

## METHOD FOR MEASURING DISTRIBUTION OF ELECTRIC POTENTIAL IN A LAYER OF POLYMER SOLUTION IN A STRONG ELECTRIC FIELD

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### Abstract

Method for measuring a distribution of electric potential distribution in a layer of polymer solution under real conditions during electrospinning enables detection of charged quasi-layers organized in the polymer solution.

**Keywords:** Electric double layer, Debye layer, electrospinning, polymer solution

### 1. INTRODUCTION

Electrospinning is a method for manufacturing polymer nanofibres, utilizing strong electric field applied on a layer of polymer solution. Self-organization leads to the formation of fibers. Polymer solutions are not perfectly conductive. These solutions are usually dielectric fluids. Electric fields then enters the solution. It can be assumed that the polymer macromolecules somehow organizes in the direction of the electric field. Our method allows measuring the distribution of electric potential within the layer of polymer solution. The potential changes make it possible to conclude the arrangement of macromolecules. The first works were carried out in [1].

### 2. METHODS

An important consequence of existence of electrical charges on particle surfaces is that when influenced by the applied electric field, the charges can exhibit certain effects. These effects are collectively defined as electro kinetic effects. The [2], [3] and [4] show various forms of direct and indirect measurements of electric double layer in solution. In all cases, two plate electrodes were inserted into the electrolyte.

In case of electrospinning on a free surface of the solution, measurement according to [2], [3] and [4] cannot be considered, since the second electrode - nanofibres collector - is distant from the liquid surface. To create the electrospinning effect, a minimal electric intensity at the surface of free surface is required in the order of 2.5 MV / m [5]. Inspired by tunneling microscopy, [1] used the method of measuring electrical potential in a solution by means of a needle electrode. The size of the potential is read depending on the position of the measuring electrode in comparison to the base. A drop of polymer solution is placed on an electrically grounded base, which is a typical arrangement electrospinning in real conditions. We assume that in conditions just before the initiation of electrospinning, polymeric macromolecules organizes in a drop of solution. The organized macromolecules are likely to create electrically charged quasi-layers. We are able to detect their position and thickness in the axis of the drop.

The measurement electrode moves within the drop of solution. Surface of the drop creates a partial electrical shielding of the external field. The measurement electrode uses an electrometric amplifier input with  $10^{13}\Omega$  resistance to measure actual electrical potential in the given point. In case of needling the polymer drops from the outside by means of an electrode, a deformation will occur due to surface tension and deformation of the outer electric field. This method is unusable for our purpose. Therefore, a method of moving the electrode within the polymer solution was used [1].

### 3. EXPERIMENTAL

The first measuring equipment model in [1] had a manual drive, since there was no electrical interference on the sensitive amplifier. Detection of measuring electrode position was performed using a rotary incremental

encoders. Feed of the electrode sliding bolt and the encoder was geared so that it secures achieving resolution of the electrode position of 23 nm / div. High voltage was applied on the collector at a distance of approximately 3 cm from the surface of the drop. To ensure that the drop is of a constant size during the process, the dosage of the liquid was performed under visual control. The image of the drop has been magnified and projected on a screen using an optical system. According to the image on the screen a moment where the electrode touched the surface of the drop was determined. Measurements were laborious and time consuming. Yet, interesting results were obtained.

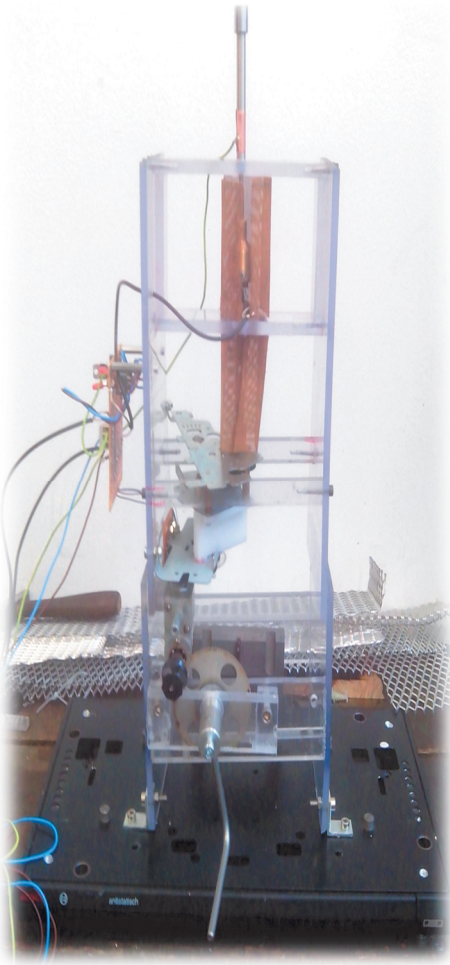


Figure 1 Photo of the measurement equipment [1]

