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REVIEW OF LITERATURE

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2.1 Healthcare Textiles

Textiles have always played a central role in the evolution of human culture by being at the forefront of both technological and artistic development. The protective aspects of textiles have provided the ground for innovative developments. Textiles have such an important bearing on our daily lives that everyone needs to know something about them. From earlier times, people have used textiles of various types for covering, warmthness, personal adornment, and even to display personal wealth. Today, textiles are still used for these purposes and everyone is an ultimate consumer. The consumers are now increasingly aware of the hygienic life style, and there is necessity and expectation for a wide range of textile products finished with antimicrobial properties (Saranya and Bagyalakshmi, 2015).

"Wellness" is a trend in modern society, which opens up a range of new possibilities i.e textiles with antimicrobials. There are many different types of textiles used today in an attempt to either limit or prevent the transmission of hazardous microorganisms. These materials range from solitary layers of non-woven single use products to composites of woven and knitted multiple use products (Achwal,2003). Hygienic life style has acquired an important place in recent years. Hence there is a need to exhibit high degree of performance in terms of longevity, durability and antimicrobial properties of the fabric (Gopalakrishnan, 2006).

Although bacteria and fungi are normal components of the natural environment, they cause specific problems such as odour, staining, discolouration and deterioration of the fabric. In textile industries, there are many opportunities to improve and add value to products by incorporating novelty finishes (Sakagami, 1995).The key advantage of the antimicrobial textile finish or modification is to protect the wearer against biohazards, control of foul odour and improvement in the performance and aesthetic characteristics of fibre (Mucha et al, 2005).

Combination of textile and its application in medical sciences has resulted into a new field called medical textiles. New areas of application for medical textiles have been identified with the development of new fibres and manufacturing technologies for yarns and fabrics. Development in the field of textiles, either natural or man-made textiles, normally aimed at how they enhance comfort to the users. Development of medical textiles is really meant for converting the painful days of patients and surgeons into the comfortable days (Chinta et al, 2013).

2.1.1. Materials Used for Healthcare Textiles

Healthcare and medical textiles are a major growth area within the scope of technical textiles,which is defined as "Textile materials and products manufactured primarily for their technical performance and functional properties rather than their aesthetic or decoration characteristics". Technical textiles include, in addition to healthcare and medical textiles, aerospace, industrial, marine, military, safety and transport textiles and geo-textiles. Over the last few decades, there have been significant changes in the textile market, where traditional textile products, or the textile products produced primarily for their aesthetic or decoration properties (e.g.,apparel), account for an increasingly smaller portion, while technical textile products constitute an increasingly larger portion(Zhong, 2013).

The textile material in healthcare and medicine can be used mainly in three forms; Fibre form which is obtained naturally or artificially include fiber and yarn form cotton, wool, silk and artificial fibres include polyester, polypropylene. Yarn form includes staple yarn, twisted yarn and braided yarn.

Fibres used in medical textiles are classified as;

- Degradable fibres: The fibres which gets absorbed by the body within two to three months of implantation. Examples are cotton, viscose, chitin, collagen.

- Non-degradable fibres: The fibres which get degraded by the body in more than six months, generally these fibres are synthetic fibres. Examples are polyester, polypropylene, poly-tetra-fluroethylene.

- Re-absorbable fibres: The textile fibre which is completely biodegradable by the body and produce no harmful degraded product. Examples are polyglycolic acid, polylactic acid and polydioxanone (Junare and Vishwanath, 2017).

2.1.2. Types of Healthcare Textile Products

The variety of natural and man-made fibres available today, offer a wide selection to be used in clothing. Globally natural fibres contribute about 48% to the fibre basket with 38% from cotton (Sharma et al, 2015). Now-a-days, environmental issues are becoming the major factors during the selection of consumer goods. Renewable resources are gaining popularity among the people due to their positive effects on agriculture, environment and economy. Natural fibres being biodegradable are now considered as solemn option to synthetic fibres for use in various fields (Christy and Kavitha, 2014).

Non-implantable materials are used for external applications on the body and these materials may or may not have contact with skin. This includes wound care, bandaids, plasters, pressure garments, orthopaedic belts etc. Implantable materials are used in effecting repair to the body whether it is wound closure such as sutures or replacement surgery such as vascular grafts, artificial ligaments etc. Extra corporeal devices are extra corporally mounted devices used to support the function of vital organs, such as kidney, liver, lung, heart pacer etc. The extracorporeal devices are mechanical organs that are used for blood purification and include the artificial kidney i.e dialyser, the artificial liver,and the mechanical lung. The function and performance of these devices benefit from fibre and textile technology.Health care and hygiene products made of textile materials are an important area of the healthcare and hygiene sector. The range of products available for healthcare and hygiene is vast, but they are typically used either in the operating theatres or in the hospital wards for hygiene, care and safety of the staff and patients. They could be washable or disposable (Akter et al, 2014).

Wound healing is a dynamic and complex process which requires suitable environment to promote healing process. With the advancement in technology, more than 3000 products have been developed to treat different types of wounds by targeting various aspects of healing process.Local factors which includes hypothermia, pain, infection, radiation and tissue oxygen tension directly influence the characteristics of the wound where as systemic factors are the overall health or disease state of the individual that affect individual's ability to heal. In addition to these factors, poor nutrition, age and protein, vitamins and mineral deficiency canalso prolongs healing times. Based on the wound type, suitable dressing material must be used (Dhivya et al,2015).

Traditional wound dressing products including gauze, lint, plasters,bandaids (natural or synthetic) and cotton wool are dry and used as primary or secondary dressings for protecting the wound from contaminations. Gauze dressings made out of woven and non woven fibres of cotton, rayon, polyesters afford some sort of protection against infection (Boateng et al, 2008). Modern wound dressing have been developed to facilitate the function of the wound rather than just to cover it. These dressings are focused to keep the wound from dehydration and promote healing. Based on the cause and type of wound, numerous products are available in the market (Pandey et al, 2009).

2.1.3. Structure of Textile Materials

Textile is defined as "a general term for fibres, yarn intermediates, yarns, fabrics, and products that retain all the strength, flexibility, and other typical properties of the original fibre or filaments". In other words, textiles are made from the basic elements of fibres. However, to develop healthcare and medical textiles, materials other than textiles have to be included. The medical textile industries have diversified with new materials and innovative designs. Recently, application of textiles has been utilised beyond the usual wound care, incontinence pads, plasters etc. This makes it necessary, at the very beginning to list related materials and structures that comprise healthcare and medical textiles. Fibres composed of natural or synthetic polymers are spun into yarns, followed by being weaving or knitting into fabrics and further fabricated into specific products, including apparel. Beyond that, there is a variety of structures that are more often used in technical end uses: laminated fabrics can be made by bonding a fabrics with a polymeric films or foams by using an adhesive or by the adhesive properties of one of the layers. By controlling the pore sizes in micro-porous films, waterproof but breathable i.e., water vapour permeable fabrics can be obtained. Such fabrics are desirable in applications like surgical gowns, where both protection and comfort are essential (Jewel,2005).

The development and introduction of new structures of textiles have made revolutions first in our mind and then in the market. Natural fibres are derived from plants, animals, or minerals, to be respectively referred to as cellulosic fibres, protein fibres, and inorganic fibres. They vary in macroscopic size, length and shape (FTC, 1958). Man-made fibres are regenerated from natural resources or synthesized from small, organic molecules. They are generally known as regenerated fibers or synthesized fibres (Zhong, 2013).

Cotton is the backbone of the world's textile trade. It is also known as “King of fibre” and “White gold”. It is said that cotton is the fibre, which has no season it is equally good for all seasons. Due to its unique fibre structures, it can absorb water up to 2.7 times of its own weight. India is the second largest producer of cotton after china. Cotton is grown on 3% of the total cultivated area in the world (Bhat and Choudhari, 2012).Cotton is the world's most used fibre. It is cool, soft, comfortable and the principal clothing fibre of the world. Its production is one of the major factors in the world's prosperity and economic stability. It forms the background of the world textile (Kesarwanin and Archana, 2009). The unique mechanical properties of cotton make them an ideal textile fibre (Smith and Cothren, 1999).

