

Electrically controlled colour-changing textiles using the resistive heating properties of PEDOT nanofibers

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Experimental Part

Production of PEDOT nanofibers

Polyvinylpyrrolidone (PVP, 1.300.000 g/mol, Aldrich) was dissolved into the Clevios CB40 solution (iron(III) p-toluenesulfonate (FeTos) 40 wt% in butanol, HC Starck, Inc.), with a small amount of pyridine (0.5 mol/mol FeTos), by magnetically stirring overnight in a closed vial at 50 °C. The polymer solution was then filled into a glass syringe terminated by a stainless steel needle ($\phi_{\text{ext}} = 0.91$ mm; $\phi_{\text{int}} = 0.58$ mm). The syringe was placed in an automatic pump (Harvard Apparatus PHD4400) and grounded. A stainless steel substrate was connected to a high voltage power supply (Gamma High Voltage Research, Model ES75P-10W). The distance between the needle and the substrate was fixed at 15 cm and the voltage at 27 ± 1 kV. Relative humidity (RH) in the electrospinning chamber was set to 10 ± 2 % in order to prevent the nanofibers to liquefy by humidity uptake. The temperature was 30 ± 5 °C. The electrospinning process was very stable and could be typically run for hours.

After electrospinning, the non-woven mats were immediately placed in a glass reactor before taking them out of the electrospinning chamber, in order to avoid any contact of the mats with the ambient humidity. The reactor was placed under active vacuum for 15 s and then maintained under passive vacuum for the desired polymerization time. The monomer vapors, placed in a small vial containing the liquid EDOT at the bottom of the reactor, progressively filled the reactor and polymerized when they came in contact with the oxidant nanofibers. After polymerization, the mats were removed from the reactor and let in ambient atmosphere for 3 to 4 hours, to ensure complete evaporation of the EDOT vapors. They were then rinsed in methanol for 30 min and dried under vacuum at room temperature for 2 hours.

Characterization of nanofibers

Scanning electron microscopy (SEM) was performed on a Hitachi S4700 microscope. Optical microscopy was performed using a Leitz Dialux 20 microscope equipped with a Cool Snap Pro digital camera and the Image Pro Plus software. Four-point probes conductivity measurements were carried out using a home made device consisting on four parallel platinum wires positioned 0.2 cm away from each other. Thermal imaging was performed with a ThermoCAM SC620 and recorded using the software ThermoCAM Researcher Pro 2.9 (FLIR Systems AB). For the current/temperature experiments, a temperature point located at the exact center of the sample was selected and monitored. The current was supplied using a VMP3 multipotentiostat (BioLogic, Inc.), controlled through the EC-Lab software. A leuco-dye based thermochromic ink (Chromicolor AQ Fast-Blue type 37, Matsui, Inc.) was diluted by a factor 2 using pure water in order to decrease its viscosity. It was applied to the non-woven mats using a paintbrush or using a spray-through-mask technique.