ELECTRICALLY CONDUCTIVE FUNCTIONS FOR INNOVATIVE TEXTILES

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Motivation: Electrial conductivity can create a temperature rise of walls, floors or roofing made of textile materials which will lead to interesting and innovative effects in the architectural field. In this vain, electrical conductivity can also achieve that textiles serve as a sensor or that they show luminescent effects. Well known possibilities to integrate electrical conductivity in fabrics are metal wires and conductive yarns. A new approach is the application of conductive coatings based on intrinsic conductive polymers (ICPs) like polyaniline, polypyrrole, polythiophene or derivatives thereof like PEDOT:PSS. Especially the latter is known for its high conductivity of more than 10^2 Scm^{-1}. Those polymers dispose of internal electron conductivity. Unfortunately, the conductivity of ICPs is reduced by the distinct three-dimensional structure of textiles. Depending on end-use, coating materials for textile applications should be free of organic solvents. Typical textile coatings are based on polymer binders like polyacrylate or polyurethane. For a system of PEDOT:PSS and a polyurethane binder we can report a surface resistance of about 10^5 Ohm/sq on polyester fabric, which is only in the range for antistatic uses. Our solution to enhance conductivity is the addition of highly conductive pigments such as metal or carbon particles. Preferred pigments contain silver or copper particles, while carbon particles are based on carbon nanotubes and carbon black. Dispersions with conductive fillers were investigated regarding higher conductivity by forming an end-to-end grid with the addition of conductive polymers for electron transport. The combination of polymer binder, ICP and conductive pigments results in flexible coatings with surface resistance between 10^{-1} and 10^3 Ohm/sq depending on the type and concentrations of pigment and ICP. This new approach differs considerable from using conductive yarns, as design and construction of the textile base are basically unlimited.

Experimental: At first conductive textiles were tested for heating purposes. Laminar coatings of conductive dispersions on plain fabrics, woven, knitted and nonwoven were applied. Depending on sheet resistivity different currents were measured at different voltages. Thermographic images were obtained. With metal based dispersions the temperature rise of the textiles was much higher and faster. However, with carbon based dispersions the increase was less but lasted longer.

In a second step conductive coatings were investigated for textiles with light emission. Planar coatings were applied for a capacitor on the backside of textile fabrics, woven, knitted and nonwoven. The transparent front-electrode was based on PEDOT:PSS, while the highly conductive back-electrode was based on various synergistic dispersions based on ICPs, metal or carbon particles. The influence of voltage and frequency were investigated as well as the light emission by different back-electrode dispersions.

Finally, electrical conductive dispersions were used to develop a textile sensor system with special design and microelectronic configuration. Fine circuit paths were printed onto woven textile fabrics with various conductive polymer dispersions. The electrical supply was achieved by micro-current via a capacitor. In case of rupture of the textile base the circuit was interrupted and an alarm could be triggered.

Results: The results of the current research impose, that the use of intrinsic electrically conductive polymers optimizes conductivity of carbon or metal based dispersions with synergistic effect. Sheet resistance well below 10 Ohm can be achieved with layers of very few microns. Various textile constructions, woven, knitted, non-wovens and scrims made of different fibers were coated with conductive dispersions, all free of organic solvents. With solid electrical contacting and application of voltage flexible conductive textiles can be integrated into buildings for thermoregulation or sensoric duties.

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