Cotton cellulose accounts for 88 to 98 percent of the dry weight of raw cotton. Non-cellulosic constituents include wax, protein, salts of inorganic and organic acids, pectic acid and sugars. The presence of these substances affects the properties of the fibre in relation to mechanical processing, as well as the properties of the finished goods. Their removal by finishing operations is usually necessary to obtain the most satisfactory end-use products (Jones, 1962). The quality of the cotton is measured by the length and brightness of the fibre,which depends on the species, the quality of the seeds, nature of soil, the mode of cultivation and climatic conditions (Dantyagi, 2004). All fibre used in medical applications must be non-toxic, non-allergenic, and non-carcinogenic and be able to be sterilized without imparting any change in the physical or chemical characteristics. Cotton is one of the commonly used natural fibres in vast industries (Horrocks and Anand, 1997).

2.1.4. Advantage of Healthcare Textiles

Many textile materials used in traditional applications in healthcare are still found. However,recent development in the advanced healthcare has led to the development of new materials through crosscutting research approaches in the field of textiles, polymer, biomedical, pharmaceutical and medical sciences. (Chinta et al, 2013).

Antimicrobial finishing of textiles has emerged as an important market segment comprising consumer, and technical products for healthcare and hygiene control. Nosocomial infections in hospitals, and surface contamination involving microorganisms indicated the significance of antimicrobial finishing. The antimicrobial finished textiles reduce the growth and transmission of microorganisms (Uddin, 2014).

The primary function of wound dressing is to protect the wound site from contamination and further injuries.The use of standards and quality evaluation techniques to characterise the surgical or wound dressings for product will determine its acceptability and commercial success, Well-designed laboratory tests can provide a useful performance indicator, particularly in comparative terms (Chellamani et al, 2014).

2.2. Microbes

The total mass of all microbes living on earth is approximately 25-fold the mass of all animal, (Gupta and Bhaumik, 2007). Mold, mildew, fungi and bacteria are (microorganism) part of our everyday lives. There are both good and bad types of microorganisms. Thousands of species of microorganisms are found everywhere in the environment and on our body. Understanding microorganisms, with reference to their type, origin and medium of culture provide basis to control the negative effects. This control capability, with the right technology, can provide a valuable feature on a wide range of textiles (Gopalakrishnan, 2006).

2.2.1 Types of Microbes

Microorganisms or microbes are microscopic organisms that exist as unicellular, multicellular, or cell clusters. Microorganims are wide spread in nature and are beneficial to life, but some can cause serious harm. They can be divided into six major types: bacteria, archaea, fungi, protozoa, algae, and viruses (Joshi et al, 2000).

Bacteria are unicellular organisms. Most bacteria have a peptidoglycan cell wall. According to the way their cell wall structure stains, bacteria can be classified as either Gram-positive or Gram-negative when using the Gram staining. Bacteria in our body are medically seen as foreign “invaders,” and thus would be a concern due to their potential to cause infection and other problems. In line with this, research on microbiology was mainly focused on how to kill bacteria with disinfectants and antibiotics. However, over the last few years, we have begun to appreciate the symbiotic relationship we have with the microorganisms co-habiting our bodies. While some bacteria can cause disease, others play beneficial roles in human health (Daniel et al, 2016).

Bacteria use decaying life forms as a source of energy are called saprophytes. Most fungi are multicellular and their cell wall is composed of chitin. Fungi is reproduced by releasing the spores. Viruses are noncellular entities that consist of a nucleic acid core (DNA or RNA) surrounded by a protein coat. Although viruses are classified as microorganisms, they are not considered as living organisms. Viruses cannot reproduce outside a host cell and cannot metabolize on their own. Viruses often infest prokaryotic and eukaryotic cells causing diseases. Since the parasitic helminths are of clinical importance, they are often discussed along with the other groups of microbes (Badr and Arafat, 2016).

2.2.1.1 *Staphylococcus saprophyticus*

Staphylococcus saprophyticus is the leading Gram-positive aetiological agent of Urinary Tract Infection (UTI). *Staphylococcus saprophyticus*shares many clinical features of urinary tract infection caused by *Escherichia coli*, but differs in pathogenesis, seasonal variation, and geographic distribution. The gastro intestinal tract is the major reservoir of *Staphylococcus saprophyticus*. In an early study (Latham et al,1983), it is noted that rectal, vaginal, and urethral colonization of *Staphylococcus saprophyticus*was associated with UTI caused by this organism. The virulence factors of *Staphylococcus saprophyticus* include adherence to urothelial cells by means of a surface-associated protein, lipoteichoic acid; a hemagglutinin that binds to fibronectin, a hemolysin; and production of extra cellular slime (Gatermann and Heesemann, 1986).

The percentage of antibiotic resistant *staphylococci* in large hospitals through out the world has increased steadily so that now nearly three-fourths of all strains are resistant. These resistant bacteria are found not only in superlative lesions, but also in the noses and on the skin of patients and attendants. The *staphylococcus* was the most common pathogen in surgical sepsis in the pre-antibiotic era, not only in wounds of trauma but in elective surgery as well (Howe, 1957).

2.2.1.2 *Aeromonas hydrophila*

The genus *Aeromonas* belongs to the family *Aeromonadaceae* within the Gamma-positive bacteria and also comprises of Gram-negative, non spore-forming, motile *bacilli* or *coccobacilli* with rounded ends which measure 1-3.5 µm in diameter. They are facultative, anaerobic, oxidase and catalase positive, able to reduce nitrate to nitrite, glucose-fermenting and are generally resistant to the vibriostatic agent. They grow optimally within a temperature range between 22 and 35°C, but growth occurs in a temperature range from 0 to 45°C for some species (Igbinosa et al, 2012). They tolerate a pH range from 4.5 to 9.0, but the optimum pH range is from 5.5 to 9.0 (Isonhood and Drake, 2002). They are also associated with sepsis and wounds, and with eye, respiratory tract, and other systemic infections and most of them are recognized as human and animal pathogens. (Janda and Duffey, 1988; Janda and Abbott, 1996 and Nichols et al, 1996).

However, there are pathogenic as well as non-pathogenic strains belonging to these groups.Members of the genus *Aeromonas* have been related with a wide variety of illnesses in humans,most common pathogenic manifestation of *Aeromonas* in humans is Bacteraemia which means the presence of bacteria in the blood displaying symptoms such as fever and chills. The bacteria are distributed universally in the surface water and soil and humans may obtain infections through open wounds resulting in serious or fatal debilitating outcomes, such as amputations. *Aeromonas* wounds fall into three categories, listed in order of increasing severity of damage caused: cellulitis, myonecrosis, and ecthyma gangrenosum (Janda and Abbott, 2010).

2.2.1.3 *Escherichia coli*

The *Escherichia coli* bacterium is a gram-negative rod of about 1.1–1.5 µm x 2.0 – 6.0 µm in size. It grows under aerobic and anaerobic conditions because it possesses two different redox systems (menaquinone and ubiquinone) which enable it to derive energy from catabolic metabolism under both aerobic and anaerobic conditions. Under optimal growing conditions, the rate of cell division of the *Escherichia coli* bacteria is very fast and the number of bacterial cells can double every 20 minutes. However, the circumstances that are ideal for this population dynamics are not achieved in the bacteria‘s normal environment. Pathogenic *Escherichia coli* variants are characterised by the presence of various virulence factors, such as various toxins, particularly in secretion systems (Kaper et al, 2004).

Escherichia coli could pose a huge burden on the individuals' as well as the state's economy. Hence, there is a need for continued surveillance of resistant strains and proper selection and rational use of antimicrobes for treating surgical wound infections in the hospital before this problem escalates into epidemic proportions (Yadav et al, 2012).

