Aromatherapy in Textiles

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Studies on aromatherapy and textiles published between 2011–2021 were examined to explore “textile” materials as a possible carrier for essential oils. Mechanisms for the delivery of aromatic compounds on textiles are reviewed.

Keywords: aromatherapy ; textiles ; aromachology ; microencapsulation ; aromatherapeutic textiles ; bio-functional textiles

1. Introduction

Aromatic plants are a class of plants that contain fragrant compounds or essential oils (EO) and can be sourced from petals and flowers, grasses, seeds, stems, leaves, needles, rinds and fruits, roots and rhizomes, woods, and resins. They are overly complex, volatile liquids including terpenes, sesquiterpenes, oxygenated derivatives, aldehydes, oxides, phenols, ethers, acids, and ketones [1]. The earliest reference to essential oils such as sandalwood and cinnamon for human health and wellness dates to around 1200 BC, found in the ancient Hindu scriptures called the Vedas. Likewise, a written order for “imported oil of cedar, myrrh and cypress” was found on a clay tablet believed to be from Babylon dating to 1800 BC [2]. Over 3500 years ago, the Egyptians were using plants for medicine, healing massage, surgery, food preservation and mummification [3]. Such practices were also used by the Greeks and Romans who added their own rituals of fragranced baths and daily massages with fragranced oils [4].

Today, the practice of using essential oils for its positive effect on mood, behavior and wellness is known as “aromatherapy”. The term aromatherapy was coined in 1928 by a French chemist, René-Maurice Gattefossé, who was interested in the use of essential oils for medicinal purposes [5] Today, aromatherapy is defined as the skilled and controlled use of essential oils for physical and emotional health and wellbeing [6]. To bring a more scientific approach to the examination of the effects of essential oils, the term “aromachology” was coined in 1982 by the Sense of Smell Institute and is defined as the scientific analysis of olfactory effects on mood, physiology, and behavior. Although the term ‘aromachology’ did not replace the term ‘aromatherapy’ in the scientific or commercial realms, the new nomenclature did appear to bring more attention to the importance of performing empirical studies on the biological effects and health benefits of essential oils.

1.1. Revival of Aromatherapy

The use of essential oils for health and wellness has seen a resurgence in the late 20th and early 21st centuries. Acceptance of alternative methods to treat medical conditions, such as pain, anxiety, depression, and insomnia with plant-based essential oils is increasing in the world of western medicine [7]. The use has gained popularity due to its cost-effectiveness, fewer-to-no side effects compared to drug therapies, and improvement of patients’ overall sense of health and wellbeing [8]. According to the National Institutes of Health-National Center for Complementary and Integrative Health (NCCIH), Americans spend more than $30.2 billion annually on aromatherapy [9]. It is predicted that the global market for aromatherapy will grow in spending to $5 trillion by 2050 [10].

In the second decade of the 21st century, aromatherapy has shown significant medical effects in studies on dementia [11]; anxiety and depression [12]; pain management [13]; dysmenorrhea [14]; and sleep disorders [15]. However, many research studies that claim to demonstrate the effect of aromatic compounds on human physiology and psychology are vexed with problems. Scientific evidence of the therapeutic benefits of essential oils on human health remains sparse.

1.2. Effect of Aromatic Compounds on Our Senses

Aromatic compounds work on our physiology and senses in many ways. Examples of consumer products that contain aromatics are perfume/cologne, essential oil plug-ins, candles, scented aerosol sprays, fabric softeners, beauty products and food flavorings. Their route into the body can be through inhalation via the olfactory system or by oral ingestion. Upon inhalation of the essential oil aroma, its molecules activate the olfactory, gastrointestinal and/or integumentary systems based on the pathway of activation. These molecules are capable of releasing neurotransmitters such as endorphins to trigger a sense of wellbeing and an analgesic effect [7][8]. Several plant-based essential oils have therapeutic effects on our body and senses; in fact, the discovery of acetyl salicylic acid, the active ingredient in aspirin, is linked to the chewing of willow bark to alleviate pain, inflammation, and fever [16]. Numerous studies have evaluated the effects of aromatherapy on human physiology [17][18][19][20]. Nonetheless, aromatherapy was never accepted as part of mainstream medicine due to the lack of supporting evidence for its effectiveness.

