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N-TYPE THERMOELECTRIC TEXTILE FABRICS BASED ON VAPOR GROWN CARBON NANOFIBERS

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Introduction

Conductive fillers like carbon nanotubes (CNT) are extensively investigated to fabricate thermoelectric (TE) materials. Nevertheless, most as-produced CNT have positive Seebeck Coefficients due to oxygen doping (*Figure 1*). It is for this reason that similar carbon nanostructures like vapor grown carbon nanofibers (CNF) grown by chemical vapor deposition (CVD) can fill the current lack of simple pathways towards the direct production of n-type TE materials.

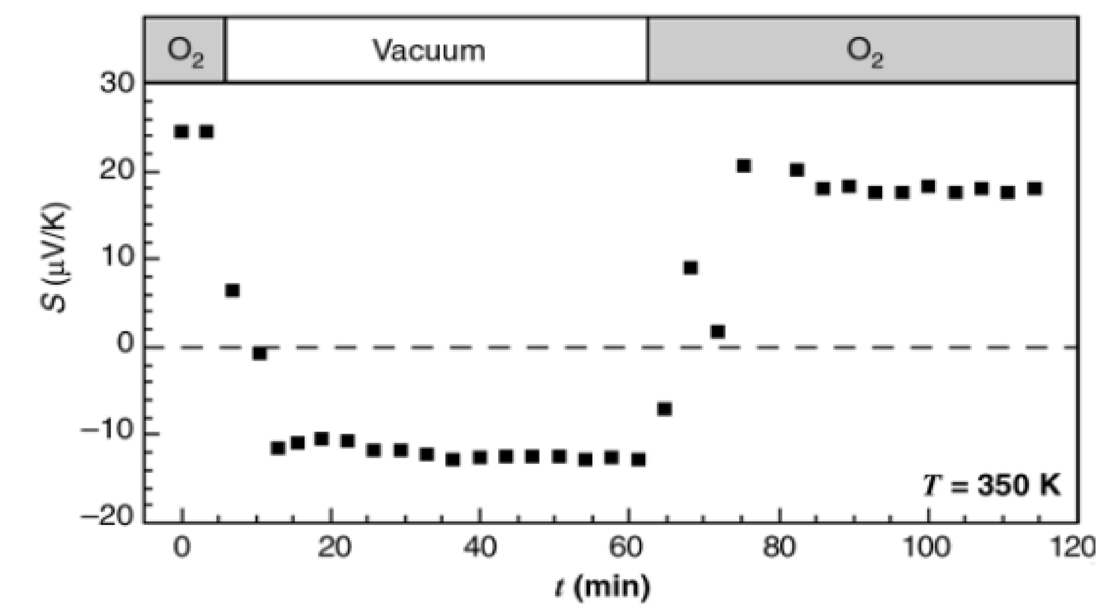
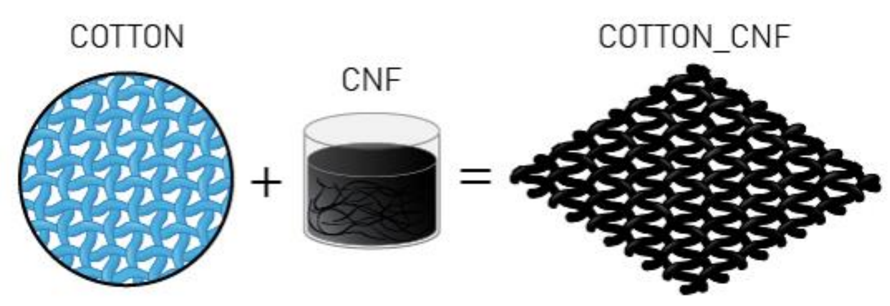


Figure 1. **Sensitivity to environmental conditions of thermoelectric power *S* for SWCNTs at *T*=350 K [1].**

Methods

Three aqueous dispersions of *Pyrograf®III PR 25 PS XT* with a pyrolitically outer stripped layer and diameters around 115 nm, grown by CVD at 1100 ºC, were used for coating 1/1 plain cotton woven fabrics of 14.9 x 20.2 Tex by dipping-drying process (*Figure 2*). Their electrical conductivity (σ) was tested by conventional four probe *van der Pauw method*, and their Seebeck coefficient (S) by using a setup system for a parallel (in-plane) measurement [2].