2.2.1.4 Pseudomonas aeruginosa

Pseudomonas aeruginosa is a Gram negative, aerobic, rod shaped bacterium with unipolar motility (Ryan and Ray, 2004). It is a common bacterium which can cause disease in animals and humans, found in soil, water, and mostly on man-made environments throughout the world. It thrives not only in normal atmospheres, but also with little oxygen, and has thus colonized in many natural and artificial environments. Because it thrives on moist surfaces, this bacterium is also found on medical equipments including catheters, causing cross infections in hospitals and clinics. It uses a wide range of organic material for food; in animals the versatility enables the organism to infect damaged tissues or people with reduced immunity (Balcht and Smith,1994). Occasionally, *Pseudomonas aeruginosa* can colonize human body sites, with a preference for moist areas, such as the perineum, axilla, ear, nasal mucosa and throat; as well as stools. The prevalence of colonization by *Pseudomonas aeruginosa* in healthy subjects is usually low, but following hospitalization, higher colonization rates can be encountered, especially amongst subjects treated with broad-spectrum antimicrobial agents. Colonization is common gastrointestinal tract of patients receiving anticancer chemotherapy, in the respiratory tract of mechanically ventilated patients, and on the burnt skin of patients (Morrison and Wenzel, 1984; Pollack, 2000).

Studies have shown that such wound infections are universal and that the bacteria types present vary with geographical locations. *Pseudomonas aeruginosa* are opportunistic pathogens and are responsible for a wide range of infections. They are common precipitants of sepsis by virtue of the inflammatory response activated by endotoxins present in the Gram-negative cell wall (Yadav et al, 2012). *Pseudomonas aeruginosa* are hard to treat because this bacterium shows intrinsic and acquired resistance to different antimicrobial compounds (Serrano et al,2017).

2.2.1.5 *Candida albicans*

The relative proportions of organisms causing nosocomial bloodstream infections have changed over the last decade, with *Candida* species now firmly established as one of the most frequent agents. *Candidemia* not only is associated with a high mortality but also extends the length of the hospital stay and increases the costs of medical care (Rauha et al, 2000).

Candida albicans is the most frequently encountered pathogenic human fungal species and commonly colonizes host mucosal and moist skin surfaces . However, under conditions of immune dysfunction, this opportunistic microbe can rapidly transit from commensal to pathogen, causing an array of infections ranging from localized mucosal to severe systemic infections with high morbidity and mortality rates. Oral candidiasis or thrush is the most common opportunistic infection in HIV-infected population with 80–90% of these individuals developing oropharyngeal candidiasis during the course of their illness. In addition, recent longitudinal studies have shown that in the ageing population, *Candida albicans* is even more frequently encountered in the oral cavity, especially in edentulous elderly populations .The success of this species as an opportunistic pathogen which is the result of its repertoire of virulence factors, including the ability to switch between a yeast and hyphal morphology, a property crucial to its pathogenicity (Schlecht et al,2015).An important group of the skin pathogens are the fungi, among which dermatophytes and *Candida spp*. are prominent (Martinez et al, 2012).

2.2.2. Human Skin and Skin Wound

The skin is the human body’s largest organ, colonized by a diverse million of microorganisms, most of which are harmless or even beneficial to their host. Colonization is driven by the ecology of the skin surface, which is highly variable depending on topographical location, endogenous host factors and exogenous environmental factors. The cutaneous innate and adaptive immune responses can modulate the skin microbiota, but the microbiota also functions in educating the immune system. The development of molecular methods to identify microorganisms has led to an emerging view of the resident skin bacteria as highly diverse and variable. An enhanced understanding of the skin microbiome is necessary to gain insight into microbial involvement in human skin disorders and to enable novel promicrobial and antimicrobial therapeutic approaches for their treatment (Elizabeth et al,2011).

Acute wounds are caused by external damage to intact skin and include surgical wounds, bites, burns, minor cuts and abrasions, and more severe traumatic wounds such as lacerations and those caused by crush or gunshot injuries. Irrespective of the nature of the cutaneous injury, acute wounds are expected to heal within a predictable time frame.The treatment required to facilitate, healing will vary according to the type, site, and depth of a wound. The primary closure of a clean, surgical wound would be expected to require minimal intervention to enable healing to progress naturally and quickly (Bowler et al, 2001).

Wound healing happens in three stages. The first is improvement in general resistance and support mechanisms that could be obtained from rejuvenative, adaptogenic, palliative, antioxidant, cleansing, detoxifying, buffering, and lubricous activities. Second, stimulating the repair and regenerative mechanisms to prolong cell life, cell migration and cell binding, remove skin blemishes, and improve tensile strength or elasticity of the skin, improve moisture-holding capacity of skin. Third, therapeutic and nutritional activities including anti-inflammatory, antiseptic, and antimicrobial, protein and collagen synthesis and increased stability of biomembranes. The polyphenols present in the polyherbal extract are capable of promoting rapid epithelialisation of wounds and also the antioxidant and antimicrobial property of the polyherbal extract promotes the healing faster when compared to the individual herb (Narendhirakannan et al, 2012).

2.2.3 Factors Influencing the Growth of Microbes in Fabrics

Textiles made from natural fibres are generally more susceptible to biodeterioration than the synthetic fibres. This is because their porous hydrophilic structure retains water, oxygen and nutrients, providing perfect environment for microbial growth. Products such as starch, protein derivatives, fats and oils used in finishing of textiles can also promote microbial growth. Microorganisms may attack the entire substrate, that is the textiles fibres or may attack only one components of the substrate, such as plasticizer contained there in, or grow on dirt that has accumulated on the surface of a product (Balouiri et al,2016).

The vast majority of antimicrobials work by leaching or moving from the surface on which they are applied. This is the mechanism used by leaching antimicrobials to poison a microorganism. Besides affecting durability and useful life, leaching technologies have potential to cause a variety of other problems when used in garments (Uddhav et al,2016).

An anti-microbial with a completely different mode of action than the leaching technologies is a molecularly bonded unconventional technology. In this method the antimicrobial agent remain affixed to the substrate-killing microorganisms as they contact the surface to which it is applied. It physically stabs and electrocutes the microorganisms on contact to kill it. Effective levels of this technology do not leach or diminish over time. A variety of antimicrobial finishes have been developed for application to textiles (Matuskova et al,2014).

Cotton textiles in close proximity to the human body provide an ideal living environment for yeast, bacteria and fungi (Payne and Kudner, 1996). Dust, soil and textiles are the sources of nutrients for microorganisms. Perspiration contains amino acids, salts, carboxylic acids and other essential nutrients. Oils or dead skin cells secreted from the skin are also a possible source of carbon. Cotton consists of hydrophilic cellulose and has a high affinity for water. Perspiring human beings have been estimated to give off an average of 0.1liter/hour of water, which accumulated in clothing and bedding. A humid environment will provide enough water to support fungal growth, whereas bacteria need more water and require dampness. Most bacteria and fungi will grow at an ambient temperature of 10-20°C. Certain bacteria prefer slightly warmer conditions of bedding or clothing in close proximity to the skin (McNeil, 1964).

The synthetic antimicrobial agents and metal oxides are very effective against a range of microbes, but it was also associated with side effects and could not be used for medical application. Hence, there is a great demand for eco-friendly antimicrobial finishes on textiles. The herbal extract finished fabrics were considered as significant for the medical textile application (Dyke,2003).

Even mild surface growth can make a fabric look unattractive by the appearance of unwanted pigmentation. Heavy infestation which results in rotting and breakdown of the fibres and subsequent physical changes such as loss of strength or flexibility may cause the fabric to fail in service. The material is attacked chemically by the action of extracellular enzymes produced by the microorganisms for the purpose of obtaining food. Plant fibres such as cotton, flax, jute and hemp are very susceptible to attack by cellulolytic fungi. The complete degradation of cellulose can be effected by enzymes, produced by the fungi known as cellulases. Even though microbes are useful in many ways such as brewing, baking and biotechnology, they can also be harmful to both textile industries and human (Adnan et al, 2010).

2.3. Use of Herbs in Textile Finishing

Plants are the integral part of nature. Nature reflects the creative power of living god. Plants have an almost endless variety of uses to human beings. India is the birth place of indigenous medicine such as siddha, ayurveda and unani, (Suresh et al, 2012). In early days, plant use was restricted to food, medicine and shelter but with change in course of time, man started exploring the potentiality of plants for a number of useful purposes. Hence the dependency on plants increased both directly and indirectly (Ali et al., 2003 and Ali and Qaiser, 2009).

