCALE CHARACTERIZATION FOR CUTTING-EDGE MATERIALS RESEARCH AND SUSTAINABLE MATERIALS DEVELOPMENT"

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# Controlling of mechanical properties of electrospun PMMA fibers via voltage polarity

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**Abstract**

Electrospun polymer fibers due to their surface-to-volume ratio, mechanical properties and porosity are used extensively in various applications like air filtration, triboelectric generators (TENGs) and tissue engineering [1]. Fibers produced by electrospinning have unique mechanical properties due to the manufacturing method [2]. Many process parameters including humidity, flow rate, distance and the applied voltage polarity have significant influence on properties of polymer fibers [3]–[6]. In electrospinning technique, changing a voltage polarity allows to control of surface potential and moving of polymer chains [3], [7]. In our studies, we aim to verify the effect of voltage polarity on structural and surface changes of poly (metacrylate methyl) (PMMA) fiber in terms of their mechanical properties and crystallinity.

In this work, we used PMMA ($M_w$=350 000 g·mol$^{-1}$) dissolved in dimethyloformamide (DMF) to produce aligned and randomly aligned and fibers using EC-DIF apparatus (IME Technologies, The Netherlands). The applied voltage was +/- 12 kV with solution flow rate at 4 ml·h$^{-1}$, temperature and humidity in the chamber was 25°C and 40% . We produce fibers with positive (PMMA+) and negative voltage polarity (PMMA-). Electrospun fibers morphology and diameters were investigated using Scanning electron microscopy (SEM) (Merlin Gemini II, ZEISS, Germany). The mechanical testing of PMMA was performed using a tensile module equipped with a 1N cell (Kammrath & Weiss, Germany). Surface chemistry of the produced electrospun fibers was analyzed with X-ray photoelectron spectroscopy (XPS) (PHI VersaProbe II, Thermofisher, USA) with monochromatic radiation from Al Kα (1486.6 eV). Crystallinity and glass transition temperature was verified using differential scanning calorimetry (DSC) (PYRIS 1, Perkin Elmer, USA).

The fiber morphology and diameter were similar for both type of random PMMA fibers (1.51 ± 0.21 µm for PMMA+ and 1.62 ± 0.29 µm for PMMA-) and aligned fibers (1.54 ± 0.21 µm for PMMA+ and 1.65 ± 0.31 µm for PMMA-), see SEM images in Fig 1.

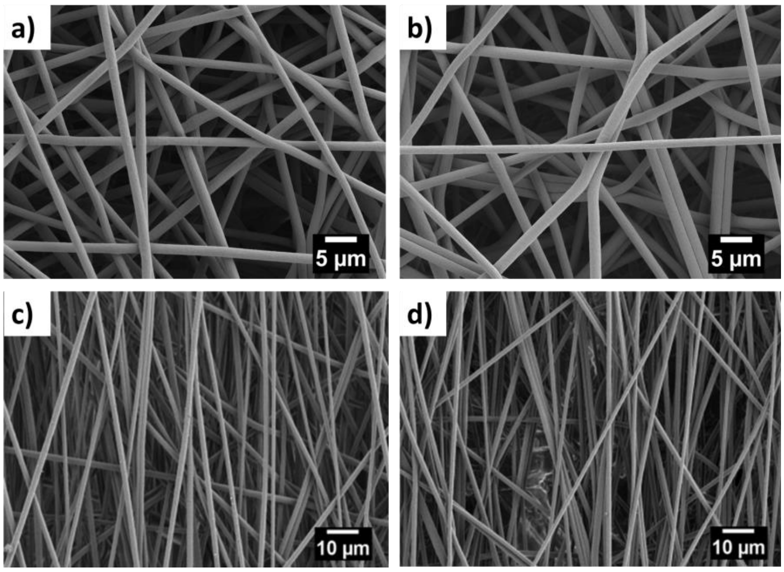


Fig 1. SEM images of electrospun PMMA fibers produced with positive a, c) and negative b, d) voltage polarity with randomly and aligned oriented fibers.

From the mechanical testing of PMMA+ and PMMA- samples, we obtained the maximum stress for random fibers 129 kPa and 230 kPa, respectively. Interestingly, for aligned fibers we observed opposite effect. For PMMA+ the tensile strength was higher, equal to 320 kPa and PMMA- it was 180 kPa. All the representative stress-strain curves for PMMA samples are showed in Fig 2. The variations in mechanical strengths indicated clearly that the highest mechanical stress was obtained for aligned fibers.

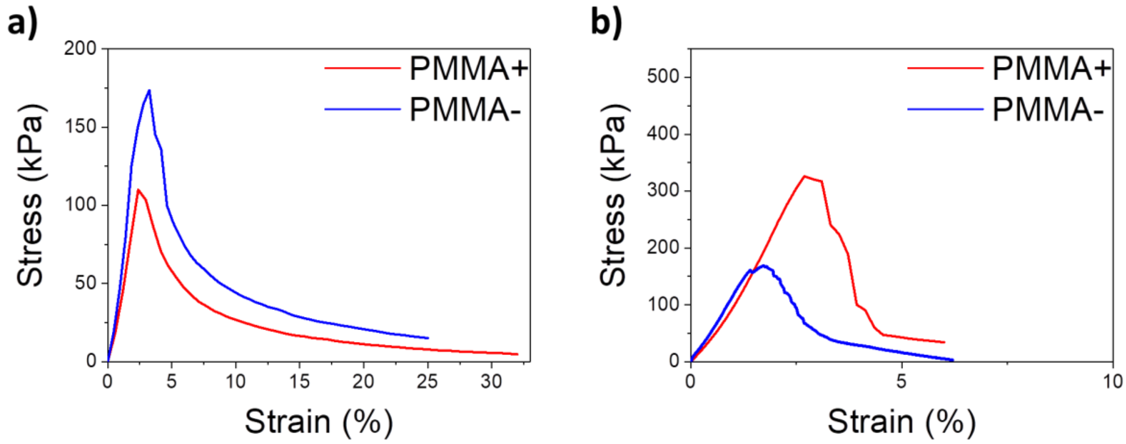


Fig 2. Stress-Strain curves of electrospun PMMA fibers produced with positive/negative voltage polarity with random a) and aligned b) orientation.

Within this study, we showed the potential of controlling mechanical properties of electrospun fibers via voltage polarities. In conclusion, electrospun PMMA fibers were successfully produced using positive and negative voltages with similar average fiber diameters and morphology. Random PMMA fibers produced with positive voltage polarity (PMMA+) proved higher mechanical properties than PMMA fibers produced with negative voltage polarity (PMMA-). For aligned PMMA fibers, we observed reveres effect. The further studies include theoretical analysis of charge effect during electrospinning on their structure in relation to mechanical properties of PMMA fibers.

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