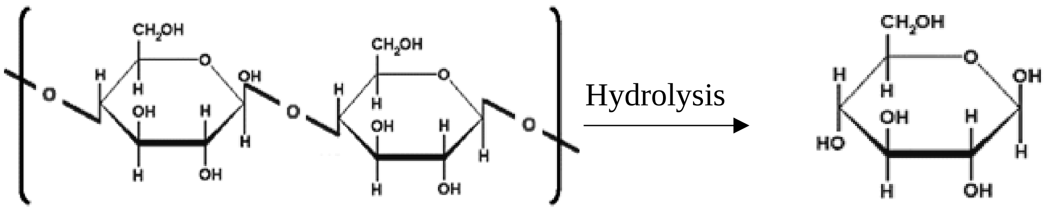
CHAPTER I

INTRODUCTION

Heritage textiles have long played a significant role in the customs and traditions of people throughout our mankind. Traditional textiles serve as significant archives that represent human history, cultural values, and their artistic creations (Shroff et al., 2022). Numerous items manufactured from a wide variety of textile materials are displayed and stored in museums all around the world. Artifacts from archaeological excavations, tombs, caskets, carpets, tapestries, and decorative fabrics, costumes, and apostolic robes that are almost a century old are all included among them. They also serve as an inspiration for designers. As mentioned by (Manek, 2012) the development of civilization in India began in the Middle Ages and persisted until the late 19th century, and the history of Indian textile crafts predates both periods. The exquisite Indian textiles reveals stories that has been influenced by a variety of cultural influences, environmental conditions, geographic variables, and trade for millennia. They play a crucial role in in educating today's generation about the stories and histories of the past. They are unique, fragile, and demand care, preservation, and conservation for them to survive for our future generations. By maintaining its remnants, museums allow for the rebirth of antiquated art forms and turn them into fashion statements (Suza et al., 2022).

They are usually made of natural fibers that can be either cellulosic or protein in nature. Under certain factors these textiles undergo deterioration easily. (Hitchcock, 2016) The natural process of degradation in textiles occurs when an item achieves a condition of chemical and physical equilibrium with its immediate surroundings. It frequently results from a confluence of physical, biological, and/or chemical elements acting in concert to cause damage. Improper temperature and humidity levels or abrupt changes in those levels combined with some mechanical force often leads to physical deterioration. Whereas, chemical degradation occurs at atomic and molecular level because of the reaction with another chemical substances causing oxidation of Zari's or metals used in the textiles, fading of dyes and pigments, acid hydrolysis, and further causing brittleness. The main causes of biological deterioration are usually excessive moisture, warmth, and food supply, which create the ideal environment for moulds, bacteria, and pests to quickly multiply and cause discoloration, fibre breaking, decline in polymerization, holes, and ultimately complete destruction. When fibres and fabrics come into touch with soil and water, the intensity of the bio damage increases significantly, especially in areas with a warm and humid climate (Pekhtasheva et al., 2012). These damages caused are irreversible and these artistic and cultural significance cannot be replicated. Additionally, because they are organic materials, textiles are inclined to attract insects, microbes, and other types of living organisms (Shroff et al., 2022). This is essentially relevant for cellulose and protein-based textiles like cotton, hemp, jute, linen, wool and silk since they offer a suitable habitat for living organisms, often serving as a source of food.

Smith and Morris first reported how the presence of fungi causes the natural plant-based fibres to break down in 1926–1928. (Gutarowska & Michalski, 2012). Majorly observed cellulose being a polysaccharide is made up of glucose molecules connected by 1,4-glycoside linkages. Microorganisms break down cellulose by hydrolysis reaction caused by enzymes and forms shorter molecules like cellobiose or glucose commonly referred as cellobiohydrolase (figure 1.1). The primary result of cellulose degradation by enzymes causes reduction in molecular weight which compromises the fibre structure and reduces its strength (Harmsen et al., 2021).The cellulose's crystallinity is particularly significant since amorphous cellulose is more vulnerable to attack than crystalline cellulose. Microbes also have the ability to produce enzymes that break down hemicellulose and pectin found in plant-based fibers.