Sample	CNF aqueous dispersion (mg/ml)	CNF	Cotton fabric linear density (Tex)
CWF@1.6CNF	1.6		
CWF@3.2CNF	3.2	PR 25 PS XT	14.9 x 20.2
CWF@6.4CNF	6.4		

Figure 2. **Dip-coating processing. (Table) Dip-coated fabric sample type.**

Results

The conductivity of the dip-coated cotton fabrics depends strongly on the concentration of CNF dispersions used. Samples CWF@1.6CNF and CWF@3.2CNF showed *σ* values of 8 and 17 S m^{-1} , respectively, and similar negative Seebeck coefficients of around -10 μVK^{-1}, whereas samples CWF@6.4CNF dip-coated with higher content of CNF dispersion (6.4 mg/ml) achieved the highest σ and S of 46 S m^{-1} and -12 μVK^{-1}, respectively.

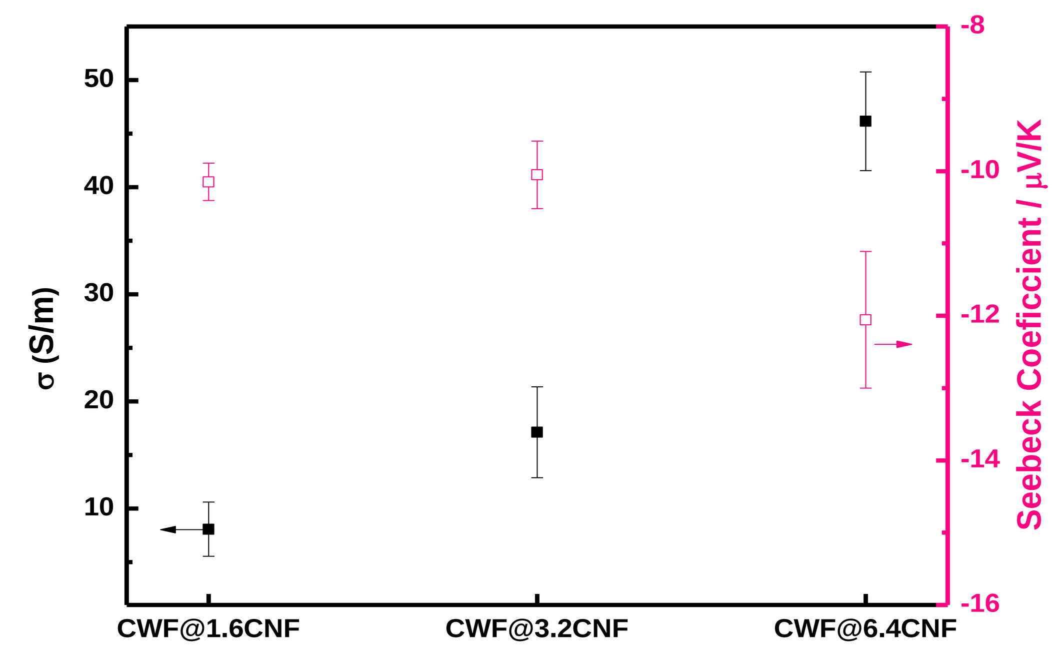


Figure 3. **Electrical conductivity (solid symbols), and negative Seebeck (open symbols) of dip-coated cotton fabrics at room temperature.**

Conclusion

The negative Seebeck of cotton fabrics based on vapor grown carbon nanofibers means that the majority of their charge carriers are electrons, in contrast with most as-produced CNT that show positive S due to their immediate oxygen doping after synthesis. We attribute this negative S to the double wall structure surrounding the hollow tube of the CNF. The n-type contribution caused by the highly graphitic character of the inner shells must counteract the -lower p-type contribution caused by the disordered and thinner outer shells [3]. These results show that commercial and as-received CNF can be used for fabricating directly N-type TE textile fabrics, without requiring deoxygenation pre-treatments and/or further specific additives during their processing.

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