CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The textile industry is exploring novel production techniques to improve the product quality and society requires new finishing techniques that can be workable in modern environment. Over the years, physicochemical procedures have become profitably attractive and begun to prevail over conventional wet processing methods for characteristics modification. The significance of surface modification of textile materials is to widen the scope of functional finishes to provide desired single or multi featured applications. It is a highly focused area of research in which alterations to physical and chemical properties of textile materials lead to innovative textile products that result in new applications.

Surface modification via plasma treatment not only eliminates the need for wet processing, but also yields exceptional surface characteristics. Several modifications include, but are not limited to: hydrophilicity or hydrophobicity alterations, surface roughening, grafting, flame retardant, antimicrobial, insect repellant, stain resistant, and single or multiple surface functionalization.

Plasma technology with all its challenges and opportunities is becoming part of our future. The possibilities with plasma technology are enormous and numerous. It can be said that the advent of plasma technology application is slow, but steady in revolutionizing the industry. The major
limitation of plasma treatment on textiles is that it cannot replace all wet processes but it can be a feasible pretreatment which can provide ample environmental and economical benefits. The executions of plasma processes in the textile industry lead to environmental advantages and also allow high value added textile products. The plasma treatment when compared with current conventional finishing treatments has the crucial advantage of reduced usage of chemical, water and energy. Plasma treatment offers the possibility of getting hydrophilic, oleo-phobic and antibacterial finishes without changing the parent textile properties. Lower cost of operation, improved durability and incorporation of new characteristics for the textiles are the key benefits that plasma based manufacturing of textiles can bring about. The technology changes from the conventional process to plasma process fundamentally change some of the textile processes which in turn improve the marketability and profitability.

The conventional textile finishing treatments have a long record of application with good establishment. However, with the ever growing demand and compulsions of the consumers and the society, the conventional treatments cannot survive with growing public awareness. Since many of them have dangerous effects on the environment which in turn lead to the pollution and the degradation of the ecology. Textile industry should be informed about the new technologies, this will help them to improve and produce high value products in order to overcome the problems connected with the conventional finishing treatments.

1.2 MULTIFUNCTIONAL FINISH

Functionalisation is an important component in textile processing for imparting additional properties to textile materials. Textile materials have many valuable basic properties such as flexibility, lightweight, strong, tactile, softness and so on. Along with these properties they are flexible enough to be
impair with additional functionalities. Multifunctional finishes are the key technologies for the current century. A large number of works are being carried out worldwide to make medical and hygienic textiles by using nano particles or creating nano structured surfaces or nano fibres which lead to extraordinary levels of textile performance on stain resistant, self-cleaning, antistatic and UV protection etc.

1.3 SIGNIFICANCE OF ECO-FRIENDLY TREATMENTS

Good care and cleanliness should be exercised on textiles and clothing. The moist and body temperature are the resources for the growth of microorganism such as bacteria, virus, yeast, algae and mould. It is necessary to prevent the growth of these microorganisms in textiles and clothing by imparting multifunctional finishes such as antimicrobial, UV Protection and thermal resistance. All the multifunctional agents’ helps to impart multifunctional finishes were eco-friendly and give good effect to human skin in addition to the values on fabrics.

The most commonly encountered toxic heavy metals are Antimony, Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium and Zinc which lead to carcinogenic effect on human beings. In conventional treatment, heavy metal toxicity may result in health hazards and lead to death. Due to the small size, large surface area and also due to strong electrostatic attraction TiO$_2$ nano particles can absorb heavy metal particles. Due to this absorption property it can prevent the ill effects of toxic heavy metals and prevent human causalities.

Almost every engineering discipline has a direct bearing on environmental features. The textile industry plays an important role in the economy of our country. The textile industry is one of the most important and fast modernizing industrial sectors in India. As the textile industry consumes
considerable amount of water and discharges highly toxic effluents which affects the environment significantly. Recently textile industry has given importance to eco-friendly processes and procedure for the betterment of the environment.

1.4 PRESENT RESEARCH WORK

In this research work cotton, viscose and polyester were selected as raw materials. The pretreatments have been given in two methods such as conventional and plasma methods. Then the evaluation of pretreated fabrics was carried out. Then the pretreated fabrics have been used for multifunctional finishes and characteristics of the multifunctional finished fabrics were assessed. The effluents of the above process have been influenced by a bioculture of *Lactobacillus acidophilus*.