Abutilon indicum is a hairy shrub with golden flowers. Various part of the *Abutilon indicum* have been used in treating various human ailments. The roots are used in treating uterine heamorrhagic discharges. Similarly, seeds are used in the treatment of bronchitis, gonorrhea and piles. Leaves are useful in treating toothache,lumbago, piles and all kind of inflammation. Bark is used as anthelmentic, diueric and alexeteric (Anyensu et al, 1978).

Cassia auriculata commonly known as tanner's cassia, also known as “avaram” in Tamil language is a shrub belongs to the *Caesalpinaceae* family. The shrub is especially famous for its attractive yellow flowers which are used in the treatment of skin disorders and body odour. It is widely used in traditional medicine for rheumatism, conjunctivitis and diabetes. It has many medicinal properties. Its bark is used as an astringent, leaves and fruits are used as anthelmintic, seeds are used to treat eye troubles and root are used in skin diseases. It is also used for the treatment of ulcers, leprosy and liver disease. The anti-diabetic, hypolipidemic, antioxidant and hepato protective effect of *Cassia auriculata* have been reported. It was also observed that flower and leaf extract of *Cassia auriculata* shown to have antipyretic activity (Maneemegalai and Naveen, 2010).

Cassia fistula is a wild tree and mainly grows on road side throughout India. It is a deciduous medium sized tree growing upto 20 - 40 meters in height. The bark of this plant is rough, grayish and the leaves are compound. It has showy racemes, up to 40cm long with bright yellow fragrant flowers. Fruits of these plants are long and have cylindrical pod. The seeds of this plant are broadly ovate and horizontally arranged in the sweetish pulps, which is having medicinally important value. *Cassia fistula* is also known as Golden shower which was widely used by tribal people to treat various ailment including ringworms and other fungal skin infection. It is used by Malayali tribe in India to treat nasal infection. It is useful against skin diseases, liver troubles, tuberculous glands and in the treatment of rheumatism, hematemesis, pruritus, leucoderma and diabetes. The effects of plant extract on bacteria have been studied by a very large number of researchers in different parts of the world. Plant parts are rich in a wide variety of secondary metabolites such as tannins, terpenoids, alkaloids, flavanoids, glycosides etc. which have been found under *in vitro* studies to have antimicrobial properties (Satpute et al, 2015).

Tridax procumbenz is common herb found in India. It is denoted by different names; in English as Mexican Daisy, in ayurvedic as Jayanti, in siddha and Tamil as Vettukkaaya-thalai and in folk as Akala kohadi. The whole plant was reported to have healing power, treat various ailments and such as bronchial catarrh, wound, dysentery, diarrhea and prevent hair loss. Pharmacological studies have shown that *Tridax procumbenz* possess properties like anti inflammatory, hepato-protective, wound healing, immune modulatory, antimicrobial, antiseptic, hypotensive and bradycardiac effects. These components show the presence of the phytochemical and antimicrobial effect of *Tridax procumbenz* (Christudas et al, 2012). There are many natural plant products, which show antimicrobial properties. Extracts from roots, stems, leaves, flowers, fruits and seeds of diverse species of plants exhibit antimicrobial properties. These antimicrobial agents can be used as textile finishing agents (Thilagavati and Krishnabala, 2007).

2.3.1 Plant Authentication

Medicinal plants cover a wide range of plant taxanomy and closely related species. There is an increasing international market for medicinal plants, which are used both for herbal medicine and for pharmaceutical products. Accurate and rapid authentication of plants and their respective adulterants is difficult to achieve at the scale of international trade in medicinal plants. The natural medicines are much safer than synthetic drugs, have gained popularity in recent years, leading to a tremendous growth of phyto-pharmaceutical usage. However, herbal medicines can be potentially toxic to human health and sometimes may cause unknown effects. The recent investigations have revealed that many plants used in traditional and folk medicine are potentially toxic and mutagenic (Matthews et al., 2003)

Due to the complex nature and inherent variability of the chemical constituents of plant-based drugs, it is difficult to establish quality control parameters.Due to the popularity of herbal drugs globally, their adulteration or substantiation aspects are gaining importance at the commercial level. Pharmaceutical companies are procuring materials from traders, who are getting these materials from untrained persons from rural or forest areas. This has given rise to wide-spread adulteration or substitution, leading topoor quality of herbal formulations.Misidentification of herbs can be non-intentional orintentional. Adulteration can occur due to ignorance or intentional substitution with cheaper plant material and may cause damage to human body. Therefore,authentication at various stages, from the harvesting of the plant material to the final product, is a need of the hour.The general approaches to herb identification are dependent on morphological (Khan et al, 2011).

2.3.2. Textile Material Used for Wound Dressing

The inherent properties of the textile fibres provide room for the growth of microorganisms. Beside the structures of the substrates, the chemical processes may induce the growth of microbes. Humid and warm environments still aggravate the problem. Infection by microbes cause cross infection by pathogen and developments of odour where the fabric is worn next to skin. In addition, the staining and loss of the performance properties of textile substrates are the results of microbial attack. Garments of health care workers are an important aspect that can easily become contaminated (Vaneechoutte et al, 2013).

The textile materials play an important and crucial role in designing appropriate structures for the healthcare and medical industries. There has been a sharp increase in the use of medical textile products not only in the hospital, hygiene and healthcare sectors but also in hotels, homes and other environments where hygiene is required. With the increasing threat from new strains of bacteria and viruses and the growing problems such as Deep Vein Thrombosis (DVT) and leg ulcer, it is vital that newer or enhanced medical devices should be developed to cope up the situation. The demand for medical textile products is enormous both in developed and developing countries (Rajendran and Anand, 2006).

Wound management has recently become more complex because of more insights into wound healing and increasing need to manage complex wound healing in order to obtain both functional and cosmetics results. A wound can be defined as a cut or breakin the continuity of any tissues, caused by injury or operation. Modern dressing are designed to facilitate the function of wound healing rather than just to cover. Wound healing is the body's natural process of regenerating dermal and epidermal tissues which involves a higher orchestered sequence of complex events, resulting in the restoration of the wounded tissue to the normal or quasi-normal state found prior to wound repair (Gupta et al, 2010)

In general, wound dressing pocesses a moist wound environment. This is the key factor to debridement and is obtained by using occlusive or semi-occlusive absorbent dressings.There are a variety of methods that can be used to dress an exuding wound and keep a moist environment. So the healing of a wound depends not only upon medication but also upon the use of proper dressing techniques and suitable dressing materials. The ideal characteristics of a wound dressing include the following aspects;

- Impermeability to water and bacteria
- Freedom from particulate matter
- Thermal insulation
- Absorption and retention of exudates
- Prevention of trauma on removal
- Removal of toxic substances
- Prevention of dehydration
- Allowing for gaseous exchange
- Pain relief and comfort

Modern dressings are required to create the optimal environment for wound healing. They should be easy to apply and can reduce the nursing time with fewer dressing changes and pains of removal with less adherence between wound surface and dressing layer (Yadie and Hu,2015).

Antimicrobial finish in textiles prevent the growth of bacteria, protect health and prevent diseases. Clothing and textile materials are not only the carriers of microorganisms such as pathogenic bacteria, odour generating bacteria and mould fungi, but also good media for the growth of the microorganisms. Among various functional ability, the antimicrobial property of fabric is being considered to be important with garments, which are in direct contact with human body (Jayapriya et al,2014).

2.3.3. Phytochemical Screening

Phytochemicals are natural bioactive compounds found in plants and are divided into two groups; primary and secondary compounds. These compounds are classified according to their functions in plant metabolism. Amino acids, sugars, proteins and chlorophyll are known as primary compounds while secondary compounds consist of alkaloids, terpenoids, phenolic compounds and many more (Krishnaiah et al, 2009). There are several known phytochemicals and are non-nutritive that have protective or disease preventive properties. Plant produces these chemicals to protect itself, and they can also protect humans against diseases (Okigbo et al, 2008).

Some of the well-known phytochemicals are lycopene in tomatoes, isoflavones in soy and flavonoids in fruits (Okwu, 2005). They are not essential nutrients and are not required by the human body for sustaining life. The different phytochemicals such as Volatile oils, Alkaloids, Glycosides, Flavanoids, Tannins and Polyphenolic compounds, Carbohydrates, Proteins, Fixed oils and Fats, Terpenoids (Cowan, 1999), found in medicinal plant parts are precursors for the synthesis of useful medicines (Sofowora,1993).

