

In Situ Polymerization of HCl-doped Polyaniline on PET Fabrics for Robust, and Flexible Humidity Sensors

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Abstract:

Conductive textiles have emerged as a pivotal research frontier due to their versatile integration into flexible electronic components. This study reports the fabrication of a novel humidity-responsive sensor based on polyaniline (PANI) synergistically doped with various mineral acids and transition metals. The sensing platform was developed by coating polyethylene terephthalate (PET) fibers with PANI through a facile *in-situ* chemical oxidative polymerization process. Sensor performance was evaluated across a wide relative humidity (RH) range of 10–80%. While hydrochloric acid (HCl)-doped PANI/PET (PANIHCl/PET) fabrics exhibited a baseline response of 23%, the incorporation of manganese (Mn) ions significantly enhanced the sensitivity, yielding a maximum response of 79%. The integration of Mn-doped polyaniline onto PET fabrics represents a significant advancement in textile-based sensing. The transition from a 23% to a 79% response demonstrates that metal-ion doping is a viable strategy for tuning the sensitivity of organic semiconductors.

Fourier Transform Infrared (FTIR) spectroscopy verified the successful integration of PANI onto the PET matrix. The spectra exhibited characteristic absorption bands at 1577 cm^{-1} and 1504 cm^{-1} , corresponding to the C=C stretching vibrations of the quinonoid and benzenoid rings, respectively. The presence of these dual bands confirms that the PANIHCl coating is in its conductive emeraldine oxidation state. Field Emission Scanning Electron Microscopy (FE-SEM) micrographs reveal a highly ordered, columnar PANIHCl architecture uniformly encapsulating the PET fiber templates. This distinct hierarchical morphology significantly amplifies the effective surface-area-to-volume ratio, thereby facilitating rapid moisture diffusion and enhancing active sites for water molecule adsorption. Furthermore, the thermal degradation temperature of PANIHCl/PET/Mn conductive fabric is measured with a thermogravimetric analyzer (TGA) to be 438°C , and the final residual content is 15.57%. Compared with pure PET fabric (430°C), PANIHCl/PET/Mn conductive fabric has better thermal stability. These results indicate that the PANIHCl/PET/Mn conductive fabric is a highly promising candidate for robust, wearable humidity-sensing applications.

Keywords: polyaniline; PET fabric; in-situ polymerization; humidity sensor.