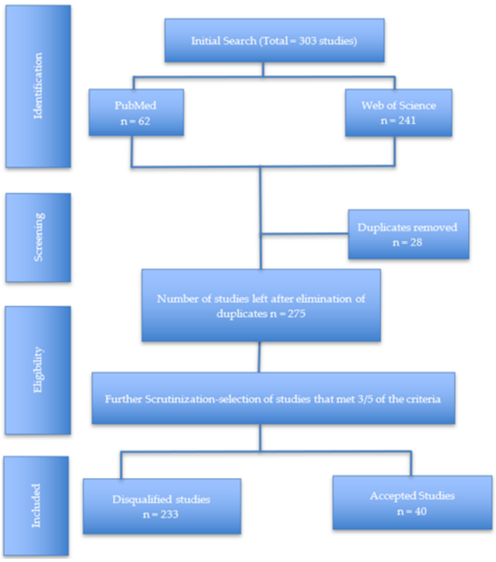

Figure 1. Selection of literature for review.

2. Mechanism for the Delivery of Aromatic Compounds

The most important question for the field of aromatherapeutic textiles is, “how can the therapeutic benefits of essential oils be delivered to the human body for long-term symptom relief?” One of the obvious ways to tackle the release of aroma is to encapsulate the essential oils

2.1. Encapsulation of Aromatic Compounds

With the essential oils being hydrophobic, formulations have been developed to protect their fragrance, bioavailability and pharmaceutical effects [21]. Encapsulation is the most common carrier mechanism, involving building a shell or wall material that entraps the aromatic compound in a miniature sealed capsule. The capsules can be designed to release their contents under specific chemical, physical, or mechanical conditions making it possible to receive the long-term benefit of the aroma at a controlled rate of release (See Figure 2). Encapsulation of essential oils can be developed at micro or nano levels. The technology of nanoencapsulation is growing exponentially and is used in a variety of industrial applications in addition to textiles, such as the food industry, cell immobilization, fermentation, drug delivery, cell transplantation and many more [20][21]. Food and pharmaceutical industries are currently using nanoencapsulation techniques to increase the storage time of volatile active ingredients. The microencapsulation technique also provides targeted release opportunities for the active ingredients in pharmacological drugs. Similarly, textiles embedded with microencapsulated essential oils can be effective in delivering the therapeutic benefits of these essential oils [22][23].

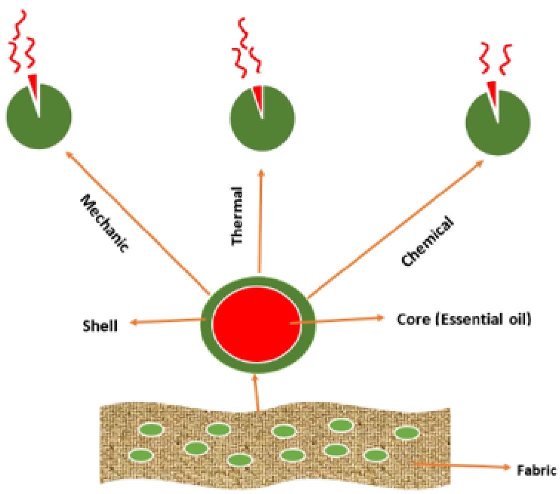

Figure 2. Slow-release mechanism of encapsulated essential oils in aromatherapeutic textiles.

Currently, microencapsulated aroma-textiles are developed mainly for their cosmetological or antimicrobial functions and their therapeutic benefit is rarely measured in empirical studies. The literature on developing textiles with aromatic compounds that will have “therapeutic” benefits and their performance efficacy assessment are essentially missing in the field of aromatherapeutic textiles. Many research studies mentioned the term “aromatherapeutic textiles”, even though the authors of such papers never measured the “therapeutic” benefit of such aroma-textiles. These studies did not include clinical trials with a suitable experimental protocol that measures the intended therapeutic effects of essential oils such as decreased anxiety, pain, heart rate, or improved sleep, for instance.

