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REVIEW ON: ADMINISTRATIVE TECHNOLOGIES FOR ESSENTIAL OIL

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Abstract: This abstract illuminates the multi-dimensional essence of essential oils, transcending their aromatic allure to invigorate the mind, body, and spirit. The burgeoning industry has evolved from its conventional perfumed origins to embrace a realm of self-care and holistic well-being. Essential oils, comprised of volatile compounds synthesized across plant components, encompass hydrocarbons and oxygenated elements. The realm of production encompasses both time-honored and innovative techniques, shaping their availability. These oils are channeled through a diverse array of delivery avenues, ranging from aromatherapy to pioneering nanotechnology. The review further delves into the utilization of assorted nanocarriers like liposomes, niosomes, nano-emulsions, and solid lipid nanoparticles. These carriers significantly amplify their attributes, as detailed within. In addition to their sensory appeal, these oils confer safeguarding attributes, combating fungal, bacterial, viral, and insect-related concerns**.**

INTRODUCTION

Essential oils are often recognized for their aromatic qualities, yet beyond their scent, they possess the ability to revitalize the mind, body, and soul.[1] Since the 6th millennium BC, there has been a continuous human fascination with fragrances. Its evolution extends beyond conventional perfumery, now permeating into realms of wellness and personal well-being. [2] Throughout diverse cultures, essential oils have held multifaceted roles. Egyptians employed aniseed, cedar, and myrrh for crafting perfumes, cosmetics, and salves. China and India utilized over 700 substances, such as cinnamon, ginger, myrrh, and sandalwood, for therapeutic reasons, while ancient Greece embraced thyme, saffron, marjoram, caraway, and peppermint for various applications. These oils were valued for their perceived natural and holistic capacity to enhance health.[3] Essential oils possess a strong scent and oily texture, dissolvable in liquid fats, alcohol, ether, or chloroform.[4] The essential oil industry has experienced remarkable growth lately, shifting significantly from its traditional use in perfumes to a prominent role in self-care and wellness. Essential oils are volatile compounds characterized by their low molecular weight[5] biological activities of essential oils are synthesized across various plant parts such as flowers, buds, leaves, stems, branches, seeds, fruits, roots, woods, and more. [1] It's made up of hydrocarbons and oxygen-containing compounds. [5]

Ancient processing techniques for essential oils persist as significant practices globally and include methods like water distillation, steam distillation, cohobation, maceration, enfleurage, cold pressing, microwave-assisted extraction (MAE), and ultrasonic-assisted extraction (UAE).[6] As technology progresses, newer methods have surfaced, and while not widely employed for commercial purposes, they serve specific roles. These methods comprise Headspace trapping techniques, Solid phase micro-extraction (SPME), Supercritical fluid extraction (SFE), Phyto-sol (phytol) extraction, Protoplast technique, and Simultaneous distillation extraction (SDE).[7]

Essential oils offer different ways to be used based on their individual traits and intended purposes. These methods encompass aromatherapy, steam inhalation, bathing, diffusing, compresses, spritzing, and misting.[8] The encouraging aspect lies in the ability of essential oils, possessing significant biological activities, to enhance penetration.[9] Nanotechnology presents a promising avenue for delivering essential oils, particularly in skincare applications.[10]

Plants with medicinal and bioactive properties offer hope for treating incurable diseases. Paracelsus von Hohenheim, a pioneering Swiss physician in medical history, coined the term "Essential Oil" (EO) during the 16th century. Essential oils from plants typically consist of intricate combinations of organic substances, both polar and non-polar in nature.[11,12] They're utilized in embalming and added to foods due to their natural antibacterial and antioxidant properties. Their well-known antiseptic and healing qualities encompass analgesic, sedative, anti-inflammatory, spasmolytic, local anesthetic, and anti-carcinogenic effects. The International Organization for Standardization (ISO/D1S9235.2) defines essential oils as products obtained through water or steam distillation, mechanical processing, or dry distillation of natural materials.[13] They manifest as clear, liquid blends of various aromatic compounds and typically originate from all parts of plants, mainly herbs and spices. Presently, researchers are exploring novel sources for essential oils, including those derived from food and plant remnants.[14] Out of the more than 3000 identified essential oils, about 300 hold economic significance and find primary usage in the fragrance and flavor industries.[13] Essential oils, a varied range of natural products, serve as crucial reservoirs of aromatic and flavoring agents utilized in food, industrial, and pharmaceutical goods. Primarily comprised of terpenes and aromatic polypropionate compounds, they stem from distinct biochemical pathways—acetate-mevalonic acid and shikimic acid pathways, respectively. [15] The chemical composition of essential oils tightly governs their biological activity.[16] For centuries, essential oils have been recognized in folk medicine for their advantageous therapeutic properties and disinfectant qualities. Presently, they are acknowledged as medicinal substances in pharmacopeias. There's a growing curiosity in their application as an alternative means to combat harmful pathogens.[17] The use of essential oil therapy serves as a significant supplementary treatment owing to the antibacterial, antifungal, antiviral, and anti-inflammatory characteristics found in oils from plants like thyme or oregano, along with the anesthetic properties present in clove or lavender oils. [18,19]

