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Essential Oils in Medical Textile Finishing

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Abstract

The importance of medical textile finishing lies in the medical protective properties it provides, such as protection against bacteria and fungi, as well as its ability to alleviate pain and aid in wound healing, among other benefits. The use of natural resources as sources for these finishes is advisable due to their safety for both the user and the environment. These natural sources are eco-friendly, biodegradable, non-toxic, and non-carcinogenic. Examples of such natural sources include lavender, thyme, and vetiver. These plants yield essential oils through extraction processes containing compounds known for their soothing properties, wound healing capabilities, antibacterial effects, and antifungal properties. Therefore, this article elucidates the findings of previous researchers on this matter.

Key words: medical textile, finishing, lavender, thyme, vetiver.

Introduction

Since the discovery and advancements in yarn and fabric manufacturing techniques, the uses of textile materials in a variety of industries have expanded dramatically. Medical textile is one of the most essential uses of these textile materials. Medical textiles such as personal protective equipment (PPE), dressing materials, bandage, implantable prosthetics, bio-scaffolds and tissue engineering is an important growing sector in technical textile industry, mainly due to the advancements in nanotechnology, biotechnology, and nano-materials which have led to the creation of novel polymers, hydrogels, composites, and fibrous structures with distinct properties for various medicinal uses. Medical textiles are textile structures created specifically for use in a range of medical applications, such as wound healing, implantable textiles, bandaging and pressure garments. It may be made from fibers of natural (cotton, silk, wool etc.) or synthetic (Poly-ester, polypropylene, polyamide, viscose, glass, carbon etc…), and it can also be made from woven or non-woven fabrics.[1, 2]

Generally speaking, textile materials offer a wide range of special qualities, including absorbency, fineness, cross-sectional form, strength, extensibility, flexibility, and air permeability. These characteristics render them perfect for use in medical applications. Medical and healthcare textiles need also to be biologically active to delivering the drug with a controlled rate to the target organ. [2-10]

It also must be biocompatible, hypoallergenic, non-toxic and non-carcinogenic and exhibit certain properties according to the overall purpose. This purpose is achieved by the functional finishing that is carried out on the medical and healthcare textiles. Textile finishing is a final step in textile production in which the textile properties are adjusted or determined according to its end use. Medical textile finishing means giving the textile's surface super-hydrophobicity or hydrophilicity, according to if the intended use specifically demands moisture repellency or absorption. Finishing can also include coating the textile with one or more agents to impart specific properties such as antibacterial, analgesic, anti-inflammatory, anti-allergic, blood coagulation, anti-coagulation, wound healing and prevention of diabetic complications or help the drug absorb or retain its characteristics. [2, 3, 11, 12]

The awareness of Consumers with the benefits of natural sources in textile finishing has grown the demand on using it. Medical textiles finishing can be obtained using essential oils of natural sources

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such as Lavandula angustifolia (Lavender), Thymus vulgaris (Thyme), Vetiver essential oil etc... And also herbal extracts like chamomile tea leaves, turmeric, neem leaves and many more. [12-14] In this review we aim to give an overview and update to the critical role of textiles importance in the healthcare filed by finishing with essential oils of natural sources and to show the present developments in this field.

Medical Textiles generation

The structural, chemical, mechanical, and physical properties of medical textile materials should be developed using a variety of techniques, including surface modification and finishing procedures, in order to enhance the performance of medical textiles for varied applications.[3, 11] From the most important finishing and modification technique for medical textiles are:-

Surface modification

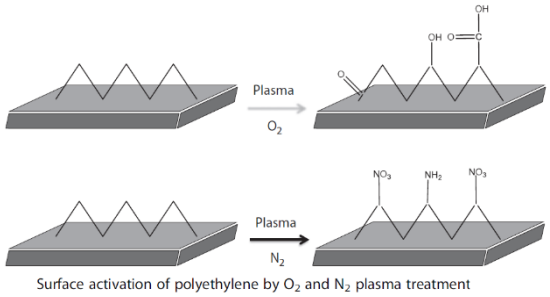
Surface properties acts a vital role medical textile applications , as it involves new functional groups and increase surface wettability, hydrophilicity or hydrophobicity and improve chemical inertness, thus, certain surface modification techniques have been designed to enhance the properties of materials for specific uses such as[3]