ß (1 → 4) Glucose Glucose

Fig. 1.1: Breakdown of cellulose to glucose by hydrolysis caused by enzymes

The deterioration of a woolen fabric happens when the disulphide bonds within the keratin, which provide its durable strength, begin to break down (Gutarowska & Michalski, 2012). Keratin is made up of amino acid cysteine, and two cysteine molecules that are bound together by a disulphide bond (figure 1.2). Proteins are enzymatically broken down into oligopeptides by proteolytic enzymes, which are then degraded into amino acids by peptidases. Both bacteria and fungus can cause wool to biodegrade. Fungi break down keratin more severely than bacteria does (Harmsen et al., 2021).

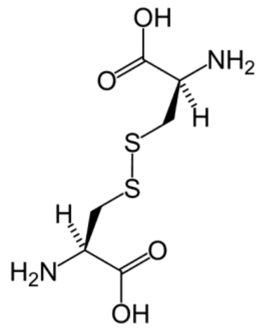


Fig. 1.2: Two cysteines bound together by a disulphide bond
Image source: (Harmsen et al., 2021)

The decomposition in silk fabric is usually caused by degradation of sericin and fibroin by proteolytic enzymes of microorganisms. It has been discovered that organic acids produced by microbes, such as lactic, gluconic, acetic, succinic, fumaric, malic, citric, oxalic, etc., breakdown textile materials in addition to enzymes. (Pekhtasheva et al., 2012). The enzymes and organic acids they released continue to break down textiles even after the microbes die. The primary fungi that damage textiles include moulds like aspergillus. Bacilli or rod-shaped bacteria are the most common type to cause damage to textiles. When fabrics are folded and kept in warm, moist environments for extended periods of time, mildew most frequently forms on them (Deshmukh et al., 2013).

Pests like beetles, moth, silverfish, cockroaches that affect textiles have been an issue since the dawn of civilisation. There are signs of insect attack on wool textile samples discovered in many places of the world. Insects are capable of digesting keratin present in the animal products like fibers, fur, hair, feathers, horn, etc. (Medha et al., 2021). They consume keratin from fibres in order to extract sulphur from disulfide bonds, which is an essential nutrient for their growth. A moth infestation is reported to reduce the weight of untreated fabric with substantial visible damage by 12.85%. Extreme infestation makes infected woollens appear as though they have been grazed by cattle, developing lengthy irregular holes and webbing. In the past, natural resources like tobacco leaves, cedar shavings, and camphor were employed to ward off fabric pests in the storage sections. Use of the smoke from tobacco and turpentine also shows prominent mothproofing properties.

Furthermore, finishes like sizing, starching, bleaching, dyeing, and the usage of lubricants can deteriorate over time as well. The ancient textiles were also dyed using natural dyes, which necessitated coating them with mordants before dying. Mordants were typically metallic salts to help the colours adhere to the fabric. Over time, natural fibres are known to deteriorate due to mordants like iron that produce brown and black hues. (Hitchcock, 2016). Due to the varied structures of the textiles, microorganisms damage fabrics at different rates (Suza et al., 2022). Thinner fabrics with lower surface densities and larger porosities are most susceptible to bio damage because of their wide surface area for contact with microorganisms and ease of deep penetration. The degree of polymerization and crystallinity of fibres also affects how susceptible they are to microbes.

Therefore, it is crucial to preserve and conserve textiles, especially those that are historically significant. With the right preventive maintenance, a textile's rate of deterioration is considerably slowed. (Hitchcock, 2016). The most efficient way to slow down the biodeterioration of textile artefacts by controlling the environmental conditions. (Merritt, 1993). It works well not only to control microorganisms but also to control other agents like insects. Given India's climatic conditions, it is challenging to store textile collections in cool, dry surroundings with enough ventilation. The two types of textile conservation are preventive conservation and curative conservation (Manek, 2012). Preventive conservation strives to reduce the deterioration to the artifacts in order to eliminate the need for invasive conservation procedures and to ensure that works of art are protected for the present and the future. Whereas, curative conservation focuses on the process of actively modifying an objects physical state through wet cleaning, consolidation, restoration, and support. A restored artefact is still susceptible to degradation even after the optimum treatment under the conditions has been chosen, having taken into account the material and climate. It is essential that while preserving traditional artifacts, one should avoid techniques that negatively impact the objects appearance and feel if a better option is available.

