
Review of Literature

2. REVIEW OF LITERATURE

The literature pertaining to the study are reviewed under the following headings.

- 2.1 Medical Textiles
- 2.2 Skin Diseases
- 2.3 Medicinal Plants
- 2.4 Scientific Classification of Medicinal Plants
- 2.5 Finishing
- 2.6 Antimicrobial Finishing
- 2.7 Microorganisms
- 2.8 Antimicrobial Agents
- 2.9 Herbal Antimicrobial Finishing
- 2.10 Cotton Fabric – The King of Fibres
- 2.11 Antimicrobial Testing Methods
- 2.12 Phytochemical Antimicrobial Compounds
- 2.13 Finish Application Method
- 2.14 Ultra Violet Protection

2.1 MEDICAL TEXTILES

Technical textiles are an innovative sector, which is highly specialized and holds great potential for the future. Technical textiles are value added textiles which span the entire spectrum of the textile industry with ever increasing applications and has been the driving force behind the innovations of new technology, as highlighted by Kothari (2000). Technical textile materials and products are manufactured primarily for their technical performance and functional properties rather than their aesthetic or decorative characteristics. The technical textile products are predominantly used for improving the life style, protecting the environment and enhancing human life, as described by Ramkumar (2011).

The technical textile products are classified according to the applications in the fields namely agro tech, medi tech (medical, hygiene), build tech, cloth tech, geo tech, home tech, indu tech, mobil tech, oeko tech, pack tech, pro tech and sport tech, as stated by Goyal and Prabhu (2008). The medi tech and pro tech are the two main branches which are focusing more on the functional textiles and apparels having

added values and specific end uses, as stated by Teli and Kumar (2007). Textiles with proximity to medical science have emerged as a new field called medical textiles, as highlighted by Chakraborty et al. (2010). Textiles used for medical, health care and hygiene are also known as medical textiles or medi tech. Medical textiles include "all textiles used for medical purpose in operative and post-operative tasks in and around a patient and the medical practitioners" as defined by Kothari (2008).

Healthcare and hygiene is a crucial part of medical textiles desired by both patient and hospital staff for protection and safety in operating rooms. Health care and hygiene products are made of four types namely woven, knitted, braided and nonwoven, as narrated by Nadiger and Ghosh (2008) and are used for medical, biological, first aid and clinical purposes. These fabrics help to reduce the opportunities for contamination by biological toxins and infectious pathogens and thereby, reduce the spread of diseases to other patients, as reviewed by Massey and Goel (2008) and Vishnu (2006). In addition, these fabrics should be soft, the garments must be comfortable, cool, fresh and must not restrict movements, as described by Pal (2009).

More than 80 per cent of the world's population relies on medical products for their primary health care needs (WHO Report, 1999), as cited by Doshi et al. (2011). Textile materials and products that are designed for the use in healthcare can be classified into the following three categories according to their applications namely healthcare and hygiene products, extracorporeal devices and surgical materials. Healthcare and hygiene products include both disposable and non-disposable products mainly used in hospitals such as surgical gowns, masks, gloves, drapes, footwear, staff apparel, towels, bedding, diapers, sanitary napkins, tampons, panty shields, wipes, eye pads, mattresses, covers, bath robes and incontinence products. Extracorporeal devices include artificial kidneys, liver and lungs. The surgical materials are classified as implantable medical textiles which include vascular grafts, artificial ligaments, artificial tendons, artificial skin, scaffolds and non-implantable textiles such as wound dressing, bandages, gauze, lint wadding, plasters and absorbent pads, as highlighted by Chakraborty et al. (2010) and Shanmugasundaram (2008).

Textile materials used for medical applications have specific performance requirements relating to strength, durability, flexibility, stiffness, abrasion resistance, biocompatibility, biodegradability, tenacity, mechanical potency, body tolerance,

hydrophobicity, hydrophilicity, alcohol repellency, water density, medicine release, nano porosity, non-toxic, non-allergic, non-carcinogenic, antistatic in nature, optimum fatigue endurance, flame proof, fast non-irritant dyes, as stated by Gopalakrishnan et al. (2007), Nadiger and Ghosh (2008) and Gulrajani (2008).

2.2 SKIN DISEASES

Our skin is the largest organ in the body and may be allergic to certain substances that are normally harmless to a non-allergic person. People suffering from skin allergies are often allergic to more than one substance, as opined by Lee (2004). Skin diseases are common but are difficult to live with.

Skin diseases affect all ages from neonate to elderly and are harmful in numerous ways. Surveys suggest that approximately one to seven in ten people visit a dermatologist. Most of the skin infection treatments take a long time to show their effects (www.skin-disease.org). Majority of skin diseases cause scarring or disfigurement (www.articlesbase.com).

Allergies are a common collection of disease symptoms caused by an over aggressive immune response. The allergies cause symptoms like sweating, burning, stinging, itching, redness, eczema or contact dermatitis.

2.2.1 Different Types of Skin Infections

Skin is vulnerable to an array of infectious diseases that occur throughout life. Bacteria, viruses and fungi can cause numerous types of skin diseases that range in severity from mild to potentially life threatening. Additionally, the skin is prone to abnormal immune system activity, which cause several types of chronic skin diseases (www.livestrong.com).

- **Bacterial Infections of the Skin**

Bacterial infections of the skin are the most common type of skin infections. There are mainly two types of bacteria causing these infections namely *Staphylococcus aureus* and *Escherichia coli*. *Staphylococcus aureus* bacterial infections are common and cause skin boils, bed sores, erysipelas, cellulitis, folliculitis, furuncle, erythrasma and impetigo.

- **Fungal Infections of the Skin**

Fungal infections of the skin are caused by the fungi that reside on our body where it is warm and moist all the time. Mostly they are not problematic but

sometimes they can cause skin infections in certain areas of the body due to various reasons. The different types of fungal and yeast infections of the skin include athlete's foot, tinea versicolor, jock itch and ringworm.

There are mainly three types of this fungal infection namely inter-digital, moccasin and vesicular. Out of the three, inter-digital athlete's foot is the most common infection (www.buzzle.com). Athlete's foot, which as the name suggests, occurs on the feet. It is a common skin infection found in men as compared to women and is seen in those who wear tight-fitting shoes which provide the best environment to the fungi. The second common infection is cracked heels which is a condition of thickening and fissuring of the skin on the heel of the foot. When the fissures are deep, the skin bleeds easily and cause a lot of pain in the soles, developing red flaky patches on the heel causing peeling of cracked skin, reports (www.mamashealth.com).

- **Viral Infections of the Skin**

Viruses are a major cause of selected rashes that people may develop. "Skin rashes" is a general term that describes a group of spots, an area of inflammation or changes in the colour or texture of the skin. Some skin rashes may affect the whole body or appear on discrete areas of the skin, (www.medicinenet.com). It may be associated with itching, tingling, burning, pain, swelling or no discomfort at all. Almost everyone, at some point in their lives, will encounter skin rashes, contact urticaria, diaper rash and cradle cap (infants), ringworm and chicken pox (children), acne and athlete's foot (teens), measles, rubella, roseola rash, shingles, warts and molluscum contagiosum, psoriasis and rosacea (adults), shingles and scabies (seniors) (www.emuoilcanada.com and www.buzzle.com).

- **Air, Dust, Environment and Chemical Infections of the Skin**

There are many temporary skin problems caused by natural sources namely air, dust, environment, chemicals and insect bites. Diseases like contact dermatitis, dandruff, wounds, acnes, skin cancer and parasites are examples. The causes of skin disorders range from sunburn and drug reactions to genetics and pregnancy. Many of the causes can be avoided with a little prevention, while others are more random in occurrence (www.healthtree.com).

- **Contact Dermatitis**

The Greek word meaning "inflammation of the skin", dermatitis is caused by

touching a certain substance or contact with an outside agent which can be chemical, biological or physical in nature. There are two types of contact dermatitis associated with skin exposure to chemicals, like Irritant Contact Dermatitis (ICD) and Allergic Contact Dermatitis (ACD). The signs of contact dermatitis include redness, swelling, blistering, flaking and cracking. It can lead to itching, bleeding and puss formation, (Schindler and Hauser, 2004 and www.hse.gov.uk).

- **Dandruff**

Dandruff is a very common skin condition that nearly all people experience at one point in their lives. Dermatologists commonly refer dandruff as seborrhea or seborrheic dermatitis, as reported by Vyjyanthi et al. (2004). Dandruff can affect any hair-bearing area or an area with even very small hair follicles. It affects not just the scalp but also the ears, eyebrows, sides of the nose, beard, and less commonly the central (often hair-bearing) part of the chest. In infants, scalp dandruff is commonly known as "cradle cap". The signs and symptoms include white flakes on shoulders of dark clothing, itchy scalp, dry facial skin, recurrent ear "eczema", facial rash on eyebrows, nose, ears, oily scalp, eyebrow dandruff, beard dandruff and chest rash with dry flakes and red spot (www.emedicinehealth.com).

- **Wounds**

Wound infection is one of the most common diseases in developing countries because of poor hygienic conditions, as quoted by Kumar et al. (2008). Wounds are the physical injuries that result in an opening or breaking of the skin. Appropriate method for healing of wounds is essential for the restoration of disrupted anatomical continuity and disturbed functional status of the skin.

- **Acnes**

Acne is the diagnostic term for pimples. It is a chronic inflammatory disease that appears more frequently on the forehead, chin or lower jaw and the black-heads are quite numerous in the same area. Their usual form is small red bright or dark red pin-head or pea-size papule and the skin may appear thick, dirty, greasy with pus and sebaceous matter in the lesions (www.buzzle.com).

- **Skin Cancer**

Sunlight contains harmful ultraviolet rays that can damage the skin causing skin cancer due to sunburn and tanning. Premature ageing of the skin also occurs

with prolonged exposure to the sun. Therefore outside workers are particularly at risk. People who are exposed to ionizing and non-ionizing radiation may be susceptible to work related cancers. In hot and humid weather prickly heat rashes can develop. So, staying cool and dry, wearing light cool clothing and drying thoroughly after bathing is a must (www.ohioline.osu.edu).