Essential oils hold a primary position in the cosmetic and skincare industry primarily due to their delightful and distinctive scents. The market offers a wide array of skincare and cosmetic products leveraging their ability to enhance attractiveness and contribute to cleaning, beautification, nourishment, and perfuming of the human body. Some essential oils, such as orange, lemon, and corn mint oils, are produced extensively, particularly citrus oils, driven by their significant presence in the fragrance and flavoring sectors.[10]

PHARMACOLOGICAL ACTIVITIES OF ESSENTIAL OILS

Anti-microbial profile:

In recent years, essential oils (EOs) have attracted considerable interest due to their antibacterial properties. Studies indicate that essential oils derived from aromatic medicinal herbs exhibit remarkable antibacterial effects against bacteria, yeasts, filamentous fungi, and viruses. Evidence suggests that specific plants like fennel (Foeniculum vulgare), peppermint (Mentha piperita), and thyme (Thymus vulgaris) are effective against a broad spectrum of microbes, including both Gram-positive and Gram-negative bacteria, as well as yeasts, fungi, and viruses. [20,21]

Antifungal profile:

Fungal infections, often recognized by superficial lesions, can range from mild to challenging to manage. Beyond human health, these infections also affect agricultural outcomes. Reports suggest that diseases, weeds, and animals contribute to approximately 20% to 40% of the total decline in agricultural productivity. Such losses have significant repercussions on the economy, the environment, and human well-being.[22] Multiple research works have highlighted the antifungal traits of essential oils derived from diverse plant species. These oils show potential in prolonging the shelf life of products, ensuring their quality, and presenting a promising substitute for artificially produced additives.[23] The study evaluated the inhibition of fungal growth by different essential oils through direct contact on both broth and agar media. It then compared the fungistatic effects of their vapors using a micro atmosphere method.[24] The most potent antifungal effects were observed in plants such as Chenopodium, sassafras, cinnamon, red thyme, imported lemongrass, red Origanum, sweet birch, select savory, and distilled lavender leaves.[25]

Antiviral profile:

Plant products represent a fascinating alternative reservoir for uncovering lead compounds that guide the discovery of new antiviral medications.[26] In traditional medicine, plant extracts serve as therapeutic options to alleviate ailments. The virucidal effects of essential oils from aromatic and herbal plants have demonstrated susceptibility against various viruses like IFV, HSV, HIV, yellow fever virus, avian influenza, among others.[27] Numerous potent antiviral agents, such as cinnamon, clove, eucalyptus, lemongrass, oregano, Lippia, TTO, thyme, and specific oil compounds like carvacrol, 1,8-cineole, eugenol, germacrone, PA, thymol, and terpinen-4-ol, have been identified among essential oils. [28]

Anti-inflammatory:

It's a biological response triggered by harmful stimuli such as infections that damage tissues and cells.[29] The anti-inflammatory properties of essential oils are commonly attributed to their terpenoid content. Compounds like D-3-carene, myrcene, and limonene, among various mono- and sesquiterpenes isolated, exemplify these effects.[30] Apart from various terpenoids known for reducing inflammatory cytokines, multiple essential oils have been employed in treating inflammation. [31] Rosehip seed oil (Rosa canina L.), frankincense (Boswellia sacra), geranium (Pelargonium graveolens), lavender (Lavandula angustifolia), and neroli (Citrus aurantium) essential oils possess properties that aid in alleviating inflammation.[32]

Antioxidant properties:

In traditional medical texts, spice plants are noted for their antioxidant, antibacterial, diuretic, antiseptic, anthelmintic, stimulant, anti-inflammatory, analgesic, and carminative properties.[33] Essential oils consist of diverse organic compounds containing conjugated carbon double bonds and hydroxyl groups. These components possess the ability to donate hydrogen, aiding in the suppression of free radicals and diminishing oxidative stress. [34] The effectiveness of essential oils as antioxidants can be influenced by various factors, including the pro-oxidant or synergistic actions of micro-components, along with concentration, temperature, light exposure, substrate type, and the physical state of the system. These effects operate regardless of the structural features of the essential oils.[35] Due to the significant presence of phenolic compounds in mint plants, their aqueous extracts and essential oils (EO) hold promise as natural antioxidants.[36]