Surface coating

Polymeric coatings which can be obtained by using polymeric binders often with cross-linking agents gives long lasting finishing on the textiles to withstand better resistance to wear, hydrolysis, abrasion and repeated washings. The most common types of medical textiles coating are electro-spun nano-fibers, nano-capsules, colloidal nanoparticles, plasma-sputtered coatings, metallic nanoparticles, cold plasma polymerized coatings and nano-coatings such as nano-capsules, nanoparticles and thin films which are used extensively in medical fabrics, textile implants, textile substrates for cell growth, and other medical textiles. Numerous coating technologies exist, including rolling, painting, dipping, spraying, and more. However, microwave and ultrasonic technologies are thought to be novel approaches that can get beyond the shortcomings of conventional procedures.[3]

Plasma treatment

Textile surface modification with plasma treatment, a dry and water-free technique, is an effective technique which gives great characteristics to the surface of modified fabric for different applications. Plasma technology main role is imparting hydrophilic groups to the textiles which are used as blood filters, sterilization the medical fabrics in addition to saving energy, because the fabric won't need to be sterilized before use with high pressure and temperature, reduced thrombogenicity and improved healing rate.[3, 15-18]



Surface activation of polyethylene by O_2 and N_2 plasma treatment

Figure 1

Medical finishing

The way that fibers, yarns, and textiles are functionally finished has a significant effect on textile materials used in the medical industry so that a variety of finishing techniques should be developed to achieve many functions and individual needs such as antibacterial finishing, Anti-odor finishing, Blood coagulant finishing, Blood anticoagulant finishing, Drug delivery applications, Water and blood absorption finishing, Blood repellent finishing, etc... [3, 11]

Table 1

Method	Mechanism	Advantage	Drawbacks
Coating	Drug is directly loaded on to the fabric surface by dipping the fabric in a drug-containing solution or coating it with drug-encapsulated particles	Easy process	Unsuitable for sustained drug delivery
Encapsulation	Drug is loaded into the fiber structure via a diffusion process by soaking the textile fabric in a drug-containing solution	Uniform distribution of drug, suitable for controlled delivery	–
Fiber spinning	Drug-containing fibers can be spun in a number of methods such as melt-spinning, wet-spinning, electrospinning	Controlled drug delivery, high efficiency of drug	Material limitation, time consuming, and complex processing

Essential Oils

Essential oils are found in aromatic plants that are cultivated in tropical and subtropical climates.[14, 19, 20] they are becoming more and more popular as a green alternative in textile finishing, and because they are bio-degradable and environmentally safe, they may be utilized to give textiles specific finishing properties. Certain essential oils have the ability to impart fragrance to textiles while simultaneously possessing antibacterial, antifungal, antiviral, antiseptic, and antioxidant qualities that are beneficial for many textile uses. [21-23]

Among other components of aromatic plants, essential oils are derived from their leaves, flowers, fruits, seeds, buds, rhizomes, roots, and barks.

There are several techniques used to extract essential oils from plants, including solvent extraction, cold pressing, hydro distillation, and supercritical fluid extraction, but steam distillation is the most popular technique.[19, 24-31]

The addition of aromatic essential oils to textiles enhances their worth greatly, providing cosmetic-therapeutic and medical advantages to consumers who prioritize aesthetics in fashion. Aroma textiles can be used to introduce essential oils with a noticeable aura via the surface of human skin because of their skin permeability qualities. The therapeutic and affective benefits of fragrance oil-treated textiles can be experienced via a variety of goods, including fibers, fabrics, non-fabrics, and clothing. [14, 22]

Essential oils Properties

Essential oils are liquid aroma compounds with a volatile quality that are extracted from natural sources, primarily plants. They are used to improve physical and mental health, treat illnesses, and serve as natural substitutes for synthetic preparations used to treat and prevent infectious diseases. They are not found in plants as free-moving materials; rather, they are contained in tiny cellular containers that are taken from the root, seed, trunk, leaf, fruit, and flower, among other sections of the plant. When applied, breathed, or consumed, the distinct chemical composition of each essential oil can react with molecules already existing in the body and mind.[14, 21, 22]

