CHAPTER 2

REVIEW OF LITERATURE

2.1 INTRODUCTION

The curative textiles field is the highlighted newborn area of medical textiles. Though the literature specific to the copper enriched curative effects is not rich, there have been many research work related to textile applied with herbal products and chemicals. Curative textiles are merger between textiles and curative components. Curative textiles can be generally classified into two types: curative utility performed by regular textiles substrates and textiles augmented with external curative components (Shanmugavasan 2011). The curative components could either be natural medicinal herbs or synthetic compounds. The era of multifunctional textile started with the introduction of antimicrobial textiles. The compound with antimicrobial activity would add an additional functionality to the textile material and it’s used in variety of applications such as health and hygiene products, especially the garment worn close to the skin and several applications, such as infection control and barrier material. The relatively lower incidence of adverse reactions of herbal products as compared to modern synthetic pharmaceuticals, coupled with their reduced cost, can be exploited as an attractive ecofriendly alternative to synthetic antimicrobial agent for textile applications (Joshi 2009; Samantha 2009). But such textiles cannot be considered as curative textiles as their role is mainly preventive in
nature and their support is only secondary to the healing process. In case of curative textiles the role played by multi-function textiles is vital and primary.

The developments in the field of curative textiles were made possible due to the development in the field of finishing technologies. The finishing method is crucial in order to deliver the applied component in the right way. With the advent of concepts such as eco-friendliness and biocompatibility of medicinal herbal products are being preferred over synthetic chemical compounds. The extraction methods used in the herbal medicinal system have vastly grown. Sophisticated instruments and precise characterisation have been put in place. The herbal compounds have low side effects compared to the allopathic chemicals, and moreover, in medicinal herbals related to human health, a high degree of accuracy is required in their characterisation (Shanmugavasan 2011, Joshi et al 2009).

Application of curative textiles and their evaluation is also of equal importance. Though the requirement for the evolution is high, there are only a few methods available for the characterization. The need for novelty in the evaluation methods for the curative garments has to be addressed.

2.2 APPLICATION OF TEXTILES IN MEDICAL FIELD

Traditionally, textiles were considered as low technology domain as their primary functions are protection of modesty, providing microclimate and good look (Anita 2011). The current circumstances of environmental awareness, the new quality requirements not only emphasize on the inherent functionality and along with service life of the product but also a production process that is environment friendly. Therefore, research on environment friendly antimicrobial agents based on natural products for textile application is gaining worldwide interest. Different classes of active ingredients are found in extracts of natural products (Thilagavathi & Kannaian 2008). With the
advent of new technologies, the growing needs of the consumer in the wake of health and hygiene can be fulfilled without compromising the issues related to safety, human health and environment. Tapping new potential antimicrobial substance with curative effects, such as natural herbs and also some biodegradable chemicals from nature can considerably minimise the undesirable activities of the antimicrobial products (Chandrasekaran et al 2012, Jagtap et al 2010).

2.3 CURATIVE TEXTILES

Curative textiles are also called as a medical component in ayurvedha, the traditional medicinal system using various categories of medicinal herbs for different diseases. During the time of construction of curative textiles to impart medicinal herbal properties to textile substrate by using combined theories and concepts of alternate medical concepts such as siddha, ayurvedha, naturopath, etc., and also changeover to environment friendly processed textile products not only for apparel purpose but also for curing various skin and allied diseases. It is also for safeguarding the environment, pollution prevention and to promote ecofriendly textiles and to create a true awareness. Curative garment prevents pollution by avoiding the use of more than 0.15 kgs (1/3 pound) of lethal chemicals which is essential in making of one product. It encourages tree plantations because the herbs used, they are the main source of together it conserves soil and the waste from the herbal finishing would serve the purpose of fertilizing the soil.

2.4 STRUCTURE OF THE SKIN

The skin has several important functions. It provides a protective barrier, defending the body from all outside environmental influences, including extremes in temperature and exposure to disease organisms such as harmful bacteria and their infections, wind and UV rays from sunshine, it acts
as a thermostat, retaining heat are cooling down with sweat, it helps in a waste disposal also. Certain waste is expelled from the body 24 hours a day through the skin in the form of excess water, toxins and carbon dioxide, it is important in body processes like respiration and metabolism, it provides the sense of touch to help to communicate with the outside world and it responds to sudden changes in emotions (Somayaji et al 1995).