2.3 MEDICINAL PLANTS

Plants were commonly used by indigenous people in India and China for curing diseases, as reviewed by Perumalsamy and Ignacimuthu (2008). India has one of the richest medical plant traditions in the world ensuring health security to the teeming millions. Plants are the main medicinal and economical source to treat infectious diseases and to cure diseases, as opined by Pei (2001) and Agarwal and Pardhavi (2007). It is estimated that there are around 25,000 effective plant-based formulations which are used in folk medicine and are known to rural communities in India. Since medicinal plants are nontoxic and easily affordable they play a vital role for pharmacological research and drug development, as revealed by Doshi et al. (2011). World Health Organization (2002) reports nearly 88 per cent of the global population turn to plant derived medicines as their first line of defense for maintaining health and combating diseases, as cited by Cowan (1999). The medicinal herbs would be an excellent remedy for repairing the skin and maintaining its beauty, safety and efficiency, as revealed by Arunkumar and Muthuselvam (2009).

The traditional methods practiced in India are Ayurveda, Unani and Siddha as the primary source of health care and complementary health care system which are effective, less harmful and safe without any side effects, as revealed by Chitravadivu et al. (2009) and Schmutterer (1995). Ayurveda has a vast medical literature with many classics to its credit, as remarked by Karnick (1996).

Plants are used medicinally in different countries and are a source of many potent and powerful drugs, as highlighted by Srivastava (2010). Historically all medicinal preparations were derived from plants, whether in the simple form of plant parts or in the more complex form of crude extracts and mixtures. The different parts used include root, stem, flower, fruit, twig, exudates and modified plant organs, as stated by Uniyal et al. (2006). Medicinal plants represent a rich source of antimicrobial agents and contain physiologically active chemicals, secondary plant metabolites which have been used over the years in traditional medicine for treatment of various ailments, as remarked by Barooah and Konwar (2010). The

plant metabolites according to their composition are grouped as alkaloids, glycosides, corticosteroids, essential oils (www.vedamsbooks.in).

Traditional healers use these plants to promote healing of cuts, wounds besides other ailments such as cold, fever, cough, headache, diarrhea as antiseptics, coagulants, wound wash (extraction of pus), for fertility problems, toothache, stomach ache, diabetes, rheumatism, asthma, dysentery, small pox, bone fractures, earache, hair loss and poison bites, as revealed by Biswas and Mukherjee (2003), Chopda and Mahajan (2009) and Ignachimuthu et al (2006). In Indian systems of traditional medicine the species of the following genera are commonly used to treat wound and related injuries *Abutilon*, *Achyranthes*, *Acorus*, *Aegle*, *Aerva*, *Aloe vera*, *Azadirachta indica*, *Bambusa*, *Bidens*, *Boerhaavia*, *Butea*, *Caesalpinia*, *Calotropis*, *Carissa*, *Cassia*, *Cucumis*, *Curcuma*, *Cynodon*, *Acalypha indica*, *Datura*, *Dodonaea*, *Eclipta*, *Euphorbia*, *Ficus*, *Hyptis*, *Lantana*, *Leucas*, *Morinda*, *Ocimum*, *Opuntia*, *Pavetta*, *Pergularia*, *Plumbago*, *Pongamia*, *Sida*, *Glycyrrhiza glabra*, *Smilax*, *Terminalia*, *Tridax*, *Vitex* and *Zizyphus* were widely used by most of the tribal communities in India, as reported by Jain (1991) and Kumar et al. (2007).

2.3.1 Aloe vera (*Aloe barbadensis*)

Aloe vera plant is called as *Aloe barbadensis* and has number of names such as 'The wand of heaven', 'Heaven's blessing', 'The silent healer', 'Plant of immortality' and 'Medicine plant'. It is an astroloniferous, acaulescent, erect or suberect, perennial succulent plant.

There are around 400 species of *Aloe*, but it is the *Aloe barbadensis* (Aloe vera or "true aloe") plant which has been of most use to mankind because of the medicinal properties it displays. The aloe vera leaves are lanceolate, thick and fleshy, green to grey-green, with a serrated margin and is made up of three layers namely Rind – the outer protective layer, Sap – a layer of bitter fluid which helps protect the plant from animals and Mucilage Gel – the inner part of the leaf that is filleted out to make aloe vera gel. Aloe vera (inner gel) contains the eight essential amino acids that the human body needs but cannot be manufactured, as claimed by Calvin (2008).

2.3.1.1 Medicinal Properties of Aloe Vera

Clinical evaluations have revealed that the active ingredients present in the gel and rind of aloe vera leaves shows analgesic, anti inflammatory effects,

antimicrobial effect, anti viral, immune stimulatory activity, cell growth stimulatory activity, bacterio static, regenerates and promotes suppleness of skin, soothes skin and beneficial for blood circulation, as reported by Hirat and Suga (1983). *Aloe* is present in many cosmetic formulations because it's an emollient, coolant, treats skin disorder effectively, cleanses and reduces scars, as revealed by Jain (2010) and Botes et al. (2008).

2.3.1.2 Chemical Components of Aloe Vera

Aloe vera comprises of anthraquinones, resins, tannins, polysaccharides and aloitin B, as remarked by Agarwal and Paridhavi (2007). Aloe vera leaf contains more than 200 different constituents like acemannan and other polysaccharides, boost T-lymphocyte cells which helps to promote skin healing and neutralize many of the enzymes responsible for damaging the mucosal wall. Aloe-emodin, aloins, barbaloin and isobarbaloin, amino acids, amorphous aloin, approximately 96 per cent water, enzymes, essential fatty acids (anti-inflammatory), essential oil, galactomannans (long chain sugars derived from plants), glycoproteins protein-carbohydrate compounds that speed the healing process by stopping pain and inflammation, minerals, polysaccharides (a type of carbohydrate that stimulates skin growth and repair), resin, vitamin C, vitamin E, zinc and mucopolysaccharides (MPS) (long-chain sugars) are present in aloe vera.

2.3.1.3 Medicinal Uses of Aloe Vera

Medically recognized as a therapeutic preparation, there have been many reports of the healing power of aloe vera, as revealed by Fulton (1990). The gel of the leaves is used as hair conditioner and the best remedy to check hair fall, dandruff, sunburn, skin eruption and sun protection. Aloe vera is used widely in dermatology as it acts as an astringent and humidifier. The benefits of aloe vera juice are to improve the skin injured by burns, irritations, cuts and insect bites, relieve itching and swelling of irritated skin, diminish wrinkles, improve the effectiveness of sun screen products, heal skin conditions such as eczema, psoriasis, acne, seborrhea, herpes, red spots, mycosis, fever blisters, skin irritation, and also to aid muscular-skeletal conditions like arthritis, rheumatism and provide protection to the skin and against pollution (www.garden.lovetoknow.com). It is ideal for sunburns, fragile skin and for removal and repair of dead skin and cells, as quoted by Danhoff and McAnally (1983).

Aloe vera is commonly used for internal applications like bacterial, viral, fungal and parasitic conditions namely AIDS, eliminates parasites (especially protozoan infections), relieves herpes simplex and zoster, symptoms of candida, Epstein-Barr virus (chronic fatigue syndrome), fungal infections, genital herpes, yeast infections, Staphylococcus infections, vaginitis and viral infections (www.natural-medicinal-herbs.com). Other medicinal uses include treating radiation ulcers, peptic ulcers, pimples, freckles, split ends, menstrual problems, abrasions, boils, bursitis, carbuncles, chafed and cracked skin, scratches, denture (gum) sores, edema (swelling), hemorrhoids, inflamed eyes, post-treatment dental discomfort and pain, radiation burns, rashes, warts, X-ray burns, constipation, urine disorders and improving digestion (www.rootsherbal.com).

2.3.2 Marigold (*Calendula officinalis*)

Marigold is an ancient, brightly coloured summer flower known as *Calendula* with many medicinal properties and uses. Its medieval nickname is "poor man's saffron" because it gives vivid color and flavour to rice, chowders and soups. Marigold looks like a large yellow or orange coloured daisy, each floret being about half an inch long. The plant produces its bright flowers throughout the summer. The flower heads may grow up to three inches in diameter (www.herbs.hands.healing.co.uk). Marigold is used in homeopathic and domestic medicine with powerful properties, as reported by Kurian (1984) and Sreekanth et al. (2008).

2.3.2.1 Medicinal Properties of Marigold

The important properties of marigold are antibacterial, antifungal, anti-infective, anti-inflammatory, antiseptic, antispasmodic, antiviral, astringent, detoxifier, diaphoretic, estrogenic, haemostatic and immune-stimulant, (www.womens-health-symmetry.com). Clinical studies reveal that marigold kills bacteria and fungus. Marigold is an effective remedy against *Candida albicans*. Medicinal properties such as antibiotic, cathartic, diuretic, emetic, expectorant, poultice, tonic and treatment of warts are reported by traditional medical practitioners and modern medical doctors, (www.improvehomelife.com). There are no instances of toxicity from the use of marigold (www.herbs2000.com).

2.3.2.2 Chemical Components of Marigold

Marigold flowers contains such high concentrations of water/alcohol-soluble flavonoids and fat-soluble carotenoids which have been used as yellow-orange

natural dyes, as revealed by Sreekanth et al. (2008). Marigold has been reported to contain 5-(3-buten-1-ynyl) 2, 2-bithienyl and alpha terthienyl. Alpha terthienyl, in a synthetic form had been reported as an active component in marigold. The root of marigold has also been reported to contain amines, flavonoids, amides, phenols and ketones. Marigold contains type of flavonoids, flavones and flavonones lacking a free 5-OH. The plants constituents include saponins, mucilage, essential oils, steroidal compounds and resins (www.herbs-hands.healing.co.uk).