The following are typical procedures used at textile museums: Maintain constant ventilation and air conditioning, at 23°C, and relative humidity up to 50%. Placing dehumidifiers or silica gel in areas that need the right humidity level. Use of acetate foils, lead bulbs, and sun filters to control the amount of light that is projected. Periodic examination and inspection of the textiles especially for any signs of insect infestation, use of insect traps to detect any pest infestation. If needed use of traditional compact fumigants with low toxicity but strong insect repellent properties, such as paradichlorobenzene ($C_6H_4Cl_2$), naphthalene ($C_{10}H_8$), and camphor, for fumigation against insects (Suza et al., 2022)**.** Other procedures that are used are use of muslin coated archival cardboard tray to support fragile textiles and fragments (Hitchcock, 2016). Folding the textiles as little as possible or insulating the interior of costumes with crumpled, unbuffered, acid-free tissue as over time, fold lines in textiles often causes breakage of yarns. At the end of the 1980s, nanoscience was employed for the first time in an artefact conservation (Shroff et al., 2022). The use of isotropic and thermodynamically stable micro emulsions which are oil-in-water nanodroplets provides detergency properties have also been used to clean dirt off of fabrics and paints. In the late 1980s, Renaissance artworks were cleaned using them in order to conserve cultural heritage. A liquid medium microemulsion made of dodecane nanosized droplets was successful in removing wax spots from the paintings that were detected by UV light. Since 1960s use of polyvinyl alcohol and polyvinyl butyral in combination with other solvents was employed for the conservation of textiles. But, the application of these polymer coatings causes mechanical stress and leads to hydrolysis of the textiles. Meanwhile, the use of polyethylene glycol, which is extremely hygroscopic, darkens the fabric when coated with it. This results in the dust and other contaminants becoming ingrained in the textiles. Nevertheless, these traditional techniques of repairing them have unfavourable long-term repercussions.

In India, there is an ancient tradition of using herbs and spices for the preservation of textiles. These natural ingredients, such as clove, cinnamon, and neem leaves, have been used for centuries and are still considered safe and effective due to their scientifically established antibacterial and insect repellent properties. By placing small fabric bags or sachets filled with these dried herbs and spices on shelves or in textile storage boxes, fabrics can be protected from damage caused by insects and bacteria. (Parikh, 2017; Dave, 2017, & Medha, et al., 2021). The active ingredients found in these herbs and spices have been studied extensively, and they have been shown to have biocidal and insect repellent effects. For example, clove contains eugenol, camphor has monoterpenes, and tobacco leaves contain nicotine. Lavender oil contains phenolic chemicals, and oregano contains carvacrol, a phenolic monoterpenoid. Lemongrass essential oil (Cymbopogon citrates) contains phytochemicals such as terpineol, dipentene, limonene, alpha-terpineol, citronellol, methyl heptanone, dipentene, geraniol, limonene, nerol, farnesol, and triterpenoids. Tulsi (holy basil) contains eugenol, ursolic acid (triterpenoid), rosmarinic acid (phenyl propanoid), caryophyllene, and oleanolic acid and linolenic acid, all of which contribute to its insect-repellent and antimicrobial properties. The use of neem extracts and essential oil has shown to be successful in preventing insect attacks on wool fibres (Medha et al., 2021). It has both antifeedant and insecticidal properties across a broad range of biological activities because of the presence of compounds like the limnoid, triterpenoid and azadiractin.