The raw materials were selected on the basis of non-toxicity, non-allergic and non-carcinogenic effect which is more suitable for the research study. So many functional fabrics for different applications having different yarn counts in warp and weft vary from 29.5 to 7.4 Tex. Hence for this research work, an attempt has been made with nominal count of 14.76 Tex. Based on the sustainable product point of view cotton, viscose and polyester fabrics were selected to develop plasma pretreated multifunctional finished fabrics. Also, it is noticed that the plain structured fabric has many advantages such as simple and tightest woven structure which are more suitable for multifunctional finish processes. Chitosan, TiO₂ and ZnO have eco-friendly properties and commonly used to impart multifunctional finishes.

The effect of the air and oxygen plasma pretreatment to cotton, viscose and polyester fabrics and their characterization was compared with the conventional pretreatments. The evaluation of pretreated fabrics of both conventional pretreated and plasma pretreated was assessed in terms of
wettability, wickability, weight loss, surface modification studies, drape and air permeability.

Synthesis of Chitosan nano-particles were carried out using an ionic - gelation technique and for TiO$_2$ and ZnO nano-particles synthesis was carried using the ball milling technique. The characterization of nano particles was assessed using the modern analytical instruments namely the X-ray Powder Diffraction Method (XRD), Dynamic Light Scattering Technique (DLS) and Transmission Electron Microscope (TEM) to study the size and shape. Nanotechnology can offer high durability for fabrics, because the nano-particles have a large surface area-to-volume ratio and high surface energy, thus presenting better affinity for fabrics and leading to an increase in durability of the function. In addition, a coating of nano-particles on fabrics will not affect their breathability or hand value. The use of nano particles of TiO$_2$ and ZnO has been seen as a feasible solution to stop infectious diseases due to the antimicrobial properties of these nano particles.

Application of nano particles on both conventional pretreated and plasma pretreated cotton, viscose and polyester fabrics was carried out. The conventional pretreated fabrics were imparted multifunctional finish by the synthesized nano particles of Chitosan, TiO$_2$ and ZnO. The assessment of both conventional pretreated and plasma pretreated multifunctional finished fabrics of cotton, viscose and polyester were assessed in terms of antimicrobial activity, UV Protection, thermal resistance, physical characteristics and presence of proscribed toxic substances.

*Lactobacillus acidophilus* culture was developed and its influence on effluents has been studied. The characteristic of effluent after influencing the bio culture of *Lactobacillus acidophilus* culture was studied. The characteristics of effluents after treatment were compared with general
standards for discharge of environmental pollutants recommended by the Central Pollution and Control Board (CPCB), INDIA.

1.5 OUTCOME OF THE RESEARCH STUDY

The evaluation of pretreated fabrics both conventional pretreated and plasma pretreated results show that the plasma pretreated fabrics show significant improvement in wettability and wickability, lesser weight loss, structural modifications, improvements in drape and air permeability characters when compared with conventional pretreated fabrics. The nano particles treated fabrics have high durability because of smaller nano-particle size. Thus, nano finishes have new and highly improved functions when compared to conventional treated fabrics.

The assessment of both the conventional pretreated multifunctional finished fabrics and plasma pretreated multifunctional finished fabrics demonstrated significant antibacterial activity against Staphylococcus aureus and Escherichia coli in both qualitative and quantitative tests. It is found that all functional properties were enhanced in plasma pretreated multifunctional finish fabrics when compared with conventional pretreated multifunctional finish fabrics. The UPF factor in both cases is above 30 nm which means good protection against Ultraviolet rays. The plasma pretreated multifunctional finished fabrics show significant protection than the conventional pretreated multifunctional finished fabrics. This is due to surface modification of cotton, viscose and polyester fabrics in the plasma pretreated fabrics.

The thermal resistance for conventional pretreated multifunctional finished fabric exhibits better thermal resistance value (nearly double times) than the control fabrics. There was a significant difference of one and quarter time’s improvement in plasma pretreated multifunctional finished fabrics.
when compared with conventional pretreated multifunctional finished fabrics. It is concluded that TiO₂ nano particles treated samples offers higher thermal resistance significant value compared to the conventional pretreated multifunctional finished fabrics.

The presence of proscribed heavy metals results of conventional pretreated multifunctional finish fabrics and plasma pretreated multifunctional finish fabrics were compared with the Good Environmental Choice Australia (GECA) standards. The plasma pretreated multifunctional finish fabrics show ten times lesser value when compared with conventional pretreated multifunctional finish fabrics. From the results we can safely conclude the plasma pretreated multifunctional finished fabrics will not cause any irritation or toxic effect on the skin.