Phenols are a member of a group of aromatic chemical compounds with weakly acidic properties and are characterized by a hydroxyl (OH) group attached directly to an aromatic ring. The simplest of phenols 32 derived from benzene is also known as phenol and has the chemical formula C_6H_6OH. The presence of phenols is considered to be potentially toxic to the growth and development of pathogens (Okwu and Okwu, 2004).

Phenolic compounds may reduce risks of many infectious diseases. The use of traditional medicine mainly derived from plant sources has become an attractive segment in the management of many lifestyle diseases. Plants produce phenolic compounds as secondary metabolites involved in diverse processessuch as growth, lignification, pigmentation, pollination, and resistance against pathogens, predators, and environmental stresses (Kyselova, 2011).Polyphenols are secondary metabolites of plants and are generally involved in defense against ultraviolet radiation or aggression by pathogens (Pandey et al, 2009).

Flavonoids are 15-carbon compounds generally distributed throughout the plant kingdom. They are known to be synthesized by plants in response to microbial infection and have been found *in vitro* to be effective against a wide array of microorganisms (Harborne, 1973). This group has a common basic structure consisting of two aromatic rings bound together by three carbon atoms that form an oxygenated heterocycle. More than 4,000 varieties of flavonoids have been identified, many of which are responsible for the attractive colours of flowers, fruits and leaves. Based on the variation in the type of heterocycle involved, flavanoids may be divided into six subclasses. Flavanoids are potent water-soluble super antioxidants and free radical scavengers which prevent oxidative cell damage (Kyselova, 2011). They have strong anti-cancer activity and protect against all stages of carcinogens. Flavanoids are well known to reduce the risk of heart diseases in patients (Urquiaga and Leighton, 2000).

Alkaloids rank among the most efficient and therapeutically significant plant substances. Some 5,500 alkaloids are known and they comprise the largest single class of secondary plant substances which contain one or more Nitrogen atoms, usually in combination as part of a cyclic structure. For thousands of years, indigenous groups around the world discovered, through self-experimentation with locally available plant extracts, that they could provide materials for hunting prey, culinary enhancement, amelioration from disease, relief of pain, and healing for 200-year period, many alkaloids became critical components of the global pharmaceutical armamentarium, and tremendous healing has resulted from their clinical application (Amirkia and Heinrich, 2014).

Quinones have aromatic rings with two or more ketone substitutions. The natural quinone pigments range in colour from pale yellow to almost black and there are over 450 known structures of quinones. These compounds are responsible for the browning reaction in cut or damaged fruits and vegetables and are an intermediate in the melanin synthesis pathway in human skin.Quinones are of interest from a medical and toxicological perspective due to their unique reactivity and high prevalence in the environment (Madeo et al, 2013).

Tannin is a general descriptive name for a group of polymeric or phenolic substances capable of tanning leather or precipitating gelatin from a solution, and astringency (Harborne, 1973). They are divided into two groups, namely hydrolyzed and condensed tannins. Many physiological activities such as stimulation of phagocytic cells and wide range of anti-infective action have been assigned to tannins (Okwu and Okwu, 2004).

Terpenoid essential oils are the main compounds found in the volatile steam distillation fraction responsible for the characteristic scent, odour or smell found in many plants. Some essential oils possess medicating properties and are used in the pharmaceutical industry (Krishnaiah et al,2009).

Herbs and spices produce these bioactive compounds which react with other organisms in the environment to exhibit antioxidant activity and inhibit bacterial and fungal growth. The majority of the active compounds are phenols, vitamin C, vitamin E, tannins and carotenes (Aqil et al, 2006; Thitilertdecha et al,2008). Sources of natural antioxidants are primarily plant phenol such as flavanoid that exhibit antioxidant, antimicrobial, anti- carcinogenicity and other biological active compounds (Demiray et al, 2009; Mohan et al, 2008; Sengul et al,2009). The substances that inhibit the growth of pathogens and are least toxic to host cells are considered good medium for development of new antimicrobials. The extraction process of phytochemicals in enormous amount by rapid and accurate methods of screening plants for antimicrobial product development (Banso and Olutimayin, 2001) are recently emerging procedures. Many phytochemicals originally rare in occurrence are of almost universal distribution in the plant kingdom contain physiologically active principles that over the years have been exploited in the traditional system of medicine for the treatment of various diseases (Adebajo et al, 1983). There is a reasonable likelihood that medicinal plants with a long history of human use will ultimately yield novel drug prototypes (Eshrat and Hussain, 2002).

Phytochemical investigation of crude plant extracts is very important with regard to their potential pharmacological effects. With the advent of separation techniques and instrumental analysis, it is possible to perform physical evaluation of a crude extracts, which could be both qualitative and quantitative in nature (Grover et al, 2014).

2.4. Antimicrobial Finishing on Textiles

Functional finishes of textile materials can be defined as a process of providing functional properties to textile and clothing materials. Functional properties can be obtained either by:

- The fibre itself (characteristics of the polymer or additives before fibre spinning)
- Yarn, fabric or material construction (for instance, with different fibres or different layers)
- Textile finishing.

In many cases, the functional properties involve a surface modification, which can be obtained by means of chemical modification, by applying of a surface layer or by more ecological friendly treatments such as the use of enzymes or physical modification. Some of these properties were developed mainly for “protective” clothing but nowadays they are often present in functional textiles used for “normal” clothing. Many fabric producers are devoting more and more attention to try to put into the market products with new effects that can represent an important added value (De Almeida et al, 2005).

The finishing technologies employed in textile treatments are based on direct incorporation or reaction or binding of functional agents, UV blockers, water or oil repellents. Recently, these functional finishes are being developed and applied after appropriate modification to enhance activity on textiles (Gulrajani 2013).The functional finishes are classified into Stabilization, Durable press, and Soil release finish. Appearance retention, Abrasion resistance, Anti fibre-shedding, Carpet back coating, Crease-resistance, Comfort-related, Water-proof, Hydrophilic, Softening, Rot-proof, Biological-control, Antimicrobial, Aroma, Flame-retardant, Safety-related, Water-repellent and UV protection finish (Pan et al, 1997; Prayag 1994 and Samantha 1994).

2.4.1 The Need for Antimicrobial Textiles

An important and growing part of the textile industry consists of the medical and related healthcare and hygiene sectors. A hospital contains an enormous amount of textiles with the added threat of high volumes of traffic. Because of the continuous flow of people, particularly those with infectious diseases, both patients and employees are at risk of cross transmission of diseases and other health issues. The increasing rate of drug-resistant bacteria also heightens the importance of finding safe and durable antimicrobial finishes (Chinta, 2013)

The increasing demand for comfortable, aesthetic, durable, functional, and safe textile products dictates the development of new and contemporary techniques of processing and designing textiles (Tomsic et al, 2008). Bacteria and fungi are microbes that can grow on textiles.Garments of healthcare workers are a significant contributor to the spread of infections since they are easily contaminated. Moreover, it has been shown that bacteria can grow and survive on fabrics commonly used in healthcare environments for more than ninety days, contributing to the transmission of diseases (Appidi et al, 2008).

The word Antimicrobial is a general term for any product that kills or controls microbes (Srikanth, 2010).Antimicrobial finishing causes a fabric to inhibit the growth of microbes in textile materials (Kadolph and Sara, 2007).Antimicrobial finished fabrics are important not only in medical applications but also in terms of daily life usage (Erdem and Yurudu, 2008).Common problems in hospital and healthcare institution is microbial contamination of surface, including textile fabrics, which can lead to infection and cross infections. Hence, it is extremely important that protective clothing and hospital linens meet the demand of antimicrobial protection (Ristic'et al, 2011). Antimicrobial finishing of textiles has become extremely important in the production of protective, technical and decorative textile products. This has provided opportunities to expand the use of textile applications in medical, pharmaceutical, engineering, food and agricultural industries (Simoncic and Tomsic, 2010). The antimicrobial fabric gained significant momentum in the recent past due to its wide acceptance as surgical apparel, baby clothing and undergarment etc. There has been a growing need to impart antimicrobial and infection resistant properties into textiles such as inner clothing which comes into direct contact with human skin because the growth of microbes on it may negatively affect the wearers as well as the textile itself (Yi and Yoo, 2010).