2.4.1 Parts of the Skin

Our skin is a complex engineered covering layer. Figures 2.1 and 2.2 show the structure and part of the skin, the skin has three layers. The innermost layers are known as the lower dermis, the middle layer is called the dermis, and the outer layer is known as the epidermis. The skin has a slightly acidic coating of oil at the surface. This coating protects the skin against some bacteria. Below the surface is a complex of sweat and oil glands, hair follicles, blood vessels, nerves, and muscle tissue. These are held together by a tough connective tissue called collagen plate. Collagen is very important in determining the health of the skin. The relative health of the collagen determines the contour of the skin, how wrinkled and lined it is. Healthy
collagen is often called soluble collagen, because it can absorb and hold moisture. Below the collagen is a layer of fat and muscle, which provides some contour and acts as a cushion and as insulation.

Figure 2.2 Structure of the skin (Wikipedia 2013)

2.4.1.1 Lower dermis

The various glands such as the oil and sweat glands originate in the lower dermis and from here; they rise to the surface of the skin to eliminate waste matter. Lower dermis also acts as a cushion for the rest of the skin. It contains the finely distributed muscles of the skin which regulate body temperature.

2.4.1.2 Dermis
It is composed entirely of living cells. It consists of bundles of tough fibres which give the skin its elasticity, firmness and strength. There are also blood vessels, which feed vital nutrients to these areas. The most important function of dermis is respiration. The countless tiny blood vessels or capillaries end here in finely – drawn networks. The dermis is the layer that lies underneath the epidermis, and it feeds the outer skin layer. Dermis also determines the tone of the skin.

2.4.1.3 Epidermis

This is the top layer of skin. It protects the body from invasion and infection and helps to seal in moisture. It’s built up of several layers of living cells which are then topped by sheets of dead cells. It’s constantly growing, with new cells being produced at its base. They quickly die, and are pushed up to the surface by the arrival of new ones. These dead cells eventually flake away, which means that every new layer of skin is another chance to have a soft, glowing complexion. The lower levels of living cells are fed by the blood supply from underneath, whereas the upper dead cells only need water to ensure they are kept plump and smooth. The epidermis is responsible for the colouring, as it holds the skin pigment. It ranges in thickness from 1/20th of an inch on the palms and soles, to 1/200th of an inch on the face.

2.4.2 Specialized Organs of the Skin

Sebaceous glands are tiny organs which usually open into hair follicles on the surface of the skin. They produce a secretion, called sebum, which is the skin’s natural lubricant. The sebaceous glands are most concentrated on the scalp and face, particularly around the nose, cheeks, chin, and forehead, which is why these are usually the oiliest areas of the skin. Sweat glands are all over the body. These are millions of them and their main function is to regulate the body temperature. When sweat evaporates on the
skin’s surface, the temperature of the skin drops. Hairs grow from the hair follicles. They can help keep the body warm by trapping air underneath them. There are no hairs on the soles of the feet and palms of the hands (Lingaraju et al 2007).

2.4.3 Absorption Function of the Skin

The herbal molecule responds to the warmth of human skin and is subsequently absorbed into the body through sweat pores of the skin and it will diffused into the blood vessel and after that it gives the desired medicinal quality. The cloth has to be in direct contact with the wearer’s skin for the above process take place.

2.4.4 Various Skin Diseases

2.4.4.1 Eczema

Eczema is a common skin condition hallmarked by itchy and inflamed patches of skin, particularly on faces in infants, as well as inside the elbow and behind the knees of children, teenagers, and adults. Also commonly known as atopic dermatitis, eczema is caused by an overactive immune system. The skin condition is more common in babies and young children, but eczema can also occur in adults. Up to 20% of children and one to three percent of adults develop atopic dermatitis, according to the American Academy of Dermatology (AAD) (Lichenplanus 2013). Atopic dermatitis crops up during the first year of life for 60 percent or more sufferers. At least 80% have the inflammatory skin condition before the age of five. In rare cases, atopic dermatitis can first appear during puberty or adulthood. It affects males and females equally.

Types of Eczema
When people refer to eczema, they generally mean atopic dermatitis, which is the common and chronic form of eczema. Other types of eczema include:

**Contact Dermatitis**

Contact dermatitis occurs when certain irritants come in contact with the skin and cause inflammation—namely, burning, itching or redness. When the irritant is removed, the inflammation goes away.

**Dyshidrotic Dermatitis**

Dyshidrotic dermatitis affects fingers, palms of the hand, and soles of the feet, causing itchy, scaly patches of skin that flake constantly or become red, cracked and painful. The condition is twice more common in women than in men.