2.3.2.3 Medicinal Uses of Marigold

Marigold has a long history of medicinal use, stretching back to the Roman's and the ancient Greeks, who drank marigold tea to relieve nervous tension and sleeplessness. Due to its natural iodine content, it is used to heal all types of skin problems (www.onlinegardenertips.com). *Calendula officinalis* petals constitute the drug which was reported to possess traditional remedy for treatment of wounds and sores. It has a strong bacteriostatic activity inhibiting growth of various strains including *Styphylococcus aureus*, *Bacillus subtilis* and *Salmenolla*. It is also used as stimulant and diaphoretic for injuries, as described by Vardhana (2008) and Pullaiah (2002). Marigold enhances the production of collagen in the skin and fills in facial wrinkles, tones tender skin, treats acne, sunburn, insect bites and protect babies sensitive skin especially in case of diaper rash (www.herbalist.com).

Flavonoids is the major component of this extract which is a traditional wound cleansing agent (www.botanicalnet.com and www.assgein.gov). Marigold is used in both homeopathic and conventional medicine as a healing ointment for cuts and grazes. Marigold petal is used to treat, scars, cracked skin, rashes, inflammations and viral infections. It is also known as an herb for treating HIV, menopausal symptoms, menstrual cramps, minor burns, phthiriasis (dry), colitis, ringworm, sore throats, skin ulcerations, bedsores, swelling, chapped lips, snake bites, sprains, scars, sunburns, cracked skin, varicose veins, warts, as reported by Podlech and Dieter (2001) and Lawless and Julia (2001).

2.3.3 Kuppaimeni (*Acalypha indica* L.)

Indian acalypha is a common annual herb in Indian gardens and commonly seen in marshy places. Kuppaimeni is a species of plant that occurs throughout tropical Africa, South Africa, India, Sri Lanka and Pakistan. Indian nettle or kuppaimeni in Tamil, is a member of the Euphobiaceae family. Its scientific name is

Acalypha indica, which is an erect pubescent 30-80 cm high with more or less angular branches, as described by Vardhana (2008). The leaves have long petioles (upto 12 cm long) arranged spirally, with blades that are ovate or rhombic-ovate, acute at the base. This plant is highly esteemed in traditional Tamil Siddha medicine as it is believed to rejuvenate the body. It is a plant of many surprises and often called as 'miracle plant' or 'natural healer'.

2.3.3.1 Medicinal Properties of Kuppaimeni

The medicinal property of this plant has been known to Siddha medicine where it is called as Poonai Vanangi. Parts used for medicine are leaves, root, stalks (young shoots) and flowers, as opined by Singh and Panda (2005). *Acalypha indica* is considered by traditional practitioners to be bitter, acrid, expectorant, purgative, gastrointestinal irritant and diuretic. Ethanol extracts of dried leaves of *Acalypha indica* Linn. (Euphorbiaceae) fight against fungi (*Candida albicans*) and bacteria (*Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella typhosa*, *Bacillus subtilis* and *Klebsiella pneumonia*), as revealed by Durga et al. (2010).

2.3.3.2 Chemical Components of Kuppaimeni

The major chemical compounds in *Acalypha indica* L. are acalyphin, acalyphamide, acalyphal acetate, aurantiamide, succinimide and flindersin. Alkaloids "acalypus" and "acalyphine" are cathartic, anthelmintic, expectorant, emetic, anodyne and hypnotic. Kaempferos glycosides, mauritianin, ditorin, nicotiflorin and biorobin, acalyphin, epicalyphin, tannins, beta-sitosterol, acalyphamide, aurantiamide, succinimide, flindersin, triacetoneamine, n-octacosanol, quebrachitol, hydrocyanic acid are the other chemicals found in the plant (www.globinmed.com).

2.3.3.3 Medicinal Uses of Kuppaimeni

Kuppaimeni was considered to be the best medicinal herb for antimicrobial finish because of its remarkable properties. The fresh juice of kuppaimeni leaves is applied for scabies, cathartic, cooling, burns, and other skin infections, as revealed by Pullaiah (2002). According to the Siddha text, 'Pathartha Guna Chintamani', kuppaimeni cures stomach pain, diseases due to pitha, bleeding piles, irritations, stabbing pain, wheezing, sinusitis and neutralizes predominance of the Kabha factor, as remarked by Singh et al. (2004). In addition it eliminates mucus from intestine, is used to cure ulcers, relieves sprain, remedy for asthma, pneumonia, relief from

running nose, cure tooth ache, ear ache, head ache and severe cough. The leaves are known to have laxative properties and are given in the form of powder or decoction by Indian's to treat constipation (www.siddham.in, www.a1tamilnadu.com and www.achomeopathy.com).

2.3.4 Neem (*Azadirachta indica*)

Azadirachta indica (Neem) is a tree in the mahogany family Meliaceae. It is one of two species in the genus *Azadirachta* and is native to the Indian subcontinent, growing in tropical and semi-tropical regions. The Sanskrit name of the neem tree is 'Arishtha' meaning 'reliever of sickness' and hence is considered as 'Sarbaroganibarini'. Neem is one of the oldest medicinal plants in the world and has been in use in ayurvedic and unani medicine and homeopathic medicine for 4000 years and has become a cynosure of modern medicine (www.en.wikipedia.org). The importance of the neem tree has been recognized by the US National Academy of Sciences which published a report in 1992 entitled 'Neem – a tree for solving global problems'.

2.3.4.1 Medicinal Properties of Neem

All parts of the tree are said to have medicinal properties and biological activity. Seeds, leaves, flowers and barks are used for preparing many different medicinal preparations. Almost every part of the tree is bitter and has found application in indigenous medicine. The tree stem, root, bark possess astringent, tonic and healing properties. Leaves yield quercetin (flavonoid) which has antibacterial, antifungal, antimalarial and antiviral properties. Medicinal properties of neem are anti-inflammatory, anti-arthritic, anti-pyretic, hypoglycemic, spermicidal, diuretic and anti-tumor (www.neem.products.com). It has been considered as a universal cure for a number of diseases and is also used as a pesticide, as remarked by Dhillon and Khajuria (1966).

2.3.4.2 Chemical Components of Neem

Neem (*Azadirachta indica*) is one of the richest sources of antimicrobial compound and the methanolic extract of its leaves gives green colour. Several compounds were isolated from neem leaves, seeds and barks, as revealed by Mishra et al. (2010). The neem oil contains terpenoids, steroids, alkaloids, flavonoids and glucosides. The isolated constituents are margosic acid, bimbidin, nimbinin, kaemperol, azadirone and vanilic acid. The leaves of neem yield glyceroids of

saturated and unsaturated fatty acids, the main fatty acids are oleic acid and stearic acids. Leaves mainly yield quercetin (flavonoid) and nimbosterol (β -sitosterol) as well as number of liminoids (nimbin and its derivatives).

2.3.4.3 Medicinal Uses of Neem

Neem and its compounds, its extracts and finished products have been known to cure a large number of human ailments, right from skin diseases to diabetes, from cholesterol to hair problems, from ulcers to dental problems. Neem is used in medicine, food and cosmetics. It cures skin problems like pimples, itching, inflammation and sun burns. Fruits of the neem plant are used to treat ringworm and pelvic pain. The root is used for treating syphilis and intestinal disorders. Leaves are used as a remedy for headache, hysteria, glandular swelling and menstrual disorders, body weight problems, leprosy, skin problems, ulcers, dandruff, gastrointestinal problems, healing wounds, vitiated conditions of kapha, excessive thirst and vomiting (www.rootsherbal.com). Neem bark is useful in treating malaria fever, cutaneous diseases, cough, tiredness, loss of appetite and worm infestation (www.thenaturalstore.products). The roots in powdered form help in controlling flies and ticks on pets (www.neem-products.com). The neem leaf extract has been prescribed for oral use for the treatment of malaria by Indian ayurvedic practitioners. Clinical studies with the dried neem leaf extract or a lotion indicated its effectiveness to cure dermatological diseases within three to four days in acute stage or a fortnight in chronic case, as viewed by Kanungo (1996) and Anonymous (1985).

2.3.5 Yashtimadhu (*Glycyrrhiza glabra* L.)

Glycyrrhiza glabra is a perennial herb in the subtropical and warm temperate regions. It attains a height of six feet. The useful part is root. Roots are long, wrinkled and brown in color and when the outer skin is removed it has scaly yellow texture inside.

2.3.5.1 Medicinal Properties of Yashtimadhu

Glycyrrhiza glabra has the following experimentally proven pharmacological properties namely anti-bacterial, estrogenic, anti fungal, anti activity, anti hyper glycemc, anti malarial, anti oxidant, immune stimulatory, anti cancer, anti viral, anti ulcer, anti-inflammatory, anti asthmatic, anti diuretic and anti hepato toxic activity (www.ayurdrugs.com., www.answers.myyog.com and www.neeroga.com).

2.3.5.2 Chemical Components of Yashtimadhu

The main component is glycyrrizin, 50 times sweeter than sugar. Its yellowish colour is due to a glycoside isoliquiritin which changes into liquiritin. The plant also contains phytoestrogens in the form of isoflavones such as formononetin, glabrone, neoliquiritin and hispaglabridin A and B. The major bioactive constituent of rhizomes is a triterpenoids saponin glycyrrhizin, glycyrrhizinic acid, flavonoids, glabrin A and B, glycyrrhetol, glabrolide, isoglabrolide, isoflavones, coumarins, triterpene sterols, asparagines and chalcones (www.medwellpublishing.com).

2.3.5.3 Medicinal Uses of Yashtimadhu

Medicinally, it is used internally for Addison's disease, asthma, bronchitis, peptic or gastric or mouth ulcer, arthritis, fever, allergic complaints and steroid therapy, as revealed by Khan and Khanum (2008). Externally, liquorice is used for head ache, eczema, herpes, eye burning and eye irritations. Economically the roots are boiled to extract the familiar black substance used in liquorice confectionary and this is sold dried to eat.

Glycyrrhetic acid has an effect like aspirin and may have an antibacterial action as well. As an anti-hepatotoxic herb it is effective in the treatment of chronic hepatitis and cirrhosis for which it is been widely used in Japan, as reviewed by Agarwal and Paridhavi (2007) and (www.glycyrrhiza-glabra.101herbs.com). Various scientific studies suggest that yashtimadhu also acts as a memory enhancer and mental rejuvenator. Ghruta (Indian clarified butter) treated with yashtimadhu is used for the management of pain on the cut of a sharp weapon and also increases one's body strength. It improves complexion, prevents premature greying and analytical abilities. It is also helps in managing under nutritive, emaciating conditions, increases sexual desire, prevents erectile disorders and premature ejaculation.