Substances added to the fibre, such as natural-based auxiliaries, lubricants, antistats, and dirt provide a food source for microorganisms. Cotton is more likely to be attacked by fungi. Hence, healthcare is a serious business which is not only influenced medical professionals but also by the manufacturers of diversed medical products (Erkan and Merih, 2004).

Textile materials found different end uses in medical and healthcare application depending on the specific endurance performance (White et al, 2010). Irrespective of the end application of medical textiles,the material should possess basic bio active properties especially antimicrobial. Antimicrobial finishes are currently being used on disposable, nonwoven textiles for the medical industry. Currently, testing is being done to find safe and efficient antimicrobial finishes for woven fabrics (Harrison, 2002). Although people have used natural materials agents to combat diseases for millennia, only in the twentieth century, people started to produce antimicrobial compositions and add them to textile materials (Ramchandran et al, 2004).

2.4.2. Application of Antimicrobial Agents

To impart an antimicrobial ability to textiles, different approaches have been studied, being mainly divided into the impregnation of antimicrobial agents in the textile polymeric fibres or on the polymer surface. Regarding the antimicrobial agents, different types have been used, such as quaternary ammonium compounds, triclosan, metal salts, polybiguanides or even natural polymers. Any antimicrobial treatment performed on a textile, besides being efficient against microorganisms, must be non-toxic to the consumer and to the environment (Morais et al, 2016).

Antimicrobial properties are given to textile materials by various application methods such as by using spun in additives padding, spraying, polymer modification and microencapsulation (Landage, 2012).

Poly herbal extractions are known to express high effectiveness in a vast number of diseases. The therapeutic effect was easily obtained due to the presence of different phytochemicals and the effects are further potentiated when herbals are formulated together in poly herbal extractions. Till date, many researchers had conducted studies on poly herbal extracts to evaluate their effectiveness against various microorganisms (Srivastava et al, 2013).A survey study performed in UK noted that the main reason underlying in the use of medical herbs in polyherbal combination has produced effective and favourable outcomes of the treatment (Parasuraman, 2014). Poly herbal extractions are usually found to have wide therapeutic range of application. Most of them are effective even at a very low dose and safer at high dose. Thus, they have minimal risk to and maximum capacity to cure the disease ratio (Joshi, 2000).

2.4.3. Antimicrobial Finishing

The medical textile industries have always played an important role in the protective aspects of fabrics. The fabrics have long been recognized as a good support medium for the growth of microbes. A microbe on textile causes the unwanted effects to both the wearers and textile itself. The negative factor of the microbes has resulted in the development of innovative and hygienic finishes on textiles. The consumers are also demanding for the hygienic clothing which resulted in antimicrobial textile products. Antimicrobial finish prevents the growth of bacteria. Anti-microbial textiles with improved functionality find a variety of applications such as infection control and barrier control (Rajendran et al,2016).

2.4.4. Antimicrobial Finishing Methods

A major factor that has stimulated interest in antimicrobial finishes using textiles with improved functionality are a variety of health care applications. Antimicrobial finishes using natural source have been the current vogue that promotes natural and eco-friendly life style. Natural products can be selected for biological screening based on medicinal use of plants, because many infectious diseases are known to have been treated with herbal remedies throughout the history of mankind. Even today they continue to play a major role in primary early care as therapeutic remedies in many developing countries (Sumathi et al, 2015).

The antimicrobial agents can be applied to the textile substrates by pad and dry curing, exhaust, spray and foam techniques and coating. The substances can also be applied by directly adding into the fibre spinning dope. It is claimed that the commercial agents can be applied online during the dyeing and finishing operations. A variety of methods for enhancing the durability of the finish include:

- In-solubilisation of the active substances in or on the fibre.
- Treating the fibre with resin, cross-linking agents or condensates.
- Micro encapsulation of the antimicrobial agents with the fibre matrix.
- Fibre surface coating.
- Chemical alteration of the fibre by covalent bond formation.

Use of graft polymers, homo polymers and co-polymerization on the fibre (Gopalakrishnan, 2006).

2.4.4.1. Dip and Dry Method

The application of the finish is now extended to textiles used for outdoor, healthcare sector, sports and leisure. Herbal products seem to possess moderate efficacy with no or less toxicity and are less expensive as compared with synthetic drugs. In dip and drying method, the fabric is dipped into the bath containing herbal extract for half an hour at room temperature and then the garment is dried in the room temperature. This method is called as dip dry method (Sumithra and Raaja, 2014).

2.4.4.2. Exhaust Method

The exhaust method can be followed for coating fabric. The fabric can be mordanted prior to dyeing. The treated fabric was introduced to the plant extracted solution. Exhaustion application is also done in the jigger drum etc. Pad and exhaustion application are noted to be permanent application (Malik et al, 2011). Among various methods tested, exhaust coating was found to be more effective for antimicrobial finishing (Mahesh et al, 2011).

2.4.4.3. Microencapsulation

Microencapsulation may be defined as a micro packaging where in active core material is encapsulated in a polymer shell of limited permeability. It is a process in which tiny particles or droplets are surrounded by a coating to form small capsules, containing of many useful properties. In general, it is incorporated in food ingredients, enzymes, cells or other industrial based products too on a micro metric scale (Singh et al,2010). Moreover, it is the formation of a barrier to avoid chemical reactions and to enable the controlled release of the ingredients (Vilstrup, 2001).

The micro encapsulation technique was brought to use for the first time in 1940 by B.K. Green, for the production of No Carbon Paper - NCR (Alat and Sarat ,2005).The development of micro encapsulation products started in the 1950s with research into pressure–sensitive coatings for the manufacture of carbonless copying paper. The textile industry has, however, been slow to envisage applications for innovative micro encapsulation techniques. Micro encapsulation technologies offer many opportunities to improve the properties of textiles or to give them new functions (Dixit et al, 2006).

The objective of this technology is either to protect the active core material from the external environment until the right stimulus is encountered. In this technique, tiny droplets of benefit laden products such as moisturizers, fragrances, deodorizers,vitamins or repellents are packed in microscopically small capsules. It is vital that microencapsules are stable and durable (Ramalingam and Subramanian,2006).

The term microencapsulation is appropriate since, the particles are very small the particle sizes between 3-800 mm are known as microcapsules or microspheres (Achwal, 2003). The microcapsules are produced by depositing a thin layer of polymers on small solid liquid particles, or dispersion of solid in liquid. The core materials in the shell may be released by friction, pressure, diffusion through the polymer walls or by the diffusion of the polymer coating. (Jin et al, 2008)

The following are the characteristics of microcapsules (Saravanamuthu,2010).

- Microcapsules can be made in size ranging from few microns to thousand microns in diameter or even larger.
- Rate of release from microcapsules depends largely on the polymer wall structure, which in-turn is influenced by the conditions employed in the preparation
- Microcapsules show good thermal stability
- Higher is the ratio of loading fraction, the better is the efficiency.

The effect of microencapsulation is based on the selection of methods (Nelson,1991); such as core and wall of the polymer, wall thickness, wall permeability, particle size range and release mode of the contents etc. Manufacturing methods for microencapsulation can be categorised namely chemical encapsulation and mechanical encapsulation. In chemical encapsulation, the production and isolation of capsules is done in a liquid medium and involves chemical or phase change separation (Gomez and Genovez, 1997). The mechanical encapsulation technique is characterised by continuous operation, restricted diversity in size of the nucleus particle and there is a need for specialized mechanical equipment like spray dryer for the formation and isolation of capsules (Gomez and Baptista, 2001).

There are several other types of microencapsulation techniques such as the centrifugal extrusion process. Pan coating method and Air suspension coating (Aggarwal et al,1998), Spray-drying (Mauriello et al, 1999), Hot melt encapsulation (Erkan et al, 2004), Interfacial polymerization (Ziegler, 1951) and Coacervation technique (Lazko et al, 2004).