**Nummular Dermatitis**

Nummular dermatitis causes dry, round patches of skin in the winter months. It can affect any part of the body, but commonly appears on the lower leg. It is more common in men.

**Seborrheic Dermatitis**

Seborrheic dermatitis leads to itchy, red, scaly rashes in different locations on the body, particularly the scalp, eyebrows, eyelids, sides of the nose, and behind the ears.

2.4.4.2 **Lichen planus**
Lichen planus is a fairly common skin rash that is thought to be triggered by the immune system (Lichenplanus 2013). Exactly why the immune response occurs is not known. There may be several contributing factors, and each case is different. Potential causes include viral infections, an allergen, or even stress or genetics. Sometimes lichen planus occurs along with autoimmune disorders.

While it may be uncomfortable, in most cases lichen planus is not a serious condition. It is not contagious. There are some rare variations of the condition that are more serious and painful. It can be treated by using topical and oral medications to reduce symptoms, or by using drugs that suppress the immune system.

2.4.4.3 Vitiligo

Vitiligo is a condition in which you lose the pigment of your skin (Vitiligo 2011). Pigment causes skin color and is produced by cells called “melanocytes”. Another word for pigment is “melanin.”

Most people with vitiligo lose pigment in patches of normally pigmented skin, which is replaced by flat white patched with irregular borders. This loss of pigmentation can occur in small patches, on one side of the body or in large areas covering over 50% of the body. These patches are usually in areas of the body that are exposed to the sun, such as hands, face, arms, and feet, but the genitalia can also be affected.

Vitiligo can be treated, but not cured. The disorder has to be managed throughout life. The National Vitiligo Foundation (NVF) of US estimates that 0.5 to one percent of the general population suffers from vitiligo.
The condition is not contagious, does not cause pain, and is not medically dangerous. Vitiligo affects males and females of all races equally. However, the loss of pigment, called depigmentation, is more noticeable in people with dark skin.

2.4.4.4 Psoriasis

Psoriasis is a medical condition that occurs when skin cells grow too quickly. The body does not shed these excess skin cells, so the cells pile up on the surface of the skin and lesions form. It is a chronic, inflammatory disorder of the skin. It is not contagious. It is the result of an abnormally rapid multiplication of the cells of the epidermal layer of can affect any area of the body, but is most commonly found of the scalp, elbows, hands, feet and genitals (Nagano et al 2005).

2.4.4.5 Inflammatory skin disease

These inflammatory skin diseases include psoriasis, pityriasis rubra pilaris, pityriasisrosea, dermatitis herpetiformis, subcorneal pustular dermatosis, perioral dermatitis, allergic contact dermatitis, autosensitization dermatitis, Behcet’s disease, and atopic dermatitis. These diseases are also caused by microbes.

2.4.4.6 Detergent allergy in hands

Allergic reactions like renders, heat, swelling and pain on the skin when it comes in contact with on the skin when it comes in contact with harsh substances like detergents leads to a condition called ‘contact dermatitis’.

Contact dermatitis is caused either by an allergy or sensitivity (a non-allergic response) to common substances. About 80% of skin reactions are caused by direct contact with an irritating, harsh or dangerous chemical.
Household cleaners, dish detergent and soap are everyday examples of products that also can cause irritant contact dermatitis in many people, especially with longtime use. Battery acid, drain cleaner and turpentine are chemicals that cause irritant contact dermatitis in everyone.

2.4.5 History of Copper and Wound Healing

Copper is an essential trace element which has been known to be in living tissue for more than 200 years. Even before it was known to play an integral role in the human body, ancient cultures, such as the Egyptians, used copper for water sterilization, headaches, trembling of the limbs (likely seizures or Parkinson’s like symptoms), burns, and itching (Dollwet & Sorenson 1985). Copper was also used in the Roman Empire to treat many ailments including intestinal worms, chronic ulcers, and ear infections (Dollwet & Sorenson 1985). The Aztecs and nomadic Mongolian tribes also used copper for medicinal purposes (Dollwet & Sorenson 1985). In the 19th century, copper’s medical potency was first observed during the outbreak of cholera, in Paris, in 1832, when copper workers were found to be immune to cholera (Dollwet & Sorenson 1985). Other early medicinal applications of copper typically involved the treatment of painful joints and muscles using copper bracelets, or copper-containing ointments (Hawlader et al 2003, Huff et al 2007). In the 20th and 21st centuries, copper is found in dietary vitamins, and has been used to treat chronic wounds, tuberculosis, burns, rheumatic fever, rheumatoid arthritis, sciatica, seizures, and as a supplement for general disease prevention (Dollwet & Sorenson 1985, Diazvisurraga 2012).