A wide range of human ailments can be prevented and treated with essential oils and their volatile ingredients. These oils function as antioxidants, anti-diabetic agents, antibacterial, antiviral, and have a significant role in the prevention and treatment of cardiovascular illnesses such as atherosclerosis and thrombosis. These oils have therapeutic qualities that make them useful for massage and aromatherapy as well as transdermal medication administration and natural skin penetration enhancers. Aromatherapy is a medical practice that uses only 100% pure plant essences to treat physical, mental, and spiritual illnesses. The brain receives a signal from the aroma of essential oils, which can disrupt the brain's release of neurotransmitters and provide analgesic effects. It can also affect mental, emotional, and physical health as well as relaxation and overall well-being. [21, 32]

Essential oils are highly concentrated plant-based oils that do not include any base oil, alcohol, water, or diluting agent. Instead, they retain the aroma, flavor, and therapeutic qualities of the original plant. These come in a wide range of colors, viscosities, and smell intensities and are, to varied degrees, antiseptic. Some even contain antiviral, antifungal, and antibacterial qualities. [22, 33]

Some examples for Essential oil

Lavender Essential oil

Lavender is a bushy green shrub with woody straight branches that is flowering at the end of each skinny torso where the densely packed layers of flowers seem to be in whorls. Lavender is an important source of excellent scent and widely utilized in aromatherapy. Lavender essential oil has several biological activities such as antioxidant, antifungal, antibacterial, tonic, depressive, anti-rheumatic, anti-inflammatory and insect repellant. It is well-known that the plant's essential oil is the main active component and that the flowers have greater amounts of it.[20, 34-36]

Table 2

Sedative properties for the pharmaceutical and emotional effects of essential oils.

Essential oils	Effects
Basil	Uplifting, clarifying, relieves mental fatigue, improves memory and concentration
Bay Laurel	Stimulating, effective expectorant, builds confidence, reducessleep disorders
Benzoin	Relaxing, comforting, uplifting, warming, reduces stomach aches, insomnia
Bergamot	Uplifting, refreshing, calming, provides antibacterial and antibiotic properties
Black pepper	Soothing, warming, aids digestion, provides antiviral and antioxidant properties
Chamomile	Refreshing, relaxing, calming, soothing, balancing, relieve restlessness
Cedarwood	Sedating, calming, soothing, strengthening, improves concentration
Cypress	Refreshing, relaxing, provides astringent qualities, relieves muscle and joint pain
Clary Sage	Balancing, clarifying, relaxing, soothing, stimulant, tonic, vulnerary
Eucalyptus	Head clearing, provides antiseptic, antibacterial, antiviral, decongestant properties
Fennel	Provides relief from gas and indigestion , antiseptic, antiviral, bactericidal
Frankincense	Relaxing, calming, immune stimulating, anti-aging properties
Geranium	Balancing, sedative, deodorant, diuretic, haemostatic, stimulant, mood-lifting
Ginger	Stimulating, warming, soothing, helps for apathy, shock, headache, migraine
Grapefruit	Uplifting, calming, toning, diuretic, hypertensive, insecticidal, restorative
Helichrysum	Comforting, provides anti-inflammatory properties, promotes appetite
Hyssop	Refreshing, clarifying, provides antioxidant, anti-inflammatory properties
Jasmine	Relaxing, soothing, builds confidence, effective for mental fatigue
Lavender	Refreshing, soothing, provides therapeutic qualities, reduces nervous problem
Lemon	Refreshing, stimulating, uplifting, motivating, restorative, tonic, haemostatic
Lemongrass	Toning, refreshing, fortifying, ease stress and fear, reduces high blood pressure
Mandarin	Calming, soothing, uplifting, detoxing, digestive, hydrating
Melissa	Uplifting, refreshing,nervousness, antiseptic, antiviral, bactericidal
Neroli	Relaxing, dispels fears, uplifting effect, relieves from stress related problems
Orange	Refreshing, relaxing,antiseptic, antiviral, astringent, bactericidal, disinfectant
Patchouli	Purifying, refreshing, sedating, antiseptic, laxative, relieves from grief, depression
Peppermint	Cooling, refreshing, head clearing, relieves mental fatigue and depression
Petitgrain	Stimulating, toning, clarifying, antispasmodic, antidepressant
Pine	Refreshing, stimulating, provides antiseptic, antimicrobial, antirheumatic properties
Rose	Relaxing, soothing, enhances sensuality, builds confidence, disinfectant
Rosemary	Refreshing, stimulating, prevents respiratory infections, improves concentration
Sandalwood	Relaxing, warming, grounding, builds confidence , effective for mental fatigue
Tea Tree	Act as antiseptic, strengthens immune system, relieves circulation problems
Thyme	Act as antiseptic, refreshing, strengthens immune system, relieves from stress
Vetiver	Refreshing, relaxing, calming, soothing, antimicrobial, antirheumatic, antiseptic
Ylang-Ylang	Relaxing, soothing, enhances sensuality, reduces high blood pressure