2.3.6 Tanner's Cassia (*Cassia auriculata* L.)

Cassia auriculata is a legume tree in the subfamily Caesalpinioideae. *Cassia auriculata*, native of India, an evergreen xerophitic, is a branched and gregarious shrub with one to three meters height, reddish brown branches, flowers bright yellow and fruit pods flat, thin, papery, pale brown. They grow wild in the Central Provinces, Western Coast, South India and Ceylon. Its flowers are irregular, bisexual, bright yellow and large, nearly five centimeter across the pedicles glabrous around two and a half centimeter long (www.parisaramahiti.kar.nic.in).

2.3.6.1 Medicinal Properties of Tanner's Cassia

The leaf and flower extracts of *Cassia auriculata* exhibit significant broad spectrum microbial activity against *Bacillus subtilis*, *Staphylococcus aureus* and *Escherichia coli*, as reported by Perumalsamy and Ignacimuthu (2008), Narayanan et al. (2007) and Prakash (2006). The plant has been reported to possess antipyretic, hepatoprotective, antidiabetic, antiperoxidative, antihyperglycemic and microbicidal activity, as narrated by Doshi et al. (2011).

2.3.6.2 Chemical Components of Tanner's Cassia

Cassia auriculata contains several constituents such as flavonoids, β -sitosterol- β -D-glucoside, polysaccharides, anthracene, glucoside (sennapicrin) in sap, leaves and bark yield anthraquinones, while the later contains tannins, dimeric procyanidins and myristyl alcohol. Preliminary phytochemical studies had shown the presence of carbohydrates (reducing sugars), saponin glycosides, flavonoids, alkaloids, tannins and phenolic compounds. Auricassidin, kaempferol, α -sitosterol, octasonol, hentrioctanol, ceryl alcohol, peonidin-3-O- α -L-rhamnopyranoside are also present in the flowers. Steroids, triterpenoids, lipids and flavonoids were found to be present in the alcoholic extract of the flower while steroids and lipids were in its petroleum ether, as informed by Shendarkar et al. (2008).

2.3.6.3 Medicinal Uses of Tanner's Cassia

The leaf of this plant has been used in the traditional system of Indian medicine for the treatment of jaundice, liver diseases, leprosy and ulcers. The powdered dried flower bud is used as a substitute for tea in the case of diabetic patients and it is also supposed to improve the complexion in women. Plant root and flower is used for curing burning sensations, ring worm and vomiting. It is reported to be a safe and effective drug against habitual constipation, abdominal disorders, leprosy, leucoderma, jaundice, dyspepsia, cough, bronchitis, typhoid, anemia and tumors, as revealed by Ayyanar and Ignacimuthu (2009).

2.3.7 Tridax Daisy (*Tridax procumbens* L.)

Tridax procumbens is a species of flowering plant in the daisy family. It is best known as a wide spread weed and pest plant (Singh and Semwal, 2009). *Tridax procumbens* (Tridax) or the Mexican Daisy is a native of South America. It is a small, hairy, straggling perennial herb which can be easily located among the weeds along the road or in waste lands (www.healthmed.com). *Tridax procumbens* commonly

known as “Ghamra” and in English popularly called ‘coat buttons’ has been extensively used in ayurvedic system of medicine for various ailments.

2.3.7.1 Medicinal Properties of Tridax Daisy

Tridax procumbens is known for several potential therapeutic properties and extensively used in Indian traditional medicine for antiviral, antibiotic efficacies, anticoagulant, antifungal, insect repellent, antioxidant and anti-inflammatory, as highlighted by Suseela et al. (2002) and Ali et al. (2001). The extract of *Tridax procumbens* has been reported to have various pharmacological effects, antimicrobial activity against both gram positive and gram-negative bacteria and stimulate wound healing.

2.3.7.2 Chemical Components of Tridax Daisy

Alkaloids, flavonoids, saponins, flavones, glycosides, polysaccharides, monosaccharides and asteraceae have been isolated from the leaves of the plant, as reported by Saxena and Albert (2005).

2.3.7.3 Medicinal Uses of Tridax Daisy

Tridax procumbens is a coagulant, cures boils, cough, asthma, swelling pain, cut wounds, bronchial catarrh, dysentery, malaria, stomach ache, diarrhea and high blood pressure. Reports from tribal parts of India reveal the usage of *Tridax procumbens* leaf juice for curing fresh wounds, bleeding and remedy for hair problems, as revealed by Udopa et al. (1991).

2.3.8 Vettiveru (*Vetiveria zizanioides* L.)

Vettiveru (*Vetiveria zizanioides* L.) belonging to the family Poaceae is a densely tufted grass with the culms arising from an aromatic rhizome up to two meters tall. It is a perennial grass with thick fibrous adventitious roots. The roots are stout, dense and aromatic. Leaves are narrow, erect, keeled with scab rid margins. Inflorescence is a panicle, up to 15-45 cm long of numerous slender racemes in whorls on a central axis (www.mouthshut.com).

2.3.8.1 Medicinal Properties of Vettiveru

The therapeutic properties of vetiver oil are antiseptic, aphrodisiac, cicatrisant, nervine, tonic and vulnerary. Roots are stimulant, tonic, cooling, diuretic, antispasmodic, as reported by Jain (1991) and (www.ayurvedaconsultants.com).

2.3.8.2 Chemical Components of Vettiveru

The chemical constituents present in the plant are vetiverol, vetivone, khusimone, khusimol, vetivene, khositone, terpenes, benzoic acid, tripene-4-ol, β -humulene, epizizianal, vetivenyl vetivenate, isokhusimol, β -vetivone and vetivazulene, as reported by Rao and Suseela (2000).

2.3.8.3 Medicinal Uses of Vettiveru

The bulk of the roots obtained from vettiveru are used for the extraction of oil. On the skin, it has a nourishing and moisturizing effect. It is useful for dry, irritated or dehydrated skin. According to ayurvedic literature the plant is used as digestive, carminative, haematinic, expectorant, antispasmodic, anti asthmatic, anti gout, antimicrobial and as a diuretic.

Various tribes use the different parts of the grass for many of their ailments such as mouth ulcer, cracked heels, snakebite, scorpion sting, sprain, as reported by Shah and Maheswari (2006). The tribes of the Varanasi district inhale the root vapour for the cure of malarial fever. Smoke of grass is inhaled to relieve headache, as revealed by Ghani (2003). Vetiver oil has extensive applications in the soap and cosmetic industries, food flavoring and is also used as antimicrobial and anti-fungal agent in the pharmaceutical industry, as opined by Kindra and Satayanaraya (1978). This oil is principally used in high class perfumery where its persistent odour makes it of great value, relieves from stress, anxiety, nervous tension and insomnia.

2.3.9 Flax Seed (*Linum usitatissimum* L.)

Flax is also known as common flax or linseed. *Linum usitatissimum* is a member of the genus *Linum* in the family Linaceae. Flax is an erect annual plant growing to 1.2 m (3 ft 11 in) tall with slender stems. The leaves are glaucous green, slender lanceolate, 20-40 mm long and 3 mm broad (www.en.wikipedia.org). The use of flax seed for medicinal purposes dates back to the Romans, perhaps to the Greeks and Egyptians.

2.3.9.1 Medicinal Properties of Flax Seed

Flax seed has enjoyed a long history of folk medicinal use in Asia, Europe and North America. Flax has been used for centuries as a source of potential health benefit properties such as the prevention of chronic non-communicable diseases, laxative, anti-ageing, anti-biotic, anti-cancer, muscular degeneration, demulcent,

emollient, wound healing, moisturizing, anti-inflammatory, expectorant qualities and soothing irritated tissues.

2.3.9.2 Chemical Components of Flax Seed

The external wall of the seed contains high amounts of mucilage, while the seed itself contains linoleic acid, proteins, fibers, sterols and triterpenes (www.botanical-online.com). Oil extracted from flax seed contained 51.86 per cent of linolenic, 16.34 per cent of linoleic and 20.98 per cent of oleic acid. Additionally, a polysaccharide was isolated with low protein content as impurity, 10.71 per cent yield with 1.37 mg of glucose equivalent to per gram of polysaccharide. Active components present in flax seeds are mucilage, pectin, acids like chlorogenic, oleic, linoleic, alpha-linoleic, palmitic, linamarin, linustatin, lotaustralin, proteins, fiber, magnesium, phosphorus, potassium and iron.

2.3.9.3 Medicinal Uses of Flax Seed

Flax seed can be used internally and externally (www.medicinenet.com and www.scalppsooriasisblog.com). Externally, flax seed or flax seed oil can be used in making homemade skin care products. Flax seed oil is useful for healing scars, abrasions and used to cure skin disorders like psoriasis and eczema (www.ezinearticles.com and www.bodybuildingforyou.com). Flax seed improves skin conditions by providing healthy cellular activity and skin regeneration. It softens skin, reduces scars, heals burns, reduces the redness of rashes, inflammation, eczema, swelling produced by blows or twists and maturation of furuncles. Flax seed is useful to treat local inflammation such as boils, abscesses and skin ulcers (www.flaxseedoilguide.com). In Indian ayurvedic tradition, flax seed is recommended for the treatment of constipation, urinary problems, cardiac diseases, burns, swelling, abscess and eye diseases. The herb helps to control cough and to relieve pain, as enema to reduce swelling of the rectum, reduce dark rings around the eyes, fight wrinkles, heal sunburns and heal scars (www.ageless.co.za).

2.4 SCIENTIFIC CLASSIFICATION OF MEDICINAL PLANTS

Scientific classification of medicinal plants are given in Table – 1.