2.4.6 Role of Copper in Skin Diseases

Copper is a mineral stored primarily in the liver, with small amounts in all tissues in the body. Although only a small amount is needed, copper is an essential nutrient that plays a role in the production of
hemoglobin (the main iron component of red blood cells), myelin (the substance that surrounds nerve fibers), collagen (a key component of bones and connective tissue), and melanin (a dark pigment that colors the hair and skin). Copper also works with vitamin C to help make a component of connective tissue known as elastin (Kumar et al 2007).

Copper can act as both an antioxidant and a pro-oxidant. As an antioxidant, it scavenges damaging particles in the body known as free radicals. Free radicals occur naturally in the body and can damage cell walls, interact with genetic material, and possibly contribute to the aging process as well as the development of a number of health conditions. Antioxidants can neutralize free radicals and may reduce or even help prevent some of the damage they cause (Krejpcio et al 2007).

When copper acts as a pro-oxidant at times, it promotes free radical damage and may contribute to the development of Alzheimer's disease and, possibly, cervical dysplasia (pre-cancerous lesions of the cervix which forms the opening to the uterus). Maintaining the proper dietary balance of copper (along with other minerals such as zinc and manganese) is important (Kumar et al 2007).

Signs of possible copper deficiency include anemia, low body temperature, bone fractures and osteoporosis, low white blood cell count (the cells that help fight infection), irregular heartbeat, loss of pigment from the skin, and thyroid disorders. Gastrointestinal disease is a common cause of copper deficiency. Infants who do not have enough of this mineral tend to have poor feeding habits and lack proper growth (King et al 1995).

Foods that contain copper include oysters, organ meats (especially liver), whole grain breads and cereals, shellfish, dark green leafy vegetables, dried legumes, nuts, and chocolate.
2.4.6.1 Anemia

Copper supplementation may be beneficial for individuals with anemia (a condition characterized by low hemoglobin levels) because this mineral works together with iron to form hemoglobin.

2.4.6.2 Arthritis

Animal studies suggest that oral copper supplements reduce the development and progression of arthritis. Many people with arthritis (both rheumatoid and osteo) apply copper solutions to their skin or wear copper bracelets in hopes of relieving pain and inflammation associated with this joint condition. Reports of success with these methods are mixed, but one clinical study from the 1970s found that copper bracelets worked better than placebo bracelets. Sweat can interfere with how well the topical copper solutions and bracelets work.

2.4.6.3 Burns

When skin is burned, a substantial percentage of micronutrients, such as copper, selenium, and zinc may be lost. This increases the risk for infection, slows the healing process, prolongs the hospital stay, and even increases the risk of death. However, people with major burns tend to lose copper more rapidly than other minerals. Although it is unclear which micronutrients are most beneficial for people with burns, many clinical studies suggest that a multivitamin including copper and other minerals may aid in the recovery process.

2.4.6.4 Inflammatory bowel disease

People with the Inflammatory Bowel Diseases (IBD), ulcerative colitis, and Crohn's disease cannot absorb essential vitamins and minerals,
such as copper, as well as healthy individuals. When treating IBD, clinicians often recommend multivitamin containing essential minerals. In addition, inflammatory bowel disease may be related to oxidation or damage caused by free radicals. In fact, copper levels may be low in the inflamed tissue of those with IBD, particularly Crohn's disease.

Finally, a laboratory animal study found that copper-deficient rats tend to have elevated blood sugar levels over time, indicating a possible connection between low copper and diabetes. A clinical study including people with diabetes, however, found very different results. Copper levels were higher in people with diabetes compared to those without. In fact, the higher the copper level, the more likely the person was to have complications from diabetes, including retinopathy (damage to the retina of the eye), high blood pressure, or vascular disease (Bugel et al 2005).

2.4.6.5 Wound healing

Copper plays a major role in wound healing. Scientists think that introducing copper into wound dressings would not only reduce the risk of wound and dressing contamination, but also stimulate faster healing. Releasing copper from the dressings directly onto the wound promotes skin regeneration.

