

## ABSTRACT

Advancements in textiles by creating new functionality is in demand. Textiles are the most attractive candidate for safeguarding skin of a wearer from environmental damage, such as harmful UV rays, pollution (particulate matters), chemicals (ammonia, hydrogen sulphide etc.), microorganisms and other commonly faced topical issues. Globally, the population is suffering from severe health hazards created due to various pathogens. Apart from biological attacks, the climatic change, such as ozone layer depletion, allows harmful rays of Sun (UV-A & UV-B) to reach the Earth's surface causing skin diseases. Therefore, the emergence of effective multifunctional protective textiles has become crucial for the safety of people.

The essential aspect is that the functionality needs to be durable to washing and should not affect the comfort properties and aesthetics of the substrates. In this study, the phosphate derivative of cellulose has been explored as a linking moiety to attached functional groups.

Initially, a green chemistry approach for phosphorylation of cellulose, under atmospheric pressure plasma was investigated and compared with conventional thermal method. The attachment of the phosphate groups was evaluated by  $^{31}\text{P}$  and  $^{13}\text{C}$  solid state NMR spectroscopy and XPS. The thermal method led to the formation of monophosphate of cellulose along with a side product of polymerized phosphate, whereas the plasma method produced only the monophosphate without any side products. Unlike with the thermal treatment, the appearance and the mechanical properties of the viscose fabric remained nearly same after the plasma treatment. Also, the dyeability of the plasma modified fabric remained unchanged, whereas it decreased significantly in the thermally modified fabric. The amount of phosphate quantified by phosphomolybdate assay was found to be

2.88 ±0.06 and 4.09 ±0.19 % in the plasma and the thermal methods, respectively. This method has the potential to replace the existing methods of phosphorylation of cellulose.

Further, considering the public health demands for stronger and effective personal protective clothing, antimicrobial fabrics using a known bacteriostatic and fungistatic drug zinc pyrithione (ZPT) has been investigated. ZPT was synthesized *in-situ* on cellulosic fabric, viscose (VC), using zinc metal precursor and 2-mercaptopyridine-N-oxide as a ligand (VC-ZPT). For comparison, viscose was also phosphorylated (VP) before *in-situ* functionalization with ZPT (VP-ZPT). Both approaches provided adequate protection from microbes, however, functionalization of cellulose with phosphate (VP) resulted in the formation of a linking group between cellulose and ZPT, which exhibited better uniformity of ZPT over the fabric surface and higher durability to washing. The functionalization was confirmed by ICP-MS, SEM and Raman spectroscopy. Further the bonding of phosphate with ZPT was confirmed by <sup>31</sup>P solid-state NMR. The physical properties, such as appearance, bending length and mechanical strength, of the treated fabrics remained unchanged. The antimicrobial activities of VP-ZPT with VC-ZPT were studied against *E. coli*, *S. aureus* and *C. albicans*, which were found to be effective till 20 laundry cycles in VP-ZPT. Additionally, VP-ZPT samples exhibited poor adherence of bacteria on the fabric surface.

Repurposing of antimicrobial metal pyrithione complexes for UV protective properties widens the applicability of protective textiles. Therefore, UV-protective and antimicrobial properties of cellulosic (viscose) textiles modified with various metal pyrithione complexes have also been investigated. Different metal (silver (Ag), cerium (Ce), copper (Cu), magnesium (Mg) and zinc (Zn)) pyrithione complexes have been *in-situ* synthesized on viscose (VC-MPT) as well as on phosphorylated viscose (VP-MPT). The surface morphology was characterized by FE-SEM and chemical nature was studied by XRD, Raman spectroscopy, ICP-MS and solid-state NMR. The

antimicrobial activities of different VC-MPT and VP-MPT treated fabrics were compared against *E. coli*, *S. aureus* and *Candida albicans* and found to be effective to various degrees (up to 98-99% microbial growth inhibition) based on the metal used. Additionally, the functionalized fabrics were found to have high UV blocking properties. The treated phosphorylated viscose fabrics, i.e. VP-MPT, exhibited significantly better durability for up to 20 wash cycles compared to VC-MPT fabrics possibly due to better complexation of in situ synthesized metal pyrithiones with the phosphorylated cellulose. The functionalized fabrics may find applications for topical skin diseases in reducing the necessity of repeated use of antibiotics ointments.