2.2. Techniques and Examples of Microencapsulated EO on Textiles

There are several techniques used by researchers to embed EO microcapsules on textile materials, such as screen printing [24][25], the impregnation method [24], pad-dry-cure [21][23][26][27] and polymeric nanoparticle formation [28][29][30]. Each technique has its own advantages and effects on the mechanical properties of the material being finished. Melamine-formaldehyde (MF) polymer wall capsules were used to encapsulate lavender, rosemary, and sage essential oils in a study that examined fragrance finishing of cotton [24]. In a surface morphology comparison of the treated textiles, both impregnation and screen-printing techniques produced comparable results and both were deemed appropriate for fragrant clothing [24]. While screen printing was found to provide controlled application on specific target areas of the fabric, which is an advantage, it lowered the air permeability and flexure of the fabric. A further study [25] utilizing the screen printing of (MF) microcapsules to examine separate cores of (1) a mixture of lavender, rosemary, and sage essential oils; (2) the antimicrobial triclosan (TCS) and (3) the fire-retardant try phenyl phosphate (TPP) was undertaken to achieve a fabric with lasting aroma, antimicrobial and flame-retardant properties. The printing of the MCs impacted the mechanical properties of the fabrics but there were no differences in mechanical properties between aroma, antimicrobial, or fire-retardant MCs. All treated fabric samples showed very good durability during washing. This study demonstrated that printing of melamine formaldehyde (MF) MCs can improve the functionality of textiles and may represent a universal approach to explore going forward.

Further research was conducted toward the use of MF microencapsulated essential oils in the cosmetics industry [21]. Rose and sage microcapsules were deposited by padding on 100% cotton and 50% cotton/50% polyester woven fabrics. An acrylate-based binder was used to fix the microcapsules to the fabric. The incorporation of a binder in this process can improve the fabric’s durability through washing and handling [25]. While physical and mechanical tests were performed and revealed minimal influence of the treatments on the fabrics, the major contribution of this study was the evaluation of biological properties. Human skin cells were used for in vitro biocompatibility assessment of the rose- and sage-microencapsulated fabric and confirmed the absence of cytotoxicity after short-term exposure. These findings suggest that fabrics with microencapsulated rose and sage immobilized on them may be good candidates for providing biological properties such as antioxidant, anti-inflammatory, and antibacterial effects for the wearer [21]. Further research in this area is warranted to examine these effects.

Melamine-formaldehyde (MF) and gelatine-carboxymethylcellulose (CMC) as wall materials were used for comparison in a study examining microencapsulated limonene intended as a fragrance for footwear [29]. The comparison demonstrated that the MF microcapsules were more resistant to the thermal and mechanical stresses that footwear would undergo during manufacturing, while the CMC microcapsules were more sensitive and may rupture under those conditions. It was suggested that the CMC microcapsules might still be incorporated into shoe components such as insoles after the more rigorous shoemaking process is completed.

2.3. Environmental Considerations

Nanoparticles (NP) are colloid-sized particles with diameters ranging from 10 to 1000 nm, whereas microcapsules have diameters between a few micrometers and a few millimeters [30][31]. Nanoscale materials are advantageous in microcapsules because they have a higher specific surface that enables more efficient fragrance loading in the cavity of the carrier while optimizing the interaction with the fragrance and its sustained release [28]. However, concerns regarding the accumulation of microplastics in the environment and pending regulations by the European Chemicals Agency (ECHA) have challenged researchers to design polymeric NPs that can demonstrate high adsorption to the textile and low or no desorption when it undergoes scrubbing and recurring washing. With this challenge in mind, researchers synthesized polymeric NPs with different physicochemical properties including surface charge, glass transition temperature, size and degree of cross-linking to examine how they affect the NP adsorption on a 90% Cotton and 10% elastane textile [28]. Surface charge was found to be the most important parameter in adsorption, while the degree of cross-linking had little to no effect. Transition temperature demonstrated that soft PBA NPs adsorbed more than the harder PBMA and PSTY NPs. Regarding size, bigger NPs were better for adsorption but worse in terms of encapsulation efficiency. Trials such as these demonstrate the importance of developing nanoparticles that maximize the interaction between the carrier and the EO encapsulated in the core to avoid NP desorption from the textile and further contamination of the environment with nanoplastics.