2.4.6.6 Others

One clinical study that followed over 1,600 patients with lung cancer found that dietary zinc and copper intakes are associated with reduced risk of lung cancer. Preliminary studies show that copper may inactivate HIV infectivity.

2.4.7 Copper Related Wound Healing Treatments
Alcoholic extracts of bakers' yeast (*Saccharomyces cerevisiae*) have been used for over 60 years in over-the-counter medications for the treatment of hemorrhoids, burns, and wounds. It has been suggested that small peptides are responsible for the medical observations. A peptide fraction, containing 4 polypeptides was isolated, which is 600 times more active than the initial extract in enhancing wound closure in both diabetic and non-diabetic littermates (Gadiborkow 2004). The peptides are active in nanomolar amounts. One of the peptides is a low molecular weight stress-associated protein: copper, zinc superoxide-dismutase (Schlemm et al 1999, Jagtap et al 2010).

A great many Brazilian medicinal ds are used in wound healing. They are usually applied directly to wounds, some in natural as poultices, some as dried powders, and others as water extracts (teas) for bathing. A correlation between the healing effect of 16 plants were analysed and their content of silicon, manganese, iron, copper, and zinc was reported (Pereira & Felcman 1998, Chitravadivu et al 2009).

Tolmetin is a nonsteroidal anti-inflammatory agent. This medicine is used for the treatment of pain and inflammation, rheumatoid arthritis and osteoarthritis, and juvenile forms of arthritis, since it blocks production and release of chemicals that cause pain and inflammation (Kawata 1998). Interestingly, in male albino rats bearing either sutured incision, dead space or excision wounds, tolmetin suppresses wound contraction and epithelization. However, this effect is totally reversed by copper present and when tolmetin is complexed with copper (Somayaji et al 1995, Dziezak 1998, et al, Ahmed 1999).

### 2.5 COPPER ENRICHED MEDICINAL HERBS RESOURCES

Plants are sustainable source of medicinal products especially in traditional medical practices. Medicinal herbs contain active substance such as alkaloids, tannins, metals, etc., produced during their secondary
metabolisms which serve as a potential reservoir of medicinal products (Bourgaud et al 2001). There are many extraction methods such as aqueous extraction; solvent extraction and steam distillation to extract active substance form the medicinal herbs (Harbone 1973). The traditional method of extraction of herbs using water and some solvents like menthol, ethanol petroleum ether etc., is being at present the extracts are applied on the human for the treatment of pain, inflammation and various skin diseases. There are many copper enriched medicinal herbs available for the treatment of various skin diseases (Bourgaud et al 2001, Francis 1999).

2.5.1 *Aerva lanata*

*Aerva lanata* is known as polpala. The herb is prostrate to decumbent, sometimes stiff herb, 30-60cm in height, wooly, tomentose throughout; leaves simple, alternate, short petioled, densely tomentose, usually in the flowering branches, flower very small, sessile, bisexual greenish or hairy white, often clustered in spikes, perianth calycine memberanous, five free filaments of the five stamens connate at the base with alternating linear staminodes, fruits greenish, roundish, compared urticle and seeds kidney shaped with shinning black coriaceous testa (Selvam et al 1994; Rajesh et al 2011). *Aerva lanata* plant has many medicinal properties due to the presence of numerous secondary metabolites (Nevin & Vijayammal 2003, 2006).

The chemical constitutions of *Aerva lanata* have sitosteryl palmitate; hentriacontane, β-sistosterol and its D-glucoside, α-amyrin and betulin were isolated form the whole plant. The glycosides like kaempferol 3-rhamnogalactoside and kaempferol 3O-glucoside along with alkaloids, saponis and sugar like fructose, galactose, rhamnose and sucrose and minerals also available in this plant (Aiyar et al 1973; Chandra & Sastry 1990). The herb has the remarkable properties of curing skin diseases like bedsores wounds, rashes and rheumatism (Payne & Kudner 1996).
2.5.2  *Aloe Barbadensis* Mill