Table 3: **Lavender essential oil Chemical composition by GC/MS** [20, 36, 37]

No	Compound	%
1	Tricyclene	2.42
2	Artemisia triene	0.035
3	α-pinene	3.35
4	β-pinene	1.2
5	Cineole	23.45
6	Ocimene	1.26
7	4-Thujanol	8.46
8	Linalol	29.40
9	Isophorone	0.05
10	Isophorone (4-Keto)	5.43
11	Camphor	2.41
12	Terpinoel (cisDihydro)	0.56
13	Thuj-3-en-10-al	4.34
14	DihydroCarveol (ISO)	15.90
15	Pulegol (trans)	1.71

Thyme Essential oil

Thyme is a significant medicinal herb that is a member of the Lamiaceae family, and also referred to as Ajwain. Thyme is a herb with therapeutic qualities that are used to cure a variety of illnesses. Steam distillation is used to extract the essential oil of thyme from the plant's newly blossoming aerial portions. It's a crystalline substance with a white color and a strong antiseptic, antioxidant, antibacterial, and antifungal smell. One of the essential oils with several uses is thyme oil, which may be used as an environmentally friendly finishing agent to provide fabrics useful qualities. Thymol (2-isopropyl-5-methylphenol) is the principal phenolic constituent found in thyme.[20, 34, 38]

Table 4: Thyme essential oil Chemical composition by GC/MS

No	Compound	%
1	Thujene	1.3
2	p-cymene	20.46
3	Caren-7ol	0.07
4	Thymol	37.13
5	Methyl thymol ether	1.06
6	α-agarofuran	1.02
7	Spathulenol	1.08
8	Carvacrol	10.07
9	Terpinyl acetate	15.58
10	Caryophyllene oxide	1.08
13	Caryophyllene	2.11
14	Geraniol	0.5
15	Cadinene	2.68
16	Bisabolene	5.91

Vetiver Essential Oil

Vetiver, a grass that native to India, is another example for essential oil plant. It is a multifunctional essential oil; the most important effect of vetiver essential oil is on the nervous system because it works as both strengthening and sedative. For a very long time, aromatherapy has employed it traditionally to relieve stress, depression, anxiety, tension, and sleep deprivation consequently; treating the textiles with vetiver essential oil might result in functionalized textiles with advantageous qualities. The root contains the bulk of the essential oil, which has important floral and medicinal characteristics, making it the most useful portion of the grass. Vetiver contains phenols, glycosides, flavonoids, tannins and alkaloids. [21, 22, 33]

Vetiver essential oil Chemical composition by GC/MS

The GC-MS showed that vetiver oil from ultrasonic extraction composed of the mayor compounds of khusenic acid (36.40%), zierone (13.89%), nootkatone (1.92%), γ-selinene (1.57%), α-vetivone (1.43%), isolongifolene (1.32%), δ-cadinene (0.86%), and khusimene (0.64%).