According to theory, the high toxicity in the vapour phase of many plant volatiles is what makes them repulsive to insects. For instance, studies on woollen moths have shown the effectiveness of essential oils from cedar wood, peppermint, citronellal, ocimum basilium, lemongrass, and nutmeg. In contrast, certain ingredients that have been used to flavour food for centuries, like cumin seeds, cinnamon sticks, oregano, and thyme leaves, have proven to have powerful antibacterial and antifungal effects (Liu et al., 2017). Combinations of spices have been found to perform better against particular bacteria.

But with the growing of synthetic technology over the traditional knowledge, the use of this preservative practices has been declined. The complex technique, which involves layering tobacco and neem dried leaves beneath preserved textiles covered in cotton cloth, calls for constant cleaning and inspection. The possibility exists that tiny fragments of crushed leaves will contaminate clothes. Also, a key disadvantage of placing a small bag of mixed herbs or spices on a shelf is that it does not effectively repel pests across a wide area (Parikh 2017; Dave, 2017). Furthermore, the active ingredients found in herbs and spices are frequently light-sensitive and cannot be applied directly to a surface or fabric (Shroff et al., 2022).

When it comes to enhancing and overcoming the limitations of the conventional ways of restoring and conserving cultural heritage artefacts in museums, nanotechnology provides some extremely intriguing possibilities. The most promising technique, Nanotechnology is used widely in cross-disciplinary research. Its involvement in textiles allows for a number of functional finishes, such as fire retardancy, water repellency, antibacterial properties, insect repellent, and more. Unlike polymers, which have historically been employed in conservation operations, engineered nanoparticles can be applied to textiles without changing their original properties. The solution to resolve the drawbacks of the traditional practices may lie in the nano/microencapsulation of active compound which could provide textiles a biocidal and insect repellant function. In recent years, development of numerous techniques for the encapsulation of natural products, such as extracts, essential oils, or pure natural bioactive chemicals, employing a variety of matrices have been recorded (Detsi et al., 2020). Encapsulation is a process that creates micro or nano-systems by trapping active substances inside a biodegradable matrix commonly referred as wall material. The technique also has the ability to transport bioactive substances to specific targets.

According to reports, essential oils have antibacterial, antifungal, and insecticidal properties (Medha et al., 2021). They are the form of most active compounds isolated from the herbs and spices. The polymer capsule shell diffuses the essential oils that make up the core of the capsules, allowing a controlled release of the active ingredients and offering a durable protection for the textiles against insects, fungi, and bacteria. The wall shields the bioactive ingredient from oxidation and UV deterioration as well. Additionally, it shields unstable bioactive molecules from harsh processing environments including high heat and oxygen. It also safeguards volatile substances like essential oils. Further, it hides the unpleasant tastes or odours that some active chemicals produce (Detsi et al., 2020).

The present research involves using Indian traditional application of herbs and spices with a much scientific approach through encapsulation technology. To avoid any direct contact of the finish with the heritage textiles, the research aims to develop a separate preservative fabric with antimicrobial and insect repellent fabric to preserve the rich traditional and heritage textiles of India from insects and microbes.

1.1 PURPOSE OF THE STUDY

Textiles and costumes preserved in museum collections serve as valuable archives of our history. Handwoven textiles played a more significant and valuable role in ancient society (Manek, 2012). The luxurious laces, elaborately woven fabrics showcasing wealth and status, symbolic motifs on fabrics used for dowries, births, and deaths, as well as lavishly hand embroidered textiles all served as personifications of the social ideals and conventions of their eras. In order to sustain the history of humanity, it is essential to preserve them. But they need a great protection, preservation, and conservation. Textiles are easily damaged by environmental forces that combine several biological, chemical, and physical elements (Hitchcock, 2016). Mishandling of old textiles can also result in damage to them. The surface of the textile is often where degradation occurs. Additionally, because they are organic materials, textiles are likely to draw insects, microbes, and other types of living things (Baglioni et al., 2014). This is particularly true for textiles made of cellulose, like cotton, linen, hemp and jute, as well as textiles made of protein, like silk and wool, which offer suitable environments for microorganisms to grow, often even serving as a source of food. The damages caused by microbes and insects are severe and irreversible. Therefore, it is necessary to protect and preserve traditional textiles especially from microbes and insects.