*Aloe vera* is a stem less or very short-stemmed succulent plant growing to 60-100 cm (24-39 in) tall, spreading by offsets. The leaves are thick and fleshy, green to grey-green, with some varieties showing white flecks on their upper and lower stem surfaces. The margin of the leaf is serrated and has small white teeth. The flowers are produced in summer on a spike up to 90 cm (35 in) tall, each flower being pendulous, with a yellow tubular corolla 2–3 cm (0.8–1.2 in) long. Like other *Aloe* species, *Aloe vera* forms arbuscular mycorrhiza, a symbiosis that allows the plant better access to mineral nutrients in soil. (Gong et al 2002). *Aloe vera* leaves contain chemical constitutions for possible bioactivity, such as acetylated mannans, polymannans, anthraquinone C-glycosides, anthrones, anthraquinones, such as emodin, and various lectins. (Eshun & He 1995; King et al 1995; Boudreau & Beland 2006). *Aloe Vera* has number of uses and mainly they are used as a food preservative and medicine. Commercially, aloe can be found in pills, sprays, ointments, lotions, liquids, drinks, jellies, and creams, to name a few of the thousands of products available. The herb has the remarkable properties of curing dark spots on the face, reduces the intensity of the pigmentation, seborrhoea dermatitis and best wound dressing (Boudreau & Beland 2006).

2.5.3  *Cuminum cyminum* Linn

Cumin (*Cuminum cyminum*) is a widely used spice condiment in India, South East Asia and Arabia. Cumin commonly known as jeera or Kashmiri jeera belongs to the family Apiaceae. Cumin is known for its carminative, stimulant, diuretic, emmanogogic, antispasmodic and astringent properties. It is also used in treatment of diarrhea, dyspepsia and jaundice (Wang 2009). Although cumin seeds contain a relatively large percentage of iron, extremely large quantities of cumin would need to be consumed for it to serve as
a significant dietary source. Cumin's distinctive flavor and strong, warm aroma are due to its essential oil content. Its main constituent aroma compounds are cuminaldehyde and cuminic alcohol. Other important aroma compounds of toasted cumin are the substituted pyrazines, 2-ethoxy-3-isopropylpyrazine, 2-methoxy-3-sec-butylpyrazine, and 2-methoxy-3-methylpyrazine. Other components include γ-terpinene, safranal, p-cymene and β-pinene (Li & Jiang 2004; Iacobellis & Nicola 2005; Wang 2009).

### 2.5.4 *Tagetes erecta*

*Tagetes* species vary in size from 0.1 to 2.2 m tall. Most species have pinnate green leaves. Blooms naturally occur in golden, orange, yellow, and white colors, often with maroon highlights. Floral heads are typically 4–6 cm diameter, generally with both ray florets and disc florets. In horticulture, they tend to be planted as annuals, although the perennial species are gaining popularity. Depending on the species, *Tagetes* grow well in almost any sort of soil. Since prehispanic times, this plant has been used for medicinal purposes. The Cherokee used it as a skin wash and for yellow dye (Hamelpaul & Marychiltoskey 1975). *Tagetes erecta* flowers are mainly quercetagitrin and tagetiin, two glycosides of the flavonoid quercetagetin, among which lutein (xanthophyll) amounts to 64% and sometimes up to 80%, with smaller amounts of antheraxanthin, zeaxanthin, cryptoxanthin, β-carotene and about 14 other carotenoids (Gilman & Howe 1999). Scientific study shows that thiophenes, natural phytochemicals that include sulfur-containing rings, may be the active ingredients. The whole herb is considered medicinal with anthelmintic, aromatic, digestive, diuretic, sedative and stomachic properties. It is used internally to treat indigestion, colic, severe constipation, dysentery, cough and fever, and externally to treat sores, ulcers, eczema, sore eyes and rheumatism (Francis 1999).
2.5.5  *Mentha piperita*

It is a herbaceous rhizomatous perennial plant growing to 30–90 cm (12–35 in) tall, with smooth stems, square in cross section. The rhizomes are wide-spreading, fleshy, and bare fibrous roots. The leaves are from 4–9 cm (1.6–3.5 in) long and 1.5–4 cm (0.59–1.6 in) cm broad, dark green with reddish veins, and with an acute apex and coarsely toothed margins. The leaves and stems are usually slightly fuzzy. The flowers are purple, 6–8 mm (0.24–0.31 in) long, with a four-lobed corolla about 5 mm (0.20 in) diameter; they are produced in whorls (verticillasters) around the stem, forming thick, blunt spikes. The natural photochemical that includes flavonoids, phenolic acids, triterpenes, volatile oil, menthofuran, cineol, limonene, myrcene, \(\beta\)-caryophyllene, piperitone and pulegone (Baslas & Saxena 1977; Sathyanarayanan et al 2010). The herb has the remarkable properties of curing skin related diseases, also having astringent, antiseptic, emetic and stimulant qualities.