Microencapsulation was developed as a technique over sixty years ago, but it is only over the last decade that it has become common in textile dyeing, printing and finishing (Ian, 2003). It has attracted the interest of the dyeing, printing and finishing in textile wet processing method, for the last decade (Bairagadar and Katkar,2009). The microcapsules can introduce important new qualities to garment and fabrics, such as stability and controlled release of active compounds. Microencapsulation is a unique technique which facilitates the controlled release of the finishing as and when required and also enhance durability (Chinta et al, 2013).

2.4.4.4. Nanoencapsulation

Nano technology is defined as the art and science of manipulating matters at the Nano-scale to produce novel and unique materials and products (Butola and Mishra, 2007). It is also defined as the use of structures with at least one dimension of Nano-meter size for the manufacture of devices, materials, or systems with new or significantly enhanced properties due to their Nano-size. It offers great opportunities in all fields of science and technology, textiles, material science, electronics, mechanical, optics, energy, medicine, and aerospace (Cho et al, 2006).

The particle size below 1mm are known as Nano particles (Jin et al, 2010).In 1974, Nario Taniguchi coined the term nanotechnology for management of submicron particles.Nature has created the building blocks of life in nanoscale such as DNA, RNA, amino acids, sugars, and hormones (Weiss et al, 2006). Inspired by nature’s creation, man has engineered nanomaterial for the progress and well being of mankind. In 1959, Richard Feynman proposed the concept of nanostructures, The term “nano” refers to a magnitude of 10^{-9} m (Quintanilla et al,2010). Nanotechnology has emerged as one of the most promising scientific fields of research for decades. It deals with the production, processing, and application of materials with sizes less than 1,000 nm (Sanguansri and Augustin, 2006). Additionally, nanotechnology has also improved the solubility nature of water, heat stability, and oral bio-availability of bio-active compounds (Huang et al,2010, McClements et al, 2009 and Silva et al, 2012).

Nanotechnology has become an umbrella term for a wide range of processes and technologies that can manipulate or exploit materials with an organized structure at the nanometer scale (Maskayet al, 2006). The influence of Nano technology in the textile finishing area has brought up novel and innovative finishing application technique. It has the potential to generate novel bulk materials with new properties in textile coating and finishing (Schmitt and Benjamin 2008). Discrete nanoparticles or molecules of finishes can ideally be brought individually on selected spots of textile materials in a specific alignment and trajectory through electrostatic, thermodynamic, or other technical methodologies. Gulrajani, studied and concluded that nanotechnology is making significant involvement in the field of textiles. The five main areas are Nano colouration, Nano finishes, Nano fibre, Nano filteration, and Nano composites. The types of Nano finishes are given below:

- Hydrophobic Nano finishes
- Self-cleaning Nano finishes
- Photocatalytic self cleaning
- Antimicrobial finishes (Gulrajani, 2006).

The use of nanotechnology has increased rapidly in the textile industry and also nanotechnology has real commercial potential for the textile industry. The fact that conventional methods used in fabrics finishing never lead to long-lasting effects, and will lose their functions after laundering or wearing is one of the main reasons for increased use of nanotechnology in the textile industry. Nanotechnology can deliver high durability for fabrics, since Nano-particles have high surface energy and a large surface area-to-volume ratio, thus offering improved affinity for textiles and leading to an increase in durability of the function. Also, Nano-particles coating on fabrics will not affect their hand feel or breathability (Wong et al, 2006).

According to Yadav et al (2006), coating of nano-particles on the surface of fibre or fabrics is one of the methods to create high active surfaces with distinctive properties and also to attain high durability function for the fabrics. Nanotechnology offers new and enhanced means of imparting a range of functional performance in the fabrics. In fact, textile industry is one of the first manufacturing industry to come up with finished products that are improved through nanotechnology based functional finishing (Radhakrishnaiah, 2005).

Various properties imparted to textiles using nanotechnology include wrinkle resistance, water repellence, anti-bacterial effect, soil resistance, anti-static, UV-protection, flame retardation, improvement of dye ability, electrical conductivity, photo catalytic ability, photo oxidizing capability against biological and chemical species, UV absorption, self-decontaminating and blocking functions for both military and civilian health products and so on. Nano metal oxides such as Al_2O3_3,TiO_2, ZnO, SiO_2, MgO and ceramics are used in textile finishing for modifying the surface properties and imparting functional properties (Mahltig et al, 2006).

In recent years, more attention has been given to the potential application of innovative technologies, especially nanotechnology, the wave of future, as well as the application of smart nano-materials (Dastjerdi and Montazer,2010). Following are the applications of nano materials;

- Enhancing the performance and functional properties of the current textile products
- Developing smart and intelligent textiles with novel functions
- Satisfying the growing needs of textile users for hygienic clothing and active wear
- Allowing for great opportunities and options to develop innovative textile processes and products with high-value added

The roles of green chemistry in nanotechnology and nano science fields are very significant in the synthesis of diverse nano-materials and synthesis of silver nano-particles using herbal extracts.There is a growing need to develop environmental friendly processes for nano-particle synthesis that do not use toxic chemicals. Therefore, demand for an environmentally sustainable synthesis process has led to a few biomimetic approaches. Biomimetics refers to applying biological principles in materials formation. One of the fundamental processes in biomimetic synthesis involves bioreduction. Biological methods of nano-particle synthesis using microorganisms , enzymes , fungus , and plants or plant extracts have been suggested as possible eco-friendly alternatives to chemical and physical methods. Sometimes the synthesis of nano-particles using plants or parts of plants can prove advantageous over other biological processes by eliminating the elaborate processes of maintaining microbial cultures (Patel et al, 2014).

2.5. Antimicrobial Assessment

Antimicrobial nature of plant origin have enormous therapeutic potential and have been used since time immemorial (Sharma and Kumar,2008). The use of natural products and search for drugs derived from plant phytochemicals with good therapeutic properties is as ancient as human civilization and for a long period of time, mineral, plant and animal products were the main sources of medicines (De Pasquale,1984). The antimicrobial activity of plants has been attributed to the presence of some active constituents in the extracts.The millenarian use of these plants in folk medicine suggests that they represent an economic and safe alternative to treat infectious diseases (Chaman et al, 2013). Antimicrobial activity for herbal extracts has been deliberated in a variety of research works (Mohanasundari et al, 2007). Various test procedures have been used to evaluate the antimicrobial activity (Ramachandran et al, 2004).

2.5.1. Agar Well Diffusion Assay

The determination of antimicrobial susceptibility testing has been done using the agar well diffusion method to detect the presence of anti-bacterial or anti-fungal activities of the plant samples, A sterile swab was used to distribute bacterial and fungal culture evenly over the appropriate medium prepared. A standard caliper was used to measure the zone of inhibition. The antimicrobial activity was thus determined qualitatively by antimicrobial well diffusion method (Delahaye et al, 2009).

In Agar Well Diffusion Method, a cork borer is Sterilized by auto claving or by rinsing in alcohol followed by sterile water. Nutrient agar plate and Potato Dextrose Agar (PDA) plate is prepared. Aseptically punch (4mm) holes in the agar using a cork borer. Using a wax pencil, mark the underside of the Petri plate to label the wells. Cotton swabs were dipped into the broth culture of the test organisms and were gently squeezed against the inside of the tube to remove excess fluid. *Pseudomonas aeruginosa, Staphylococcus saprophyticus, Escherichia coli and Aeromonas hydrophila* were swabbed on Agar plates and *Candida albicans* was swabbed on PDA plates.

Swabbing was done in outside diameter of the plates. The plates were allowed to dry for about 5 minutes. Then the extracts of respective source (60 µl each) were added in 2 wells of petri plates. The ethanolic solvent was used as control whereas streptomycin and nystatin was used as reference for bacterial and fungal species respectively. The plates were incubated at 37ºC for 24 hrs. The zones of inhibition were measured in millimeters, using a ruler on the underside of the plate. The zone size was recorded (Chaman et al, 2013).

