Functionalisation of textile fibres with metal nanoparticles

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There is need in the textile market for technologies that warrant efficient shielding for high and persistent levels of electromagnetic (EM) radiation, mitigating its effects on humans. In particular, applications for Individual Protective Equipment (IPE) are sought by the industry and military, for protection of individuals that are exposed for long and frequent periods to non-ionising EM radiation (from electronic equipment). EM radiation is critical to many aspects of modern life (e.g. telecommunications), and there is increasing public concern on its effects, given some studies indicate increased rates of maladies such as cancer and leukemia[1]. In particular, EM fields generated at near-field by mobile phones or far-field by e.g. radiofrequency towers causes most concern[2,3]. There is, thus, a concomitant interest and demand for EM shielding (EMS) technologies for IPE.

We propose the concept of deposition or immobilisation of a nanometric layer of metal nanoparticles (NPs) on the surface of textile fibres, resulting in high levels of conductivity that lead to EM field dissipation by the textiles through a Faraday Cage effect[4].
Our approach, in departure from previous methodologies, will be: (i) the direct growth of metal nanoparticles (NPs) on the textile fibre surfaces, and (ii) the targeted use of specific ligands to ensure the immobilisation of metal nanoparticle (NPs). This rational design will permit low temperature immobilisation of metal NPs onto different fibre compositions in a targeted manner by controlling the NP amount immobilised onto the fibres, thus providing a tuneable EMS for a wide range of EM frequencies; allow the production of EMS clothing with high standards of comfort and resistance to washing and wear, at a low cost.

Here we report our first results on the first approach (direct growth of NPs on the fibres). The growth of silver nanoparticles (AgNPs) on cotton fibres surfaces has been reported by Lee et al. [5] in an ethanol solution. Since this approach is not feasible at an industrial scale, we developed a modified method in aqueous solution. The method simply consists of placing a sample of wool or cotton fabric in water and adding buthylamine and silver nitrate, at 45ºC in constant agitation. The samples were analysed by ICP to determine the concentration of silver in the treated fibres grown as AgNPs. The results (Table 1) showed an increase in the amount of silver per weight of sample (mg/mg) for both wool and cotton when the reaction was carried out in aqueous solution when compared to an absolute ethanol solution. This suggests that the growth of AgNPs directly on the fibres is more efficient in aqueous solution than in absolute ethanol.

In accordance to the second approach (synthesise first NPs in solution and then bind them to the fibres), we have synthesised AgNPs following the borohydrate method[6]. This method also uses water as solvent and the AgNPs obtained have a average size of 8-10 nm(Fig. 1). A stability study of these particles showed they aggregated at NaCl concentrations greater than 40 mM and at pH lower than 4.

The fibres treated followed both approach are presently being analysed by SEM to observe how the AgNPs are formed and bound to both textiles. Moreover, conductivity and shielding measurements will be performed on the treated fabrics to verify that the fibres treated in aqueous solution block the EM radiation and were bestowed with a high conductivity levels

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Figure 1. TEM photograph of AgNPs synthesized.

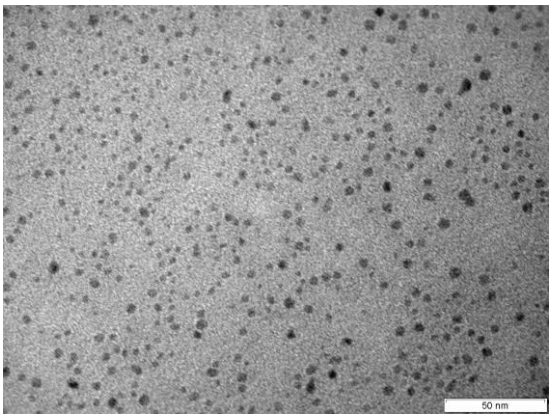

Table 1. Results of ICP in mg of Ag per mg of sample.

Solvent\Sample	Wool	Cotton
Water	7,19	12,33
Absolute ethanol	1,75	3,85