Final Report

Project acronym: *Smart RESCyou*

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Publishable project summary

This research proposal focussed on the development of the metallisation of high performance fibres in order to integrate innovative sensors into multipurpose personal protective equipment (PPE) aiming for digitally supported PPE.

The highest quality regarding the conductivity and performance can actually be reached by wet-chemically metallised yarns or fabrics. Commercially available silverised fibres are limited to aliphatic polyamide 6 and 6.6 base material. Nevertheless, foreign materials could cause weak points in the finished product due to different mechanical or themal behaviour. In order to ensure the multi norm purposes of the PPE that was aimed for, activation methods for further high performance fibres had to be studied.

The high performance polymer fibres were selected including aliphatic and aromatic polyamides, polyester (PET) and high density polyethylene (HDPE). The fibres were activated using different wet chemical and physical techniques as for instance plasma treatment, alkaline and acidic treatment, complexation techniques, and the deposition of adhesion promotion layers. Subsequently, the fibres were metallized using an electroless copper or silver deposition technique.

The metallisation and the adhesion between the fibre and the copper layer strongly improved for aliphatic polyamides using a complexation technique with calciumchloride, ethanol, and water. The alkaline treatment with a sodium hydroxide solution was found to be the best treatment for PET yarns and a dopamine treatment highly increased abrasion stability for HDPE yarns. The dopamine treatment also achieved a successful metallization for the aromatic polyamide yarns. In order to create conductive lines between sensors and a power source and therefore enabling the measurement of data and their transfer to a receiver, electroless silverization was used. Since PPE in outer wear often contains cotton in material mixtures, the activation of this type of materials for silverisation was included in the studies. The activation of the fibre surface by low pressure plasma processes followed by a silane adhesion layer led to successful metallisation on HDPE and m-Aramid. Cotton and mixed yarns containing cotton were successfully silverised, too. Surfaces for temperature and gas sensors for the detection of ammonia (NH_3) and hydrochloric (HCl) acid gas were generated using the deposition of polypyrrole (pPy) on polyamide 66 fabrics. The pPy layer presents a good sensing area for temperature measurement as its resistance decreases linearly with increasing temperature. A linear decrease in resistance with increasing HCl concentration within 20 to 100 ppm was observed and a linear increase in resistance with increasing NH3 concentration was observed.

Linear conductive lines from copper are possible to print on polyamide 66 and cellulosic fabrics. Embroidered and printed matrix structures were successfully generated.

Silverised fibres can be used to create conductive pathways in weaving or knitting processes and overcome the almost conventional add on or add in solutions by stitching or weaving and knitting conductive threads such as twists with wires onto or into textiles while using the same base material for the whole PPE.

In the prototype glove, the glued interface and the combination of embroidered and printed components as sensor matrix were investigated. Bonded contacts and the combination of embroidered and printed sensor elements were successfully tested on a prototype scale.