2.5.2. AATTC 147-2004

The Parallel Streak Method (AATCC 147- 2004) has filled a need for a relatively quick and easily executed qualitative method to determine antimicrobial activity of diffusible and non-diffusible antimicrobial agents on treated textile materials. In the “classical” Parallel Streak Method (for diffusable agents), the agar surface is inoculated making it easier to distinguish between the test organism and contaminant organisms which may be present on the unsterile specimen. The Parallel Streak Method has been proven effective over a number of years of use in providing evidence of antimicrobial activity against both Gram positive and Gram negative bacteria. A modified Parallel Streak Method can be used to evaluate the antimicrobial activity of non-diffusable agents. Thereby, a piece of textile is pressed onto an agar plate and the test bacteria are inoculated over the specimen by three or four parallel streaks (Binovation, 2010).

The utilization of antimicrobials dates back to ancient Egypt and these were used in the preservation of mummies. The initial antimicrobial textile material, in recent history, was developed by Lister in 1867.The recipe follows the procedure: from the inoculums of *Staphylococcus sapropyticus, Areomonas hydrophila, Pseudomonas aeroginosa* and *Candida albicans* using a 4 mm inoculating loop, one loopful of the inoculums was transferred to the surface of agar plates, making five parallel streaks on the central area of a plate without a refilling of loop. Test specimens (25×50) were cut with a rectangular die and placed onto inoculated petri plate transversely across the five inoculum streaks. Petri plates were incubated for 18-24 hr at 37^{o}C. Incubated plates were examined for interruption of growth along the streaks of inoculum beneath the specimen and for a clean zone of inhibition beyond its edge. Zone diameter along a streak on either side of the test specimen was measured using a scale (Mishra et al, 2016).

2.5.3. Wound Scratch Assay

Plants produce a diverse range of bioactive molecules and secondary metabolites that make them rich sources for different types of medicine. Many medicinal plant species present worldwide are used in the traditional medicine as the treatment for skin diseases caused by fungi and bacteria (Chanda et al, 2010). Presently scientists are keenly working on to evaluate the cure from plant origin. It is due to their high specific healing properties, healing nature, non-toxicity property and cost effectiveness, several plants and their products are used in folk medicine in treatment of wounds and have been reported to promote healing (Bagali et al, 2006).

Wound is a substantial trauma where the skin is torn, cut or punctured. By exposing to air, opportunistic and accidental microorganisms entering the site of the wound, which leads to wound contamination and finally development of infection. Dermal wound is a common pathologic condition and shall be defined as any break in the integrity of the skin. It is associated with high degree of morbidity due to blood loss, pain, edema, inflammation and loss of functionality. Cut wounds are majorly characterized by migration and proliferation of cells like fibroblastic cells, endothelial cells, deposition of connective tissue, angiogenesis, re-epithelization and finally reducing the size of the wound (Patil, 2010).

The wound healing assay is a powerful tool, which allows the researcher to study cell migration and cell interactions in an *in-vitro* laboratory setting. In some cases also single cell migration can be analyzed. Cell migration plays an important role in many complex physiological and pathological processes. This is also called a scratch assay because it is done by making a scratch on a cell monolayer and capturing images at regular intervals by time lapse microscope (Rodriguez et al, 2005).

Extent of wound healing was determined by the cells migrating into the denuded area. Healing of wounds involves the activity of a complex network of blood cells, cytokines and growth factors, resulting in re-establishment of normal skin tissue condition. The interest in evaluating the utility of plant extracts for wound healing process has been increased during the last decades. The significance of plant secondary metabolites as potential agents that interfered through various wound repair stages has been confirmed, both *in vitro* and *in vivo* (Ariano et al, 2005).

In addition fibroblasts also plays a critical role in generating immune response to a tissue injury. They are the important players in initiating inflammation response in the presence of invaded microorganisms. They induce chemokine synthesis through the presentation of receptors on their surface. Immune cells then respond and initiate a cascade of events to clear the invasive microorganisms (Smith et al, 1997). Receptors on the surface of fibroblasts also allow regulation of hematopoietic cells and provide a pathway for immune cells to regulate fibroblasts.The wound healing effect of the polyherbal extract was analyzed by *In vitro* Wound scratch assay in fibroblast cell lines. A fibroblast is a type of cell that synthesizes the extracellular matrix and collagen, the structural frame work (stroma) for animal tissues, and plays a critical role in wound healing.

Fibroblasts act as the most common cells of connective tissue in animals. Cell proliferation was monitored at different time points such as 1, 4, 12, 24 and 72 hours and images of the migrated cells were observed under the inverted phase contrast microscope (Liang et al, 2007).

The analyzed and exploration of coating herbal medicine in the wound dressing materials, various extracts of the medicinal substances from different plants sources were applied on the cotton fabric and their evaluation for antimicrobial property carried out. The results confirmed that extracts impart excellent antimicrobial property when applied alone as well as in polyherbal combination (Khurana et al,2016). The medicinal properties of the herbal extracts by wound scratch assay in the fibroblast cell lines concluded that this can be used as a promising scientific approach and platform to differentiate between plant extracts known for their wound healing and their anti-inflammatory properties (Fronza et al,2009). Further concluded, the polyherbal formula demonstrated high potential as therapeutic agent in wound healing (Gaspar et al, 2015).

2.5.4. Fourier Transform Infrared Spectroscopy (FTIR)

Spectroscopy has emerged as one of the major tools recently for biomedical applications and has made significant progress in the field of clinical evaluation. FTIR spectroscopic studies can lead to significant improvements both in the quantity and quality of research and their outcomes. FTIR mainly deals with non-aqueous samples (Movasaghi et al,2015).

Infrared Spectroscopy or FTIR is a standard method of analytical pharmacy and chemistry which provides the images vibration of the atoms in the compound. Therefore, it is also referred to as vibrational spectroscopy. IR (Infra Red) spectrum is obtained by passing infra red radiation through the sample and determining the fraction of the incident radiation that is absorbed at a particular frequency. Fourier transformation is a mathematical operation demonstrated by ‘Jean Fourier’ which converts the frequency domain into time domain. The instrument consists of a interfero meter, fixed mirror, a movable mirror, beam splitter. A beam emitted by a source is split into two by the beam splitter, 50% of the incident radiation will be reflected to one of the mirrors while 50% will be transmitted to the other mirror. The two beams are reflected from these mirrors, returning to the beam splitter where they recombine and interfere to give constructive interference or destructive interference, depending on the difference in the optical paths between two arms of interfero meter. The signal is then recorded by the detector (Dole et al, 2011).

FTIR-ATR (Attenuated Total Reflection-Infrared Spectroscopy) has been used extensively in textiles for the analysis of the coated surfaces of functional textiles (Meilert et al, 2005). Studying the surface chemistry of the photo catalytic self-cleaning cotton by coating TiO_2 was done using ATR-IR. The surface of polyester grafted with acrylic acid has been characterized using ATR-IR (Kawase et al, 1991). There were also reports of the use of Attenuated-Total-Reflectance (ATR) FTIR spectroscopy for the identification of cellulosic fibre and characterisation of their state of degradation (Garside and Wyeth, 2007). The speed and sensitivity of the FTIR spectroscopy allows rapid analysis of micro-samples down to the nanogram level, making the FTIR unmatched as a problem-solving tool in organic analysis. The FTIR microscope accessory allows spectra from a few nanogram of material to be obtained quickly, with little sample preparation, resulting in more data at lower cost. In some cases, thin films of residue are identified with a sensitivity that rivals or even exceeds electron or ion beam-based surface analysis techniques. This has enabled a wider use of this in textile field (Shaikh et al, 2014).

2.5.5. SEM Analysis

Scanning Electron Microscope (SEM) is used to identify morphological structure of fibre, yarn or fabric. SEM assessment is also used to identify the uniformity of finishing above the specimen. The photographic images taken from SEM analysis of microencapsulated, nanoencapsulated and washed samples were observed under different magnifications. Due to their small size in nature, a nanoparticle demonstrates original material properties, which are extensively different from those of their bulk counterparts (Bindhu et al, 2016).Advances in microscope technology have improved the accuracy and capabilities of microscopy as a mean of herbal crude material identification due to the implication of light and scanning electron microscopes in herbal drug standardization (Singaravelu et al, 2007)