TABLE – 1

SCIENTIFIC CLASSIFICATION OF MEDICINAL PLANTS

S.No.	Scientific Classification	Medicinal plants											
		Aloe vera	Marigold	Kuppaimeni	Neem	Yashthimadhu	Tanner's cassia	Tridax daisy	Vetiveru	Flax seed			
1.	Kingdom	Plantae	Plantae	Plantae	Plantae	Plantae	Plantae	Plantae	Plantae	Plantae	Plantae	Plantae	Plantae
2.	Division	Magnoliophyta	Magnoliophyta	Magnoliophyta	Magnoliophyta	Magnoliophyta – flowering plants	Magnoliophyta	Magnoliophyta	Magnoliophyta	Magnoliophyta	Magnoliophyta	Magnoliophyta	Angiosperms
3.	Class	Magnoliopsida	Magnoliopsida	Magnoliopsida	Magnoliopsida	Magnoliopsida-dicotyledons	Magnoliopsida	Magnoliopsida	Magnoliopsida	Magnoliopsida	Magnoliopsida	Magnoliopsida	Eudicots
4.	Order	Liliales	Asterales	Euphorbiales	Sapindales	Fabales	Fabales	Fabales	Asterales	Asterales	Asterales	Cyperales	Malpighiales
5.	Family	Liliaceae	Asteraceae	Euphorbiaceae	Meliaceae (Mahogany)	Fabaceae – Pea family	Fabaceae	Rosidae	Asteraceae	Asteraceae	Asteraceae	Poaceae – Grass family	Linaceae
6.	Genus	Aloe	Calendula	Acalypha	Azadirachta	Glycyrrhiza L. Licorice P.	Glycyrrhiza L.	Senna	Tridax L.	Tridax L.	Tridax L.	Vetiveria Bory Vetivergrass	Linum
7.	Species	Barbadensis	<i>C. officinalis</i>	Indica Linn.	<i>A. indica</i>	<i>Glycyrrhiza glabra</i> L. – cultivated licorice P.	<i>Glycyrrhiza glabra</i> L.	<i>S. auriculata</i>	<i>Tridax procumbens</i> L. – Coatbuttons	<i>Tridax procumbens</i> L. – Coatbuttons	<i>Tridax procumbens</i> L. – Coatbuttons	<i>Vetiveria zizanioides</i> (L.) Nash	<i>L. usitatissimum</i>
8.	Scientific name	<i>Aloe barbadensis</i>	<i>Calendula officinalis</i>	<i>Acalypha indica</i>	<i>Azadirachta indica</i>	<i>Glycyrrhiza glabra</i>	<i>Glycyrrhiza glabra</i>	<i>Cassia auriculata</i> Linn.	<i>Tridax procumbens</i>	<i>Tridax procumbens</i>	<i>Tridax procumbens</i>	<i>Vetiveria zizanioides</i>	<i>Linum usitatissimum</i>
9.	Common name	Aloe vera	Garden marigold	Brennkraut, Indian calypha	Neem	Yashthimadhu	Tanner's cassia	Vetiveru	Vetiveru	Vetiveru	Vetiveru	Vetiveru	Flax
10.	Binomial name	<i>Aloe barbadensis</i>	<i>Calendula officinalis</i> L.	<i>Acalypha indica</i> L.	<i>Azadirachta indica</i>	<i>Glycyrrhiza glabra</i> Linn.	<i>Senna auriculata</i> Roxb.	<i>Tridax procumbens</i> L.	<i>Tridax procumbens</i> L.	<i>Tridax procumbens</i> L.	<i>Tridax procumbens</i> L.	Chrysopogon zizanioides	<i>Linum usitatissimum</i>
11.	Tamil name	Sothu kathazai	Sendigai poo	Kuppaimeni	Vembu	Adhimathuram	Avaram	Vettukaya thalai	Vattiver	Vattiver	Vattiver	Vattiver	Ali vidai

(<http://garden.loveto-know.com>), (<http://www.ecoindia.com>), (<http://en.wikipedia.com>), (<http://plants.usda.gov>), (<http://en.wikipedia.org>), (<http://www.agrisources.com>), (<http://en.wikipedia.org/wiki/tridax-procumbens.html>), (<http://en.wikipedia.org>), (<http://simpleayurvedichealthtips.blogspot.com>) (<http://plants.usda.gov/java/profile?symbol=TRPRS>), (<http://plants.usda.gov/java/profile?symbol=VE2180>).

2.5 FINISHING

Finishing is anything that is done on fibre, yarn or fabric before or after weaving, to change the appearance, feel, serviceability and durability, as revealed by Gupta (2005). The term 'finishing' in the context of a textile process house encompasses several activities in its ambit, sometimes extends beyond the fabric stage to garment stage, as viewed by Lockett (2003). Finish means any modifications of fabric or fabric surface to meet certain desired needs or specifications. Finishing is the final step of chemical process carried out to improve the aesthetic appeal of the ready to use product. Finishing is not only what catches the eye, but the feel and touch that the treated material imparts, as commented by Shah and Maheswari (2006). It includes demand for more ecologically and toxicologically beneficial process and products. The aim of textile finishing is to render textile goods fit for their purpose or end use. According to Saraf et al. (2007) textiles enjoy a special status in society because of tradition and also due to the growing era of consumerism which is pushing the textile industry to higher limits. Finishing operations enhance the fabric with a particular appearance, surface texture, covering faults, increasing weight or behavior characteristics like flame retardant, water repellent, stain repellent, antistatic, biocide, stiffening, shape, increase its serviceability, retentive and wrinkle resistance, as emphasized by Smith (2006) and Rajendran et al. (2004).

Buyers always expect a high degree of comfort and finishing plays an important role in achieving that. It adds attractiveness or desirability to the fabric and makes the fabric especially suitable for a particular purpose like antimicrobial and water proof finish.

2.5.1 Classification of Finishing

The textile processing finishes are classified as chemical and mechanical. Chemical finishes are those in which chemical reactions by the treatment of alkalis, acids, bleaches, starches and resins produce a permanent change in the fibre, these are referred to as wet finishes. Mechanical finishes cause a physical change only, they are done by copper plates, roller brushes, perforated cylinders, metal flames or any type of mechanical equipment and are known as dry finishes, as suggested by Gupta et al. (2005). A finish adds minimal cost to the textile material but results in a much greater value addition. Finishing can also be categorized by why and how they are added. There are two large group of finishes, they are basic and functional finishes. Basic finishes which are also called as preparatory finishes are added at the

beginning of the textile products process. Functional finishes represent the next generation of finishing industry which makes textile materials act by themselves. Modern finishing methods are a combination of chemical finishing and mechanical finishing which renders easy care, attractive and functional properties to textiles, as pointed out by Saraf et al. (2007). The consumer's demands are not only defined by aesthetic properties, but also by the functional properties, thus increasing market share.

Finishes can be categorized by their degree of performance, as quoted by Pizzute (1985). It includes the permanent finishes, durable finishes, semi-durable finishes and temporary finishes. It is further classified as aesthetic finishes and functional finishes which modify the appearance and improve the performance of the fabric.

2.5.2 Functional Finishes

Functional finishing process include mechanical process, heat setting, chemical process and surface coating. High performance and value added finishes have become necessary for textiles in daily use. Functional or special finishes are applied to fabrics to make them better suited for specific uses. The emergence of functional textiles as mainstream materials is producing a sparking revolution in the fashion industry (www.irti.org). Specialty textiles use some specific technologies in addition to the conventional technologies so that the product would add value to a specific attribute, as remarked by Gupta and Laha (2007). Novel finishes add high value to apparel fabrics and home textiles. They are also greatly appreciated by a more, discerning and demanding consumer market, as indicated by Holme (2003). Consumers demand more durability and functionality from their clothing. Apparel makers must respond with garments that are technically advanced yet soft and comfortable, as reported by Wallace (2001).

Many times functional finishes may or may not be seen easily but they serve a significant purpose in the overall performance or function of the fibre, yarn or fabric. Some of the functional finishes are antimicrobial finish, water repellent, stain repellent and fire proof (www.tedpella.com).

2.6 ANTIMICROBIAL FINISHING

The antimicrobial finish protects wearer of the textile product from bacteria, fungi, yeasts, viruses and other deleterious microorganisms, as stated by

Chavan and Borkar (2008). Antimicrobial finishing is one of the special types of functional finishing given to the textiles where the chances of bacteria growth are low and the safety is paramount, as defined by Achwal (2003). The term "antimicrobial" is a general for any product that kills (microbiocide) or controls (microbiostat) microbes, as viewed by Korgaonkar (2006). The term antimicrobial refers to a broad range of technologies that can provide varying degrees of protection and control for textile products against the attack of microorganisms like mould, mildew, algae and the problem of deterioration, odour, rotting and health concerns ranging from simple discomfort to physical irritation, allergic sensation, toxic response, infection and disease that the presence of microbes can raise, as suggested by Harini et al. (2007) and Gopalakrishnan (2006). Antimicrobial finish is also a consequence of increasing awareness and demand for hygienic products, infections have increased to a great extent and become resistant against antibiotics, as stated by Austin et al. (1999). Functional finishing terms associated with antimicrobial and antibacterial finishes are broadly classified by many authors, as antimicrobial agent, bacteriostatic (growth inhibitors), bactericide (bacteria killing agent), disinfectant, sanitiser and detergent sanitiser, as claimed by Joshi and Joshi (2002).

2.6.1 Necessity of Antimicrobial Finishing

Microbial attack of the textile materials can be tackled well with the application of antimicrobial finishes, as reported by Singh and Maurya (2005). The function of an antimicrobial finish on the fabric is two-fold. One way, it helps in protection of the wearer from microorganisms for aesthetic, hygienic or medical reasons and also protecting the fabric from deterioration, as expressed by Taylor et al. (1996). Based on the stability of antimicrobial characteristics of textile material with antimicrobial finish, it can be categorized into two types namely temporary and durable finish. The antimicrobial finishes keep the material hygienic and fresh, improve life and durability of the article wherever it is applied, stop skin irritation and prevent skin diseases, as indicated by Sivaramakrishnan (2007). Antimicrobial finished material are recognized as very beneficial in preventing biodeterioration of technical textiles and particularly reduces the risk of cross infection being carried by feet from ward to ward in hospital. It controls spread of diseases and danger of infection following injury and deterioration of textiles particularly fabrics made from natural fibre caused by moulding, rot-inducing fungi. When exposed to weather, mildew, it makes the fabric to stay fresh all day (www.archive.org and www.indiantextilejournals.com).