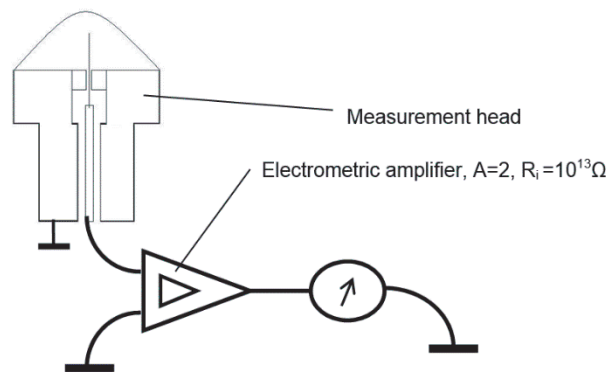


Figure 2 Schematics of measurement equipment [1]

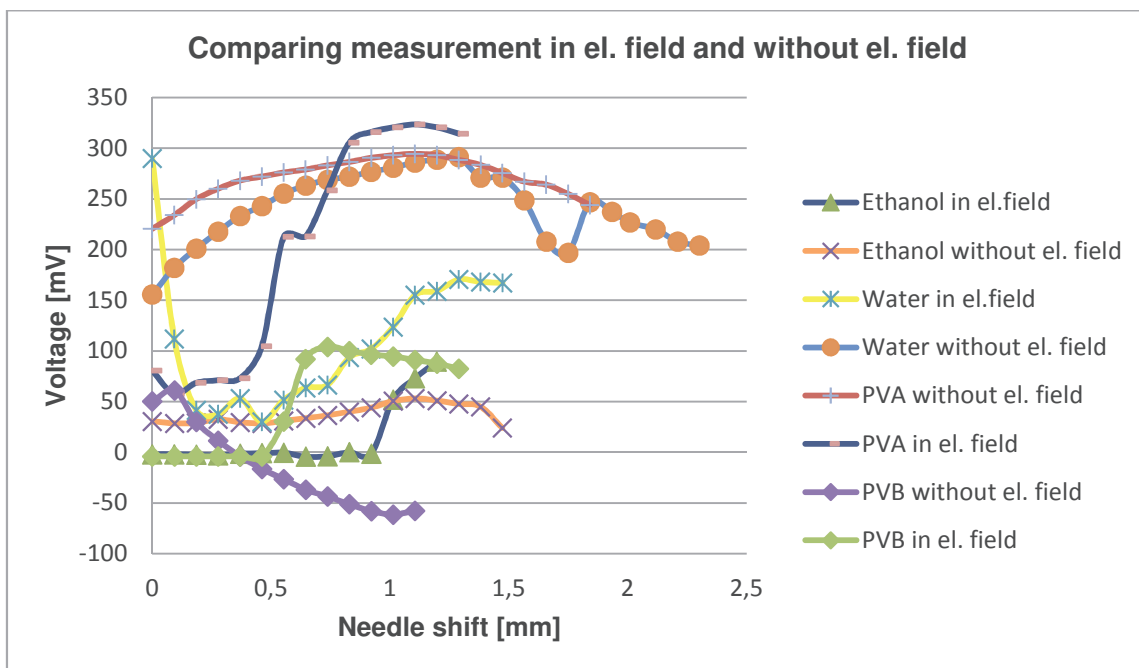


Figure 3 The results of measuring changes in electrical potential using the illustrated device [1]

#### 4. CONCLUSIONS

Our future work lies in improvement of the measuring device [1]. An asynchronous electric motor will be used as the measuring electrode. The base frequency of the electrical interference created by the motor is of 50 Hz. This interference can be eliminated by software. The motor shaft will be fitted with an incremental encoder. A 1:40 gearing will be mounted between the motor and the displacement of measuring electrode, which will improve the resolution of position sensing electrodes to 11.5 nm / div. All data will be recorded using a multi-channel A / D converter and sent to a computer. Additionally, the computer will be used to control the actuator of the device. The quantity of obtained data will allow evaluation of the level of electric potential inside drops of polymer solution along the whole path of the electrode feed. We expect to determine changes of electrical potential and to measure the size of the area with changed potential.

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