

## ABSTRACT

Denim is commonly referred as “cradle-to-grave product”, this statement is very much appropriate to denim, since it has been used by people from the age group of 2 years to 60 years. Over the years, many different researches were carried out in fabrications and finishing of denim. Functional finishes such as fragrance finish, anti-microbial finish, anti-fungal finish enhances the value of denim products in the current market scenario. But very seldom research has been carried out in this area on denim apparels. In this research work, present necessity of value addition in denim apparel is addressed and the work is carried out in the direction of multifunctional finishing on denim tops using nano particles Titanium dioxide ( $\text{TiO}_2$ ), Zinc oxide ( $\text{ZnO}$ ) and fragrance oils namely rose and citrus oils. The multifunctional finishing was carried out using direct exhaustion and microencapsulation methods. An attempt has also been made to develop design collections of denim tops for college girls suitable for the southern part of India, Coimbatore. The feedback of the product developed was obtained from a panel of experts.

Right Hand Twill (2 up and 1 down) 100% cotton denim fabric was developed at M/s. KG Denim Pvt. Ltd. Since denim finishing processes are carried out after garment construction, a simple style of denim tops with an A-line silhouette was developed for the research work. 30 denim tops of similar style with A-line silhouette were developed and the same were desized and washed using enzymes. Among the 30 denim tops, 10 denim tops were subjected to functional finishing using nano particles of  $\text{TiO}_2$  and  $\text{ZnO}$ ; 20 denim tops were subjected to functional finishing using rose and citrus oils in five proportions like rose oil (100%), citrus oil (100%), combinations of rose and citrus oils (75:25, 50:50, 25:75). Two methods were used to finish the developed denim tops like direct exhaustion and microencapsulation methods.

The multifunctional finished fabrics were critically analysed by the test results of multifunctional aspects like anti-bacterial, UV protection and stain repellency and its wash durability. Anti-fungal and fragrance intensity were done exclusively for the denim tops treated with natural oils. To analyse the particle size, Scanning Electron Microscope (SEM) photomicrographs were used. To identify the traces of various chemical groups present in the multifunctional finished fabrics, Fourier Transform Infrared Radiation (FTIR) analysis have been conducted. The denim fabrics before and after preparatory process, multifunctional finished fabrics were tested to analyse the structural and physical properties of the denim fabrics.

In the first part of the research work, the synthesis of nanoparticles of  $\text{TiO}_2$  and  $\text{ZnO}$  was done and the microcapsules were developed. Among the 30 enzyme washed denim tops, 10 tops were divided into five equal segments (2 denim tops in one segment) for application of  $\text{TiO}_2$  and  $\text{ZnO}$  nanoparticles (2 tops for exhaustion + 2 tops for micro encapsulation using  $\text{TiO}_2$  and same division for  $\text{ZnO}$ ). Remaining 2 denim tops were kept as control samples. The fabric from the denim tops treated with  $\text{TiO}_2$  nanoparticles were tested and found to have anti-bacterial property with zone of inhibition as 42 mm and 32 mm in exhaustion method; 33 mm and 26 mm in microencapsulation method against *S.Aureus* and *E.Coli* respectively. The  $\text{ZnO}$  nanoparticles treated fabric shows a zone of inhibition as 40 mm and 32 mm in exhaustion method; 30mm and 24 mm in microencapsulation method against *S.Aureus* and *E.Coli* respectively. The ultra violet protection in the fabric treated with nanoparticles of  $\text{TiO}_2$  shows UV A and UV B values as 14.17 and 17.89 for direct exhaustion method; 13.73 and 17.77 for microencapsulation method respectively. In case of the fabrics treated with  $\text{ZnO}$  the UV A and UV B values were 12.84 and 16.33 in exhaustion method; 12.89 and 16.08 in microencapsulation method. In both the treated fabrics irrespective of the method used, the grades of stain repellency were 4 and 5, other than the pickle

stain. The wash durability of the functional properties in the treated samples was found to have significant effect up to 20 washes in direct exhaustion method and up to 25 washes in microencapsulation process.

The second part of this research work comprises of application of rose and citrus oils on denim garments in various proportions like rose oil (100%), citrus oil (100%), combinations of rose and citrus oils (75:25, 50:50, 25:75) by direct exhaustion and microencapsulation methods. The multifunctional finished fabrics were critically analysed. The remaining 20 denim tops were divided into ten equal segments for the application of rose and citrus oils. Among the twenty enzyme washed denim tops, ten garments were finished with oils in direct exhaustion and ten using microencapsulation method (2 denim tops in each proportion of oils). The anti-bacterial property with zone of inhibition in the range of 30 mm to 44 mm against *S.Aureus*; 28 mm and 37 mm against *E.Coli* in exhaustion method and of 28 mm to 40 mm against *S.Aureus*; 26 mm and 32 mm against *E.Coli* in microencapsulation method. The percentage of UV transmission values, UV A and UV B values was in the range of 22 to 24 for direct exhaustion method; 20 to 24 for microencapsulation method respectively. The grades of stain repellency were between 3 and 5. The same trend was observed in microencapsulation method also. The anti fungal effect in the oil treated fabrics showed a range of 58% to 100% in direct exhaustion and 56% to 98% in microencapsulation method respectively. The fragrance was very strong in 100% rose and citrus oils followed by their combinations. In general microencapsulation showed 20% less fragrance intensity than the direct exhaustion method initially. The wash durability of the functional properties in the treated garments was found to have significant effect up to 20 washes in direct exhaustion method and up to 25 washes in microencapsulation process.

The structural and physical properties of the raw denim was tested and compared with that of the enzyme washed denim fabrics. This is further compared with the denim fabrics treated using TiO<sub>2</sub>, ZnO and various combinations of rose and citrus oils. The t-test statistical analysis has been made for the test result to assess the significance of each property. It was found that the results are strongly significant in case of the raw denim fabric and enzyme washed fabrics, since there is a notable difference in its properties and it is not significant in case of enzyme washed and TiO<sub>2</sub>, ZnO and various combinations of rose and citrus oils treated denim fabrics.

The third part of this research work comprises of the design and development of denim tops for college girls. This was carried out in seven stages namely development of hypothesis, consumer research, development of mood, fabric and colour boards, illustrations, pattern making, garment construction and finally obtaining the feedback from the experts. Initially nine hypotheses were framed based on the extensive literature. The selected target group was college girls within the age group of 17 to 21 years and the consumer survey was conducted among 500 college girls using a structured questionnaire. The questionnaire was divided into three segments which covers the consumers' attitude towards fashion, buying habits and preferences in garment design details. The mood board has been developed based on the "nature" concept followed by the development of colour and fabric boards. A design collection consisting of two divisions based on the silhouettes were done namely denim princess line top (DPLT) and denim empire line tops (DELT). Totally twenty styles of denim top designs (ten in each silhouettes) were developed based on the inspiration obtained from the mood board. Among the twenty designs, ten garments were selected randomly and developed into garments. The denim tops were evaluated by a panel of 20 experts. A questionnaire was given to the experts, the feedback obtained were consolidated and found very excellent.