There is a continuing effort to develop a system for fragrant textiles using nontoxic and planet-friendly shell materials to encapsulate fragrances that will last through consumer wear and care. The use of bio-based capsules to contain essential oils is a strategy in this direction. Gelatin-arabic gum (GAM) and yeast cell microcapsules (YCM) are low-cost, readily available, safe for human use and non-toxic to the environment, making them suitable containers for essential oils. Researchers found GAM microcapsules to be advantageous over YCM for initial fragrance intensity, fragrance-controlled release and washing durability [26]. GAM was also found to be effective in the controlled release of citronella oil from wool [27]. In another study, plant-based alginate nanocapsules of peppermint oil were used as an antimicrobial for cotton fabrics and found to be effective for reducing *E. coli* and *S. aureus* bacteria while also being durable over repeated washing while maintaining their aroma [30]. Not all synthetic polymers are toxic to the environment. For example, methyl methacrylate styrene copolymer served as shell material for a cologne essential oil nanocapsule created by miniemulsion polymerization [29]. The cologne was created from a combination of lemon oil, rosemary oil and bergamot oil. In this study, the prepared nanocapsules had good thermostability and washing durability, demonstrating positive potential as a treatment for enhancing fragrance durability in functional textiles.

2.4. Use of Cyclodextrin and Aromatic Componds

Another encouraging and more recent contender for a molecular container with the capability for sustained release of an EO from a textile substrate that also overcomes some of the environmental and health-related issues are cyclodextrins [23][32][33][34]. They provide a unique physical structure that has a hydrophilic exterior and a hydrophobic interior cavity, which makes them highly suitable to form inclusion complexes with EOs. They are especially useful in applications in the food, pharmaceutical and agricultural industries due to their biocompatibility and non-toxic nature. The fact that cyclodextrins are also regulated by the US Food and Drug Administration makes them a highly desirable compound for research purposes. Fabrics finished with β-Cyclodextrin and essential oils using the sol-gel method were evaluated by human panels in two studies [23][35]. Lavender and Cedarwood were found to be an effective remedy for stress in the first study that had subjects smell fabric specimens containing the essential oils as compared to a control fabric during an experimental protocol that involved inducing stress on the subjects [23]. In the second study, the intensity of eucalyptus, lavender and lemon fragrances was found to decrease after launderings, but a higher scent intensity was found on a poly/cotton fabric as compared to a cotton fabric. The result was attributed to a higher add-on of the inclusion compound to the poly/cotton [35].

While the use of β-Cyclodextrin is advantageous in prolonging the release of essential oils, a modified form of it, monochlorotriazine -β-Cyclodextrin (MCT- βCD), has been shown to be a more favorable host for functionalizing fabrics [36]. Eucalyptus, peppermint, lavender, jasmine, clove and cedarwood anchored with MCT-βCD on cotton were shown to have enhanced oil retention in washed fabrics over those anchored with βCD alone. Furthermore, no major changes were found in tensile strength, stiffness or air permeability.

2.5. Challenges and Opportunities in the Delivery of Aromatic Compounds

Challenges remain in the delivery of aromatic compounds in textiles and further research is needed on how the physiochemical properties of the various natural and synthetic polymers impact the adsorption of nanoparticles on textiles. The laundering durability of such finishes needs to be investigated. Further investigating the combination of EOs and active compounds to increase their potency, prolonged release and other potential functionalities will serve to stimulate applications for a variety of therapeutic functions. It is expected that continued multidisciplinary applications of microencapsulation and nanoencapsulation of essential oils will help to overcome many of these challenges and enhance future opportunities to improve human health and well-being. Finally, with cyclodextrins offering the advantages of eco-friendliness, controlled release of substance, and being an FDA regulated compound, their continued use and experimentation with aromatic compounds will encourage a host of future textile developments.

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