2.6  MICROENCAPSULATION

Microencapsulation is a process of enclosing micron sized particles of solids or droplets of liquids or gasses in an inert shell, which in turn isolates and protects them from the external environment (Ghosh 2006). The product obtained by this process is called as micro particles, microcapsules, microspheres which differentiate in morphology and internal structure. When the particle size is below 1\(\mu\)m are known as nanoparticles, nanocapsules, nanospheres respectively and particles having diameter between 3 – 800 \(\mu\)m are known as micro particles or microcapsules or microspheres. Particles larger than 1000 \(\mu\)m are known as macroparticles (Benita 2006, Lazko et al 2004).
Microencapsulation can be done

(i) to protect the sensitive substances from the external environment,
(ii) to mask the organoleptic properties like colour, taste, odour of the substance,
(iii) to obtain controlled release of the drug substance,
(iv) for safe handling of the toxic materials,
(v) to get targeted release of the drug,
(vi) to avoid adverse effects like gastric irritation of the drug.

2.6.1 Multitude of Microencapsulation Techniques

Many different methods have been proposed for the production of microcapsules with many variations in detail, depending on core and wall polymer solubility, particle size, wall thickness and wall permeability, type and rate of release of core contents required, physical properties and detailed and overall economics of manufacture. However, the potential manufacturing methods for microencapsulation may be broadly classified into two groups namely (Benita 2006);

- Chemical microencapsulation
- Mechanical microencapsulation

2.6.2 Chemical Microencapsulation

In this process, the production and isolation of capsules is normally carried out in a liquid manufacturing medium and involves a chemical change
and/or phase separation. Chemical microencapsulation processes are generally characterized by batch operation, high capacity, and conventionality of equipment and diversity in physical state and size of nucleus particle. The Table 2.1 shows the chemical microencapsulation methods.

**Table 2.1 Chemical Microencapsulation methods**

<table>
<thead>
<tr>
<th>Chemical methods</th>
<th>Size in micrometers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple &amp; Complex Coacervation</td>
<td>2 – 1200</td>
</tr>
<tr>
<td>Interfacial polymerization</td>
<td>2 – 2000</td>
</tr>
<tr>
<td>Phase separation</td>
<td>0.5 – 1000</td>
</tr>
<tr>
<td>Solvent evaporation</td>
<td>0.5 - 1000</td>
</tr>
<tr>
<td>In-situ Polymerization</td>
<td>0.5 - 1000</td>
</tr>
<tr>
<td>Super-swelling Polymerization</td>
<td>0.5 - 500</td>
</tr>
<tr>
<td>Mini-emulsion Polymerization</td>
<td>0.1 - 0.4</td>
</tr>
</tbody>
</table>

2.6.2.1 Coacervation

The term coacervation was introduced by the Dutch Scientists Bungenberg de Jong and Kruyt in 1929. It is derived from the word coacervus (Latin word meaning heap or pile) and it is meant to describe the macromolecular aggregation (phase separation) processes brought about partial desolvation of fully solvated macromolecules.

Coacervation is the separation into two liquid phases in colloidal systems. The phase more concentrated in colloid component is the “Coacervate” and other phase is the equilibrium phase. The generalized encapsulation process using coacervation can be viewed as a series of three steps (Dziezak1998; Jackson & Lee 1991)
- Establishment of a three-phase system, with liquid vehicle as the continuous phase and coating material and material to be coated as disperse phases.
- Deposition of liquid polymeric material around the material to be coated
- Gelation of the polymeric coating material.

By using coacervation for microencapsulation, a broad selection of polymer coating and methods of deposition are available, which are easily adaptable to large-scale production. The processes are highly reproducible and involve fairly simple unit operations.

2.6.2.2 Simple coacervation

In simple coacervation, addition of a water miscible non-solvent to an aqueous polymer solution causes formation of a separate polymer-rich phase due to a partial miscibility effect. The capsule walls can then be hardened by addition of an aliphatic hydrocarbon solvent with a low solvent power (Lazko et al 2004).

2.6.2.3 Complex coacervation

Complex coacervation results from the mutual neutralization of two oppositely charged colloids in aqueous solution. Complex coacervates occur with two or more colloids with opposite charges, which neutralize each other. Microencapsulation by complex coacervation consists of three stages (Hawlader 2003);

- Dispersion of the active component to be encapsulated into an aqueous solution of a polyelectrolyte.
- Deposition around the core material of the coacervate formed by addition of an aqueous solution of second electrolyte of opposite charge.
- Gelation of the coacervate.