The advantage of antimicrobially active textiles have to be documented for every agent as well as for every application. A balance has to be found between a textile's quality rating and the potential risks, sensitization, disturbance of the ecology, toxic side effects on the skin by means of systemic absorption, cytotoxicity, genotoxicity, carcinogenicity, teratogenicity and ecotoxicity for humans has to be performed, as highlighted by Ramachandran et al. (2004), (www.fibre2fashion.com, www.textileworld.com and www.ieindia.org).

2.6.2 Types and Categories of Antimicrobial Finishes

The antimicrobials are of two types namely convention or leaching type and non-leaching type. The leaching type of antimicrobial agents is a temporary finish and it is not chemically bonded with the fabrics and can be removed by contact with moisture. The mechanism involved in this type is to poison the microorganisms. The product is eventually used up by the bacteria and slowly loses its effectiveness, durability and efficacy, as suggested by Teli and Prabhu (2006). Besides affecting durability, leaching technology has the potential to cause a variety of other problems when used in garments. These include their negative effects since they contact the skin and affect the skin. They cross the skin barrier and cause rashes and other skin irritations. It is effective for single use and loses its effectiveness on subsequent washing, as described by Shukla and Sundar (2008).

The non-leaching type of antimicrobial agents is a durable finish and are chemically bonded by polymerizing, forming a layer on the surface of the treated fabric. It shows a good durability and may not provoke any health problems. The finish may withstand for more than 40 laundry washes without losing its effectiveness. This is a permanent finishing and remains functional throughout the life of the fabric.

2.6.3 Requirements of Antimicrobial Finishing

The requirements for antimicrobial properties are durability to washing, dry cleaning and hot pressing, selective activity to undesirable microorganisms, not produce any harmful effects to the manufacturer, user and the environment. It should not change the handle and other needed properties of fabrics. It should also be complete with the statutory requirements of regulating agencies, compatibility with the chemical processes, colourless and odourless, easy method of application, no deterioration of fabric quality, resistant to body fluids, resistant to disinfections and

sterilization with acceptable moisture transport properties (Dring, 2003). Generally garments in particular are more susceptible to wear and tear. It is also important to take into account the impact of stress, thermal and mechanical effects exercised on the garment alone with the effective control of bacteria, moulds and fungi, as justified by Ramachandran et al. (2008) and Gopalakrishnan et al. (2007).

2.6.4 Mechanism of Antimicrobial Finishing

The majority of antibacterial, antimycotic (antifungal) and antiinsect finishes function by the controlled release mechanism. Antimicrobial finishes also use controlled release of the antimicrobial agents which are currently used for textiles. It has a barrier action using inert films or coatings to physically block bacteria or withstand direct surface activity against bacterial growth. Regenerable active antimicrobial agents are regenerated by treatment with a bleaching agent during laundering or with ultra-violet radiation, as suggested by Holme (2003). A large number of textiles with antimicrobial finish function by diffusion type. The rate of diffusion has a direct effect on the effectiveness of the finish. Many antimicrobial products that were formerly used with textiles are now strictly regulated because of their toxicity potential, as revealed by Shukla and Sundar (2008). Antimicrobial finishes of some of the commercial products exhibit wide variation in their level of activity, by standardizing the antimicrobial agents and the process conditions for different end uses.

2.7 MICROORGANISMS

Microbes are the tiniest creatures, as quoted by Lee (2004). They are the smallest of living organisms those are not directly visible to the naked eye but only under the microscope. This is why microbes are often called "microscopic organisms". Microbes require certain conditions to grow such as a warm environment, moisture (such as humidity or spills) and a receptive surface like skin or fabric.

Clothing and textile materials are carriers of microorganisms such as pathogenic bacteria, algae, viruses, odour generating bacteria and fungi. It also acts as good media for the growth of microorganisms. The existence and progression of microorganisms can be a source of health problems, odour and ofcourse cause the weakening of the cotton fabrics, as reported by Wasif and Laga (2009).

2.7.1 Classification of Microorganisms

The general classification of the microbes includes bacteria, fungi, virus, algae and dust mites. The first two are generally applicable to textiles and cause degradation, according to Bunce (2004) and Teli et al. (2011).

2.7.1.1 Bacteria

Bacteria are unicellular or occasionally show simple arrangements growing rapidly under warmth and moisture, as described by Johri and Lata (2004) and Korgaonkar (2006). Bacteria are among the oldest living organisms on the earth, commonly found in ground water and in other living organisms. While some types of bacteria can cause diseases and become harmful to the environment, animals and humans, others offer benefits and are termed "friendly bacteria". Bacteria in our digestive system help to convert milk protein into lactic acid and inhibit the growth of potentially harmful bacteria. Bacteria feed on a variety of foods available from the fabric and the skin which results in odour and stain. In general, bacteria have an electro negative surface. The materials having positive surface such as cationic ion compounds and metals can kill the bacteria, as suggested by Yen et al. (2005) and Kanazawa et al. (1993).

2.7.1.1.1 Types of Bacteria

Bacteria are classified into two broad categories namely gram positive bacteria and gram negative bacteria. The bacteria which takes up gram stain made of crystal violet and iodine are called **gram positive (+)** bacteria those are not coloured by gram stain are called **gram negative (-)** bacteria, (www.biology-today.com). The bacterial strains used for assessing the antimicrobial activity are *Bacillus subtilis*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Enterococcus faecalis*, *Escherichia coli*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa*, *Ervinia* sp., *Proteus vulgaris*, as expressed by Bonjar (2004), Meghashri and Gopal (2009) and (www.textileworld.com). But among all these bacteria, *Staphylococcus aureus* and *Escherichia coli* bacteria cause several infections to human beings and the environment.

(a) *Staphylococcus aureus*

Staphylococci (Staph) are gram positive microscopic bacteria that occur in spherical clusters resembling grapes. Bacteriological culture of the nose and skin of

normal humans invariably yields staphylococci. *Staphylococcus aureus* and *Staphylococcus epidermidis* are significant in their interactions with humans.

Staphylococcus aureus is a facultative anaerobic, gram positive coccus and is the most common cause of staph infections, as stated by John (2007). *Staphylococcus aureus* can cause a range of illnesses from minor skin infections namely pimples, impetigo, boils (furuncles), cellulitis, folliculitis, carbuncles, scalded skin syndrome and abscesses, to life-threatening diseases such as pneumonia, meningitis, osteomyelitis, endocarditis, toxic shock syndrome (TSS), staphylococcus scalded skin syndrome (SSSS), chest pain, bacteremia, sepsis, nosocomial infections and postsurgical wound infections, as derived by Kluytmans et al. (1997). *S. aureus* infections can be spread through contact with pus from an infected wound, skin-to-skin contact with an infected person and contact with objects includes towels, sheets, clothing or athletic equipment used by an infected person. Deeply situated *S. aureus* infections can be very severe. Prosthetic joints put a person at particular risk for septic arthritis and staphylococcal endocarditis infection of the heart valves and pneumonia may be rapidly fatal.

(b) *Escherichia coli*

Escherichia coli are gram-negative rod-shaped bacterium that is commonly found in the lower intestine of warm-blooded organisms and mammals known as gut flora. *E. coli* are abundant, the number of individual *E. coli* bacteria in the faces that a human excretes in one day averages between 100 billion and 10 trillion. As gram negative organisms, *E. coli* are unable to sporulate. As a result of their adaptation to mammalian intestines, *E. coli* grows best *in vivo* or at the higher temperatures characteristics of such an environment rather than the cooler temperatures found in soil and other environments. *E. coli* causes septicemias and can infect the gall bladder, surgical wounds, skin lesions and the lungs especially in debilitate and immunodeficient patients, as stated by Gupta et al. (1993).

2.7.1.2 Fungi

Fungi are also known as moulds and mildew. They are more complex organisms, which grow more slowly than bacteria which double every 20-30 minutes, taking several days to establish colonies, as quoted by Shah and Maheswari (2006). Fungi are a large and diverse group of eukaryotic, non-photosynthetic, spore-forming organisms (www.clihouston.com). Fungi generally reproduce by the movement of

spores which travel through the air and find good conditions for growth. Fungi are single celled or multicellular organisms. Fungal infections can have effects ranging from an irritating patch of itchy skin to a life threatening condition. Fungi are active at a pH level of 6.5, as denoted by Shukla and Sundar (2008), Holme (2003) and Gopalakrishnan (2006). Fungal infections can be divided into topical infection affecting the skin, nails or mucous membranes and systematic infections affecting deeper tissues and organs, as described by Srivastava (2010). Fungi stain fabric and deteriorate its performance. A very visible example of the fungal growth is the black stain which occurs on the surface of the textiles commonly called as mildew. The difficulty of fungal staining is that they cannot be removed by washing and bleach may help.

There are several types of fungi but commonly present are *Penicillium funiculosum*, *Aspergillus niger*, *Chaetoniium gloosum*, *Aureobasidium pullulans*, *Trichoderma sporogenes*, *Epidermophyton*, *Candida albicans* (www.wikipedia.org and www.urpmc.ac.uk).

2.7.1.3 Dust Mites and Viruses

Dust mites are another class of microbes. They are eight legged creatures closely related to spiders and ticks that live on the textile products such as blankets, bed linens, pillows, mattresses and carpets, as viewed by Patel et al. (2004). The dust mites feed on human skin cells and liberated waste products and can cause allergic reactions and respiratory disorders such as asthma. The control of such allergies is an important benefit to the consumers (www.indiamart.com). Viruses are very small, ranging between 0.01 and 0.03 mm and are only visualized under electron microscope.