Essential oils extraction method [19, 20, 34-36]

- The flowering parts, roots and buds of the plants were air-dried then finely ground to convert into powder.
- The essential oil components were extracted by hydro-distillation for four hours to convert into solution form using solvents.
- Finally essential oil extract was filtered then stored at 4 °C in the dark for further use.

Table 5

Compound	Percentage
terpinen-4-ol	3.75
5-epiprezizane	0.71
khusimene	0.66
α-muurolene	1.14
khusimone	1.49
calacorene	0.94
β-humulene	2.37
α-longipinene	4.20
γ-selinene	4.13
δ-selinene	1.63
δ-cadinene	1.72
valencene	2.30
calarene,-gurjunene	9.84
α-amorphene	2.07
epizizanal	3.33
3-epizizanol	2.97
khusimol	12.71
Iso-khusimol	0.57
Valerenol	3.93
β-vetivone	1.62
α-vetivone	2.02

Figure 2

Essential oils for textile finishing

The exhaustion method was used in preparation of treated fabrics with the different essential oils extraction at 40°C for 20 min in a water bath with continues shaking. After that the treated fabrics were dried then cured. [19, 22, 39]

Lavender oil

Lavender essential oil was found to have anti-bacterial activities against positive and negative gram bacteria. The antibacterial activity of lavender essential oil is related to its antioxidant effect. Additionally, it can be shown that the tested samples are effective against Staphylococcus aureus (G^+) growth, which is greater than that of Escherichia coli (G^-). This could be because E. coli has a thick layer of cell walls that keep antibiotic substances from entering and disrupting their metabolism. Furthermore, after 50 days, a strong fragrance was detected; after 60 days, or five things washed, a medium scent was detected. [19, 40]

Thyme oil

The experimental study showed that thyme essential oil has a broad spectrum of antibacterial activity against gram $^{+ve}$ bacteria, and vice versa gram $^{-ve}$ bacteria have a significant resistance to thyme oil, it also has antifungal activity against Candida. This anti-bacterial activity is related to thyme's significant antioxidant effect which attributed to the inhibition of enzyme activity by corrosion the bacterial cell membranes. This is due to the presence of thymol and carvacrol in the structure of thyme which to disrupt the cell membrane of bacteria and causes the death of the cell due to the leakage of intracellular contents. This means that thyme essential oil can be a natural alternative to traditional antimicrobial agents due to its strong antibacterial and antifungal activity.[38, 41, 42]

Vetiver oil

The infusion of aromatic essential oils into textiles confers enormous value and medical advantages, while also invigorating and calming the user due to the distinct scent of the oils. Furthermore, microencapsulation of natural materials is one technique used to extend the endurance of the finish on textile materials, given their very volatile nature. With this method, the active ingredients are applied to the textile materials after being encapsulated in a wall material such as gum acacia, sodium alginate, or modified starch. The most often utilized methods for microencapsulation include spray drying, centrifugal extrusion, air suspension coating, pan coating, polymer-polymer incompatibility, interfacial polymerization, complicated coacervation, and emulsion hardening process. One useful and crucial technique for creating high-quality, health-beneficial products based on oil is microencapsulation.[22, 43, 44]

By employing mixes of alginate and gellan gum to create microcapsules through the inotropic gelation process, vetiver oil may be utilized in cross-linked polymeric microcapsules that have a spherical form and are cross-linked appropriately and repeatedly. The microcapsules composed of alginate-gellan gum blends did not exhibit any chemical interaction with the encapsulated vetiver oil. The microcapsules were found to be capable of delivering a sustained and prolonged release of encapsulated oil, suggesting that it could be used as a sedative.[21, 45, 46] The anti-bacterial properties of the vetiver root extract were shown to be more effective against gram positive bacteria than gram negative bacteria, and it had better antifungal activity against Aspergillus niger than it did against Candida albicans.[45-47]

Recommendations

As mentioned earlier, the importance of using essential oils in medical textile finishing has been emphasized. Additionally, conducting further research and studies on this matter is crucial to explore a wider range of natural sources containing essential oils. This includes identifying more plants containing beneficial essential oils and discovering more effective methods for extracting and applying them in medical textile finishing processes.

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Conflict of Interest

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