2.6.3 Mechanical Microencapsulation

Mechanical microencapsulation processes normally involve physical changes to a system, requiring some specialized auxiliary mechanical equipment for the formation and isolation of capsules. Mechanical microencapsulation processes are generally characterized by the combined factors of continuous operations; lower capacity, restricted diversity in physical state and size of nucleus particles, and the need for specialized equipment (Benita 2006).

<table>
<thead>
<tr>
<th>Mechanical methods</th>
<th>Size in micrometers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray drying</td>
<td>5-500</td>
</tr>
<tr>
<td>Rotating disk</td>
<td>5-1500</td>
</tr>
<tr>
<td>Stationary extrusion nozzle</td>
<td>500-4000</td>
</tr>
<tr>
<td>Centrifugal extrusion nozzle</td>
<td>250-2500</td>
</tr>
<tr>
<td>Submerged extrusion nozzle</td>
<td>500-6000</td>
</tr>
<tr>
<td>Air suspension</td>
<td>&gt; 75</td>
</tr>
<tr>
<td>Pan coating</td>
<td>&gt; 1000</td>
</tr>
</tbody>
</table>

2.7 APPLICATION OF MICROENCAPSULATION IN TEXTILES
Initially, textile industry was slow to utilize the technique of encapsulation, but now it has produced a wide variety of innovations, utilizing the basic principles of targeting, slow release and protection of sensitive materials. The major interest of microencapsulation is in the application of durable fragrance, skin softeners, insect repellents, dyes, vitamins, antimicrobial agents, phase – change materials, medical applications, antibiotics, hormones and other drugs (Nelson 2001, Sun & Xu 1998).

The combination of microcapsules and coating on textiles allow the introduction of new smart functionalities that often are not possible with any other existing technologies. Ghosh (2006) discusses about various commercially available microencapsulation technologies for the applications in textile technology. Few of the medical textile applications of microencapsulation include drug delivery system using drug loaded hollow fibre, ion – exchange fibres, fibres with bio – active, side – chains and textiles finished with cyclodextrin. Flame retardant cotton has been developed by coating the microcapsules of phosphate as the intumescing formulation of polyurethane-phosphate could not to be used permanently because of the water solubility of the phosphate (Giraud et al 2002).

2.8 MECHANISM OF ANTIMICROBIAL ACTIVITY

Antimicrobial agent inhibits or kills micro – organism in several ways, e.g. by cell wall synthesis, alternation of cytoplasmic membrane permeability, inhibition of enzyme action, and protein or nucleic acid synthesis. Negative effect on the vitality of the microorganisms is generally referred to as antimicrobial. The degree of activity is differentiated by the term cidal, which indicates significant destruction of microbes and the term ‘static’ represents inhibition of microbial growth without much destruction. Differentiation of antimicrobial activity shown in Figure 2.3.
The activity, which affects the bacteria, is known as antibacterial and that of fungi is antimycotic. The antimicrobial substance functions in different ways. In the conventional leaching type of finish, the species diffuse and poison the microbes to kill. This type of finish shows poor durability and may cause problems. The non-leaching type or bio-static finish shows good durability and may not provoke any health problems. A large number of textiles with antimicrobial finish function by diffusion type. The rate of diffusion has a direct role on the effectiveness of the finish. For example, in the ion exchange process, the release of the active substance is at a slower rate compared to direct diffusion and hence, has a weaker effect. Similarly, in the case of antimicrobial modification where the active substances are not released from the fibre surface and so are less effective. They are active only when they come in contact with microorganism. These so called new technologies have been developed by considering the medical, toxicological and ecological principles. The antimicrobial textiles can be classified into two categories, namely, passive and active based on their activity against microorganisms. Passive materials do not contain any active substances but their surface structure produce negative effect on the living condition microorganism. Materials containing active antimicrobial substances act upon either in or on the cell (Ramachandran et al 2004).
Field trials are important for any product to validate its performance. Field trials for the bandages have been done on patients to determine curative effect. The performance of the copper enriched herbal treated curative garments was evaluated once in a week and the clinical trial was conducted for 7 weeks duration. In summary, the review of literature presents evidence supporting the application of copper herbs in functional textile finishing. The review also provides evidence for the use of copper enriched herbal extract and microcapsules preparation, hence, the present study is conducted using copper enriched medicinal herbs preparation and application for functionality finishing on cotton fabrics to construct a curative garments.