As mentioned earlier, the intricate method of layering tobacco and neem dried leaves beneath the preserved linens coated with cotton cloth necessitates routine cleaning and examination since it. It is also possible that textiles artefacts can get contaminated by crushed leaf pieces. Additionally, a tiny sachet of mixed herbs or spices in a shelf or in the drawers has the significant drawback of being ineffective at deterring pests across a vast area. This of course calls for any treatment without applying anything directly to them or using any polymers, hazardous chemicals or gases that would otherwise accelerate deterioration over a long run.

The fabric under the study is developed using a nano structured method which enhances the durability of the finish that will help protect against the microbes and insects. The improved durability provided by the finish on the textile is linked to the extensive surface area of nano particles (Shroff et al., 2022; Heard, 1992). These nano particles are developed using essential oils as active compounds which are dispersed in a polymer matrix and a binder to coat the finish on a fabric substrate. This protects and stabilizes the active compounds as they are volatile in nature and sensitive to light. Due to the control and release mechanism of the nano particles, the fabric leaches out the active compounds and thus repel microbes and insects. Hence, proving the best means and ways for a greater durability of the antimicrobial and insect repellent finishes. The application of this developed preservative fabric can be used to cover or wrap and store the traditional textiles into it. It can also be used as a backing or a lining fabric to the drawers, cupboards, and boxes. The fabric can be used for padding the hangers and rollers for storage purposes. As it will be used for wrapping the textiles, it will also cover and preserve the stored textiles against dirt and dust.

The preservative fabric developed under this study would help developing a scientific environment for our heritage textiles to increase its lifespan. It also avoids direct application of any finishes on to the ancient textiles. Thus, preserving them for our future generations. The research would also sensitize the current and future generations about the traditional indigenous practices of preserving the textiles. In many cultures, textiles play various important roles. Historically, certain items were designated for ceremonial use and restricted to particular social classes, whereas others were exclusively worn by certain groups of people. Special textiles hold sentimental value related to the stories and storytellers all across the world, several of which are quilts and heirloom textiles. Along with the objects, these recollections can be treasured, and can be kept around for future generations which may be crucial for the memories they evoke as well as the hard lives and enjoyable times they represent for the people who have passed away. The fabric developed under the study can also be used by the individuals at home to preserve their heirlooms and for some their personal collections.

1.2 OBJECTIVES

1.2.1 To study and understand the preservative practices adopted by textile museums and by individuals at home.

1.2.2 To isolate and identify the microorganisms present on the deteriorated cellulosic and protein fabrics.

1.2.3 To identify the essential oils and develop nanoparticles using the same.

1.2.4 To study and compare the properties of nanoparticles in terms of its particle size, encapsulated efficiency, loading capacity, and retention property.

1.2.5 To determine the minimum inhibitory concentration of the developed nanoparticles and to compare its efficacy using individual and combination of nanoparticles against the selected microbial strains.

1.2.6 Application of the optimized essential nanoparticles on the substrate and to test the microbial and insect repellence.

1.3 SCOPE OF THE STUDY

- The research will provide compelling insights to enhance and address the limitations of conventional techniques for safeguarding and conserving cultural artifacts displayed in museums, without modifying the unique characteristics of the antique textiles.
- The preservative fabric would provide a scientific environment for our heritage textiles to increase its lifespan.
- The developed finish is non toxic and environment friendly.
- The efficacy of the fabric covers a large circumference and for a longer duration due to the control and release mechanism of the nanoparticles involved, thereby providing durability.
- The research would also sensitize the current and future generations about the traditional indigenous practices of preserving the textiles for longer time.

1.4 DELIMITATIONS OF THE STUDY

The study is delimited to the use of cotton and polyester fabric as a substrate for the nanoparticle application. It is also delimited to the use of clove, neem, cinnamon, and carom essential oils.