2.8 ANTIMICROBIAL AGENTS

In today's modern hospital environments particularly in operating rooms, the risk of transmitting disease is a vital concern. Fabrics used by doctors and nurses must be resistant to solvents and chemicals such as antiseptics. They should maintain good drape and comfortable to wear even after numerous washing and sterilizing cycles, as stated by Chavan and Borkar (2008). Preventing the spread of diseases such as hepatitis B, severe acute respiratory syndrome (SARS) and acquired immunodeficiency syndrome (AIDS). There is tremendous customer interest in the treatment of textiles with antimicrobial agent, as pointed out by Mucha et al.

(2002). Products with antimicrobial finish are divided into different categories like purely for antimicrobial purpose, to control the growth of microbes and the other is to differentiate products emphasising on cleanliness, as denoted by Pardeshi and Manjrekar (2002).

Materials with active finishes contain specific active antimicrobial substances, which act upon microorganisms either on the cell, during the metabolism or within the core substance (genome). Antimicrobial agents used to treat textiles fall into two categories, known as "static" and "cidal". Many traditional treatments fall into the "cidal" category because of their leaching action. New development tends to favour the "static" type agents as these are of lower risk, as revealed by Bunce (2004).

2.8.1 Types of Antimicrobial Agents

An effective antimicrobial agent must kill or repel microorganisms and act safely on textile substrate without negatively affecting the other important characteristics. Among the various antimicrobial agents, the metal based silver or silver ions are known to have strong inhibitory and bacterial effects as well as broad spectrum of antimicrobial activity, as viewed by Gulrajani (2008). Azo disperse dye of sulphanilamidodiazonium chloride derivatives with an 2,4,4-trichloro-2-hydroxydiphenyl ether of triclosan, PHMB based poly-hexamethylene diguanide, Quaternary Ammonium Compounds (QAC) and their water-soluble halides have been used extensively for cotton textile materials for effective control over microbial growth. They are used in very low concentrations below their toxicity threshold, as quoted by Babu (2003). An exhaust method for incorporating fluoroquinolone antibiotics in textiles designs for in vivo use either as a topical bandage or as an implantable biomedical device is developed.

2.9 HERBAL ANTIMICROBIAL FINISHING

Natural herbal products are also used as antimicrobial agents for textile application bringing out herbal textiles, as reported by Branter and Gerin (1999). Chitosan is a polycationic natural waste product and is applied to cellulose by cross linking and gives both antimicrobial and moisture control properties, as viewed by Joshi et al.(2009). Natural plants show antibacterial and antifungal properties, as reported by Shukla and Sundar (2008). These have been detected in the phytochemicals extracted from the part of plants namely roots, stem, leaves, flowers, fruits and seeds of diverse species of plants, as pointed out by Yadav (2011) and

Eloff (1998). The naturally available antimicrobial agents include neem (*Azadirachta indica*), pomegranate rind (*Punica granatum*), prickly chaff flower (*Achyranthes aspera*), white babool (*Acacia leucophloea*), sweet flag (*Acorus calamus*), garlic (*Allium sativum* Linn.), gudrisag (*Alternanthera sessilis*), marigold (*Calendula officinalis*) and Indian acalypha (*Acalypha indica*). Herbal medicine is still the main stay of about 75 – 80 per cent of the world population. However, the last few years have seen a major increase in their use in the developed world, as opined by Thiry (2010).

Natural antimicrobial agents are non-toxic and non-allergic and do not cause the problem of microbial resistance, as discussed by Gupta and Laha (2007) and Tanaka et al. (1999). An eco-friendly natural antimicrobial finish from plant extracts is found to contain active antimicrobial substances that can control the growth of microbes but exhibit poor wash durability, as described by Harini et al. (2007).

The anti-bacterial substance present in the plant extract controls the growth of odour causing bacteria. These substances kill bacteria, once the bacteria are dead they will not produce waste metabolites and freshness is maintained, as represented by Hegde et al. (2011). When exposed to skin, the herbs are absorbed into the body and may function as a means of providing ayurveda treatment for a broad range of diseases including diabetes, skin infections, asthma, arthritis, and hypertension and strengthen the immune system. Organic garments are 100 per cent free from synthetic chemicals and toxic irritants, as defined by Kumar et al. (2008).

2.10 COTTON FABRIC – THE KING OF FIBRES

Cotton is a most desirable natural cellulosic fabric. Cotton in the form of fibres or textiles is associated with man, right from birth to death. Cotton is considered as “white gold”. Cotton from the Arabic word “qutuni” is the most important vegetable fibre and has been in use for 5000 years, as opined by Mishra (2000). One of the most versatile, traditional and popular fabrics used for making clothes for many countries, as explained by Mhasalkar (2009). Cotton is strong and reasonably low in price, cool to wear, good conductor of heat, hydrophylic, absorbs moisture readily (8 per cent moisture regain), taking warmth from the body and so is particularly suitable for summer or sportswear, underwear and children’s wear. Cotton has good abrasion resistance, wet strength and softness making it suitable for frequent laundering at high temperatures.

They should be made antibacterial as they are widely used for production of surgical gowns and baby clothes. Cotton fabrics are susceptible to microbial growth because of the sweat, which contains moisture, urea and other waste materials, that provide a suitable shelter for microbial growth. At ten per cent moisture content, a cotton sample contains 1.4 million bacterial organisms per gram. This number increases to 9000 million at 50 per cent moisture level, as reported by Babu (2003).

2.11 ANTIMICROBIAL TESTING METHODS

The antimicrobial activity was assessed by various standard tests like qualitative and quantitative methods.

2.11.1 Qualitative Assessment Tests

Qualitative measures of performance generally utilize a zone-of-inhibition (ZOI) approach to roughly estimate the antibacterial activity of a material. In these types of antimicrobial tests, a sample of the test material is placed on top of nutrient agar that has been inoculated with bacteria. After an incubation period, usually 18-24 hours, the area of zone around the sample where microbial growth inhibited is measured. The antimicrobial activity exhibited by the sample is inferred from the size of this zone. The common qualitative tests include AATCC TM 147, SNV 195920, BS/EN/ISO 20645 and Kirby-Bauer Test, as highlighted by AATCC Review (2010) and Thiry (2010).

The qualitative test function is a screening and analyzing system that evaluates the effectiveness of microbial activity. The test includes Well Diffusion Test, Disc Diffusion Test, Paper Disc Method, Bacteria Counting Method and Agar Diffusion Test.

The well diffusion method was carried out to screen the activity of microbes under a cell suspension of about 1.5×10^6 CFU/mL obtained the following Mac farland turbidity standard No. 0.5, as reported by Berghe and Vlietinck (1991). The concentration of the suspension was standardized by adjusting the optical density to 0.1 at 600 nm wave length (SHIMADZU UV-vis spectrophotometer), as quoted by Tereschuck et al. (1997). The antimicrobial activity was evaluated by measuring the diameter of the zone of inhibition in mm around the well.

The disc diffusion method was used to screen the antimicrobial activity, as revealed by Bauer et al. (1996). The antifungal activity was tested by disc diffusion method. The potato dextrose agar plates were inoculated with each fungal culture

(10 days old) by point inoculation. The activity was determined after 72 hours of incubation at 28°C. The diameter of the inhibition zones were measured in mm.

In paper disc method, the inoculum (100 µl) was spreaded uniformly in N-agar plates with the help of glass spreader and kept for five minutes. Pre-sterilized paper discs were dipped into different samples placed in inoculated plates. The plates were incubated for 24 hours at 37°C and size of clear zones developed surrounding each disc was measured by scale to the nearest mm and were plotted on the graph.

For bacteria counting method, a swatch of textile was taken onto a dish containing nutrient agar and suspension of bacteria inoculated on the textile in the agar tests. The dish is then kept in a warm condition at 37°C for 1-2 days. This provides a zone of inhibition around the textile.

The agar diffusion tests include AATCC 147-2004, JIS L 1902-2002 and SN 195920-1992. They are qualitative, but are simple to perform and are most suitable when a large number of samples are to be screened for the presence of antimicrobial activity.

To analyse the antimicrobial activity of the sample, the samples were subjected to agar diffusion of AATCC – 147 and SN (195920), report AATCC (2008) for antibacterial assessment. For the evaluation of antifungal effect PDA medium was inoculated with fungal cells and the plates were incubated for 3 days at 25°C, as reported by John and Malathi (2010). When testing resistance to moulds, incubation must be at least twenty one days, as reported by Wurtz and Pirmasens (2004).

2.11.2 Quantitative Assessment Tests

Quantitative tests generally involve exposing the test material to inoculums containing a known concentration of bacteria for a specified period of time. Afterwards, the concentration of surviving microbes within the inoculums is determined. The antimicrobial efficacy exhibited by the test material is calculated by determining the per cent or log reduction in the microbial concentration on the treated sample relative to either the initial inoculums concentration or the concentration of surviving microbes exposed to a non-treated control sample. Commonly used quantitative antimicrobial tests include AATCC TM 100, JIS L 1902, ASTM E2149, ASTM E2180 and ISO 22196 (AATCC Review, 2010).

2.11.2.1 AATCC 100 or Suspension Test

AATCC TM 100 uses a full nutrient broth for dilution to achieve the required testing concentration of bacteria for inoculation. The nutrient level is much higher than expected in most real-world situations, allowing for aggressive bacterial growth and reproduction. Only a single replicate of the test is normally performed as there is no specificity in the method that requires more than one replicate, as represented by Nayak et al. (2008). This type of test is exemplified by AATCC 100-2004, JIS L 1902-2002 and SN 195924-1992. These methods provide quantitative values on the antimicrobial finishing but are more time-consuming than agar diffusion tests. The bacterial counts were reported as the number of bacteria per sample (swatches in jar) not as the number of bacteria percentage of neutralizing solution. '0' counts at 10° dilution was reported as "less than 100".

2.11.2.2 JIS L 1902 Method

JIS L 1902 was developed in Japan for testing silver-based antimicrobials. It primarily differs from AATCC TM 100 in that the nutrient level in the inoculum broth is diluted to 1:20. JIS L 1902 also is explicit about calculating results for treated products versus those for untreated controls and calls for testing in triplicate. The standard for a valid test is that there should be at least a 1.5 log increase on the untreated control, as reported by Swoffold (2010).

