

ABSTRACT

The demand for functional textiles has been increased exponentially for various end applications. It has been reported that market for functional textile finishing agents is growing at the rate of 6.1% cumulative annual growth rate (CAGR) and the market for functional textile agents at US is expected to reach 162.5 million USD dollar in 2025. Among the functional textiles, antimicrobial textiles are growing at a very faster rate because of recent happened deadly Covid 19 pandemic wherein textiles in the form of PPEs played a major role. On the other hand, textiles act as a carrier for germs and spread the infection very fast. Spread of infection through textiles can be controlled by using antimicrobial finishing treatment to it. Textiles are one of the primary needs for everyone. Sickness, mortality rate because of various infection spread by normal textiles can be minimized at rural area by making these textiles functional. Not only antimicrobial textiles, but there is also a growing demand for other functional properties imbued into textiles which can provide additional protection to human being such as protection from UV light, fire among the others. Therefore, there has always been a research trend to find novel finishing agents and their exploration on textile fabric to get multiple functionalities together. But demand has also grown to look for the finishing agents which should be safe, economical, and industrially viable as well as stable at temperature of integration to textiles. Thus, development of multifunctional textiles having various properties together such as antimicrobial, UPF, fragrance, colour, etc. using safe functional agent is currently of high priority research area.

At first vanillin alone and vanillin in presence of metals have been explored as multifunctional finishing agent on both the cotton and PET textiles. However, vanillin

alone has not provided durable function properties to treated fabric and elutes out after washing. But among the metal ions (Cu, Fe, Zn) studied, copper complex with vanillin (vanillin-Cu) has provided excellent functionalities such as 99% antimicrobial activity and 50+ UPF to cotton textiles. V-Cu has also been explored on PET fabric and the treated textile has provided similar functionalities to PET fabric.

Further, vanillyl alcohol has been synthesized, characterized, and explored alone on cotton and PET fabric. Vanillyl alcohol (VA) having mild fragrance than vanillin can be thought of as a better choice for many people. VA treated fabric has shown enhanced UPF (nearly 35) in case of cotton due to increased interaction with celluloses backbone, but due to small size it again washes out from cotton and PET textiles. To tackle this problem, vanillyl alcohol complex with Cu has been prepared in-situ and integrated on cotton and PET textile using high temperature high pressure (HT-HP) dyeing machine. The treated fabric has depicted improved functional properties to a greater extent, especially, antimicrobial and UV resistance property have been reached to excellent category. Treated fabric can also retain its functional properties up to 90 washes.

In the next study, Schiff base of vanillin (SB) has been synthesized through a new approach with high yield. It has been hypothesized that Schiff base having larger size would interact with the fabric strongly and be retained inside the cotton and PET structure. Integration of SB inside cotton and PET fabric has been done using HT-HP treatment process. It has been observed that treated fabrics provide good functional properties, like antimicrobial activity of nearly 90%, good UPF and beautiful colouration which confirm the effective retention of SB than vanillin and vanillyl alcohol within the textile structure. However, treated fabric properties have been observed to be retained till 3 machine wash only. To improve the wash

durability SB-Cu complex has been synthesized in-situ and integrated on cotton and PET textiles which provide excellent and durable (18 machine wash, i.e. 90 home washes) functional properties on to treated textiles.

In the next study, another new derivative, reduced Schiff base (RSB) has been synthesized using a single step process with high yield. Synthesized RSB molecules have been characterized and integrated on cotton and PET textiles. The treatment enhances the functional properties like antimicrobial activity up to 95% and antioxidant properties more than 90% for both types of fabric. Functional properties of the treated fabric have been found to be retained till 6 machine washes and thereafter the functional properties get diminished. To further enhance the functional properties, RSB-Cu has been synthesized in-situ on textiles using HT-HP process. The treated fabrics have displayed significant improvement in functional properties like increased antimicrobial property up to 99% along with excellent UPF and 50% antioxidant activity with attractive shade. The properties also have been found to be retained till 90 washes.

In a further study, vanillin reactive finish (VRF) has been synthesized and characterized. In the previous sections of the thesis work, it has been found that all the vanillin-based active ingredients retain in the textile structure due to physical interaction and properties get decreased after each wash. Thus, covalent bond formation between the cotton fabric and vanillin has been conceptualized and VRF has been synthesized successfully. The integration of VRF on cotton fabric has been done at 60°C (which is the optimized temperature) in alkaline pH. By this approach, finishing agent becomes a part of fabric and has shown long lasting functional effects. However, -OH group of vanillin is blocked in VRF and therefore antimicrobial activity of treated fabric has been found to be decreased

to 50%. Nevertheless, UPF value of treated fabric has been increased to 50 which even can be retained at a nearly 40 even after 90 washes. VRF treated fabric has advantage of having white colour and excellent UPF property. This finish has been explored on cotton fabric only.

In the later part of the thesis, comparison of all finishes in terms of multifunctional efficacy has been done in a very systematic way. Physical properties of the treated textiles have also been studied to check any deterioration of basic properties of the fabric because of finishing treatment. However, it has been proven that all finishes are safe and do not change handle of fabric as well as other useful properties like water absorbance, tensile strength and air permeability. Finally, mechanisms of UV resistance, antimicrobial activity and antioxidant activity have also been studied using UV-Visible spectroscopy, SEM and TEM analysis and DPPH test.

At the end, it has been concluded that vanillin and all other vanillin-based synthesized finishes are safe, and provide very useful functional properties to textile substrates without hampering their basic useful properties.