Out of various activities in textile industry, wet processing produces about 70% of the effluents. Of late textile industry is giving importance for the eco-friendly processes to protect the environment. The effluents hamper the quality of water and cause injury to the existing organisms and aquatic life. When biological treatments are given to the textile effluents it results in significant reduction in the effluent characteristics and the resultant becomes environmental friendly. This successful bio-culture treatment uses aquatic organisms to purify effluent and refresh water. The numbers of bio-cultural species are widely used in the treatment of effluents. Lactobacillus acidophilus is one such bacterium used in the effluents for purification. Lactobacillus acidophilus has the ability to remove, assimilate and decompose the biodegradable organic matters present in the effluents. In addition to these, the present research study attempts to control the levels of total suspended solids (SS), improve the dissolved oxygen content (DO), and reduce the chemical oxygen demand (COD) and biological oxygen demand (BOD).
1.6 OBJECTIVES OF THE RESEARCH

The objectives of research work are:

i. To study and select the materials for the research work.

ii. To give pretreatments to cotton, viscose and polyester fabrics in two methods such as conventional method and plasma treatment methods.

iii. To synthesize and characterize of nano-particles of Chitosan by ionice- gel method, titanium dioxide (TiO₂) and zinc oxide (ZnO) by ball milling technique for multifunctional finish.

iv. To impart multifunctional finish on conventional pretreated and plasma pretreated fabrics of cotton, viscose and polyester using Pad-Dry-Cure method.

v. To assess the multifunctional finished fabric characteristics such as antimicrobial activity, UV protection, thermal resistance physical characteristics and presence of toxic substances.

vi. To develop a bio culture of *Lactobacillus acidophilus* and its influence on effluents from pretreatments and multifunctional finished fabric processes.

1.7 ORGANIZATION OF THE THESIS

The research methodology adopted in the present research work comprises of five phases such as raw materials, pretreatments of cotton, viscose and polyester fabrics, evaluation of pretreated fabrics, synthesis and characterization of nano-particles, application of nano-particles on cotton, viscose and polyester fabrics and assessment of multifunctional finished
fabric characteristics and influence of a bio culture \textit{Lactobacillus acidophilus} treatments on effluent.

The thesis is divided into eight chapters. Chapter 1 deals with introduction to conventional pretreatments, plasma pretreatments, multifunctional finish textiles, significance of Eco-friendly treatments, present research work, outcome of the research work, objectives of the research and organization of the thesis.

Chapter 2 confers an extensive literature survey collected from 227 research articles and discussed in the areas of health and environmental care, plasma technology, generation of plasma, role of plasma finish on textiles, functionalization of plasma treatments, characterization of plasma treated textiles, synthesis and characterization of nano particles, application of nano treatments, and multifunctional finish methodologies and evaluations.

Chapter 3 describes the materials and methods used for preparing the multifunctional finishes required for the study. Further, the chapter covers with materials, conventional and plasma pretreatments of cotton, viscose and polyester fabrics, evaluation of pretreated fabrics, synthesis and characterization of nano particles, application of nano particles on cotton, viscose and polyester conventional pretreated and plasma pretreated fabrics, assessment of multifunctional finished fabrics both conventional pretreated and plasma pretreated of cotton, viscose and polyester, development of a bio culture of \textit{Lactobacillus acidophilus} and influence of bio culture \textit{Lactobacillus acidophilus} treatments on effluent.

Chapter 4 discusses about the conventional pretreatment method of desizing, scouring and bleaching, plasma pretreatment using air and oxygen, evaluation of conventional pretreated and plasma pretreated fabrics such as wettability, wickability, surface modification study through optical
microscope, weight loss percentage, drape and air permeability. Finally the effect of plasma pretreatments was compared with conventional pretreated polyester, cotton and viscose fabrics.

Chapter 5 deals with the synthesis of Chitosan by ionic gelation technique and TiO₂ and ZnO by ball milling technique and characterization of nano particles size and shape using X-Ray Diffracractometry (XRD), Dynamic Light Scattering technique (DLS) and Transmission Electron Microscope (TEM) study.

Chapter 6 deals with application of nano particles on cotton, viscose and polyester of both conventional pretreated and plasma pretreated fabrics. Further it covers assessment of both conventional pretreated and plasma pretreated fabrics multifunctional finished fabric characteristics such as assessment of antimicrobial activity, UV Protection, thermal resistance, physical properties and presence of toxic substances.

Chapter 7 deals with development of Lactobacillus acidophilus culture, method adopted for biological treatments, influence of Lactobacillus acidophilus (organism) on the effluents. The characteristics such as BOD, COD, pH, turbidity and color before and after a bio-culture treatment of the effluent were compared with norms recommended by Central Pollution and Control Board (CPCB) INDIA.

Chapter 8 summarizes the various conclusions drawn for the research work. Further it covers the recommendation for future work.