2.11.2.3 ISO 20743

A relatively quick qualitative test to establish whether antimicrobial function exists and longer quantitative testing which may include a "challenge testing" where comparisons are made between finished and unfinished materials to qualify the effectiveness of the treatment. Objective evaluation of the antimicrobial activity is arrived by making use of the challenge test. A series of test methods is available from AATCC (USA), DIN (International) and JIS (Japan), as defined by Kan and Yuen (2006).

2.12 PHYTOCHEMICAL ANTIMICROBIAL COMPOUNDS

The medicinal plants are of great importance to health whose medicinal value lie in active chemical substances called phytochemicals that produce a definite physiological action on the human body. The most important of these chemically active (Bioactive) constituents of the plants are alkaloids, tannins, flavonoids and

phenolic compounds. They are found in almost every plant parts like bark, wood, leaves, fruits, and roots, as explained by Scalbert (1991).

Flavonoids are a broad group of secondary metabolites with varied and important roles in plant physiology as well as they have gained recent interest because of their broad pharmacological activity. Putative therapeutic effects of many traditional medicines may be described to the presence of flavonoids, as revealed by Schultz et al. (2008). Flavonoids and other plant phenolics are reported to have free radical scavenging activity, multiple biological activity including vasodilatory, anticarcinogenic, anti-inflammatory, antibacterial, immune-stimulating, antiallergic, antiviral, estrogenic effects and inhibitors. Flavones are phenolic structures containing one carbonyl group (as opposed to the two carbonyls in quinones). The addition of a 3-hydroxyl group yields a flavonol, as denoted by Fessenden and Fessenden (1982).

2.13 FINISH APPLICATION METHODS

The finishing can be applied onto the substrate by exhaust, pad dry cure, coating, spray and foam techniques. It is claimed that the commercial agents can be applied online during the dyeing and finishing operation, as stated by Korgaonkar (2006). Treating the fibre with resin and crosslinking agents, microencapsulation of the antimicrobial agents with the fibre matrix, coating the fibre surface, chemical modification of the fibre by covalent bond formation, use of graft polymers, homopolymers and copolymerization onto the fibre are the various methods adopted to apply a particular finish, as quoted by Gopalakrishnan (2006).

2.13.1 Pad Dry Cure Method

Pad dry cure is a method of applying a finish on to fabric. The agent that has to be finished onto the fabric is diluted using solvent and mixed with cross linking agents like citric acid to fix the agents into the fabric surface and also to enhance the durability of the finish. The diluted mixture is taken and padded to the fabric using the fabric roll which is fixed to the rollers in the machine and it is left to run for the optimized time. During this period, temperature and concentration are maintained to get an even finishing, as remarked by Harini et al. (2007).

2.13.2 Micro Encapsulation Method

Microencapsulation may be defined as a micro packaging technique, wherein an active core material is encapsulated in a polymer shell of limited permeability. The

objective of this technology is either to protect the active core material from the external environment till required or to effect the controlled release of the active core to achieve desired delay until the right stimulus is encountered. Microencapsulation is a physiochemical technique that provides textiles with resistance to microorganisms and insects. In this technique, a substrate reservoir contains an antibacterial activity sandwiched between two layers of protective polymer, so that active agent migrates to the outer layer as needed when the agent is leached by water or degraded by UV light, as said by Khanna (2005).

The general structure of microcapsule consists of two major components. First is the active ingredient – It is the substance that may be in the form of liquid or solid. It is also referred to as the core content, internal phase, active, encapsulate, payload or fill. The second component is a polymer coating that surrounds the active ingredients which may also be called the wall shell, external phase, membrane or matrix. The release mechanisms of the core contents vary depending on the selection of wall materials and more importantly its end uses. The core content may be released by friction, pressure, change of temperature, diffusion through the polymer wall, dissolution of the polymer wall coating or by biodegradation, as described by Anon (2005) and Sudha et al. (2006). Microcapsules range in diameter from 1 to 1000 μm . Capsules greater than 1000 μm can be called macro capsules and those smaller than 1 μm are called nanocapsules, as revealed by Holme (2003). The technique of microencapsulation depends on the physical and chemical properties of the material to be encapsulated. The micro capsules are developed by using different methods like pan coating, air suspension coating, centrifugal extrusion, vibrational nozzle, pad soaking, spray drying methods, as opined by Cheng et al. (2008).

2.14 ULTRA VIOLET PROTECTION

Sunlight is important for human health. The body needs it to form vitamin D, which is important for bone structure. At the same time, ultraviolet rays contained in sunlight pose a major stress and risk potential for the skin. UV radiation on or near the earth's surface is an invisible component of sunlight, divided into UVA radiation (wavelength 315-400 nm) and UVB radiation (wavelength 280-315 nm). UV radiation penetrates the skin and may result in skin damage namely ageing, sunburn, skin cancer, as revealed by Kathirvelu et al. (2010).

UVR, ultraviolet radiation is a portion of the electromagnetic spectrum with wavelengths shorter than visible light. The sun produces UVR, which is commonly

split into three bands namely UVA, UVB and UVC. UVA rays penetrate more deeply into the skin. UVA damage is long-term and cumulative, it contributes to premature ageing of the skin and skin cancers. UVB is the most powerful and potentially harmful form of radiation. It affects mainly outer skin layers, causing sunburn while contributing to aging, wrinkling, and skin cancer. UVB is stronger in the summer than winter and higher at midday. UVC which are potentially deadly to humans but are fortunately absorbed by gases in the earth atmosphere, as reported by Yadav (2011).

2.14.1 UV Radiation

Unravelling the mysteries related to ultraviolet rays, their properties, and their effects on various living creatures has been a gradual process spanning almost three centuries starting from the seventeenth century, as reported by Perkin (2000), Saravanan (2007), Srinivasan and Gatewood (2000), Hockberger (2002), Morys and Berger (1993) and (www.eere.energy.gov). The proportion of the UV region is about 5-6 per cent of the total incident radiation and the quantum energy of UVR is similar to the bond energies of organic molecules, as reported by Achwal (2000), Malik and Arora (2003), Reinert et al. (1994) and Reinert et al. (1997).

2.14.2 UV Exposure and Human Skin

The factors affecting the solar UVR include cloud cover, the sun's altitude, geographical position, ozone layer, scattering in the atmosphere, environmental and related conditions, as defined by Dayal and Aggarwal, (1998), Bajaj et al. (2000), Gerber et al. (2002), Desai (2003) and Menter and Hatch (2003). The relationship between skin cancer and UV dosage is well correlated. Skin cells that receive sunlight absorb harmful UV radiation and slough off to excrete harmful UV from the body. But the absorption of too much UVR leads to scars that can induce diseases like skin cancer. Excessive UV radiation leads to cell damage and causes inflammation of human skin, the obvious consequences of which are erythema or sunburns, as reported by Rupp et al. (2001). The reciprocal value of these cuticle radiation doses is called erythema effectiveness whose maximum occurs at 308 nm. The total UVR dose reaching the skin is an important factor in the occurrence of both erythema and skin cancer, although there is no proven link between erythema and skin cancer, as reported by Pailthorpe and Chrisakis (1995).

2.14.3 Test Methods for Quantitative Assessment of UV Protection on Textiles

The general approach to test fabrics for the ability to prevent sunburn is laboratory testing in-vivo and instrumental simulation in-vitro. The quantitative measure of in-vivo determination is the sun protection factor (SPF) and value indicate the result obtained instrumentally is the ultraviolet protection factor (UPF), as reported by Kathirvelu et al. (2010).

2.14.3.1 *In Vitro* Study

The transmittance and absorption values of metalized and unfinished fabrics were measured using Optical Spectrophotometer with an integrating sphere according to (AATCC-test method 183-1998). The percentages of transmittance (%) and absorption (%) for the wave lengths from 200 up to 500 nm were measured in intervals of 2 nm. The mean values of three measurements were recorded, as denoted by Gorenesk and Sluga (2004). The spectrophotometric measurements are performed in the wavelength range of 290 to 400 nm, in 5 nm steps or less, (Palithorpe (1994). As suggested by the AS/NZS (Sun Projective Clothing, 1996) and European standard (CEN, 1999) spectrophotometry is an accurate and reproducible test method for determining UPF, particularly for samples with UPFs below 50. Ultraviolet transmission measurements of textiles are generally made under worst-case conditions with collimated radiation at right angles to the fabric. Thus, the actual UV protection of a particular textile would always be 50 per cent greater than the measurement obtained using spectrophotometry, as reported by Gies et al. (1997) and Ravishankar and Diffey (1997).

2.14.3.2 *In vivo* Study

With human volunteers, use of the sun as the UV source is impracticable to test the UPF of fabrics. Generally, xenon arc solar simulators are used with filters to absorb wave lengths below 290 nm and to reduce visible and infrared radiation. Based on skin phototype, MED is determined using incremental UV-B doses on the upper back of a subject and is read after 24 hours. Several studies Menzies et al. (1991), Gambichler et al. (2000) and Greenoak and Palithorpe (1996) however, the UPFs determined using the *in vivo* "on skin" method is significantly lower than the UPFs obtained *in vitro*.

2.14.4 UV Protective Clothing

The depletion of the ozone layer is increasing day by day due to the pollution which has increased the chances of skin cancer. The clothing specially designed and treated with functional finishes can protect the skin from cancer. A UPF rating of 20 indicates that only 1/20th of the biologically effective UVR striking the surface of the fabric actually passes through it. The UPF rating is done in accordance with Australian Standard AS / NZS 4399 : 1996, which involves the use of spectrophotometer in the range of 280-400 nm.

The SPF rating is done in accordance with Australian Standard AS 2604 : 1998. The SPF ranges from 2-50+, a SPF rating of 15 protects for about 75 minutes, as stated by Nayak et al. (2008). Sun protective clothing includes hats, shirts, pants, shoes and gloves that cover sufficient skin and are made from fabrics with a tight weave that does not allow UV rays to pass through it (<http://work.sunsafecolorants.org.>) and Bohringer et al. (1997).