Treats acne effectively:

Acne, typically considered a common condition among adolescents, can also affect women in adulthood. Its varied clinical presentation often involves a mix of non-inflammatory and inflammatory lesions, frequently leading to scarring. [37,38] Several compounds present in essential oils, including linalool, limonene, thymol, carvacrol, - and -pinene, 1,8-cineole, and terpinene-4-ol, exhibit potential for acne treatment. Tea Tree, Eucalyptus, Myrtle, Lavender, Oregano, and Thyme essential oils are among those that might possess anti-acne properties.[39]

Antitumor:

Cancer, a complex genetic disease, exhibits various specific symptoms. It involves altering energy metabolism, evading immune responses, sustaining signals for cell proliferation, circumventing growth suppression, resisting cell death, enabling limitless replication, promoting blood vessel formation, and initiating invasion and spread to other body parts.[40] Recent exploration in natural products has uncovered potential new molecules for anticancer medications, aiming to combat or hinder cancer development. Natural remedies, such as terpenes, have gained increased attention as alternatives in inflammation and cancer treatment. Essential oils, which may contain monoterpenes—a subset of terpenoids, exhibit diverse biological actions under investigation, including their potential anticancer effects. These highly volatile compounds are present in essential oils derived from various plant species.[41]

Pesticide/ mosquito repellent action:

Concerns have arisen regarding the impact of synthetic pesticides used for insect and arachnid control on both the environment and human health.[42] Excessive pesticide usage has become a significant concern due to its adverse effects on the environment. Many plant essential oils demonstrate a diverse range of actions against insect pests and plant pathogenic fungi, offering insecticidal, antifeedant, repellent, oviposition deterrent, growth-regulating, and anti-vector properties. Clove (Eugenia caryophyllus), rosemary (Rosmarinus officinalis), vetiver (Vetiveria zizanoides), lemongrass (Cimbopogon wintering), and thyme (Thymus vulgaris) are renowned for their pest-repelling qualities. Citronella essential oil (Cymbopogon nardus) has been used for over half a century to deter insects and animals.[43]

CONVENTIONAL ADMINISTRATIVE TECHNOLOGIES:

INHALATION

Inhalation stands out as the most prevalent and frequently associated method for aromatherapy delivery. Inhaling essential oils is a swift, convenient, and safe practice.[44] Essential oils can be applied topically through vapor balms or in compact nose inhalers resembling lipstick in size[45], Aromatherapy utilizes various methods like light diffusion, room sprays, or direct inhalation with a tissue or cotton ball soaked in essential oils. It aids in stress relief, mood enhancement, achieving balance, easing minor discomforts, and supporting immune, respiratory, and circulatory functions. However, it's not a remedy for severe conditions. Olfactory aromatherapy stems from inhaling essential oils and has shown benefits in rejuvenating the body, fostering calmness, and improving emotional well-being. Pleasant scents triggering odor-related memories can help release tension. Essential oils complement medical care but should never replace it.[46] Popular oils for inhalation include Frankincense for addressing anxiety and feelings of depression, Myrrh for soothing coughs and sore throats, Peppermint for an energizing effect, Rosemary for enhancing concentration, Clary Sage to ease tension, Chamomile for aiding drowsiness, and Eucalyptus for congestion relief.[47] Research indicates that certain essential oils are more suitable for steam inhalation due to their lower concentration and antibacterial properties, notably citrus oils like lemon or orange, which can be safely used in steaming. Lavender oil, known for its respiratory relaxation effects, is also generally considered safe for steam inhalation. This method aids in addressing various conditions and offers an easy and effective means to benefit from natural therapeutic oils, particularly for sinus congestion and respiratory issues. Vaporized essential oils swiftly clear sinus passages, alleviate congestion, and possess anti-inflammatory properties that ease airway irritation. Additionally, the steam helps loosen nasal mucus, potentially reducing sinus headache pressure and diminishing inflammation throughout the body.[48]

There are numerous ways to inhale essential oils, and several common methods are popular for doing so.

STEAM INHALATION

Inhaling essential oils through steam inhalation can provide relief for individuals dealing with respiratory problems. The vapors from these natural remedies have demonstrated a relaxing effect on the lungs and airways, potentially easing symptoms like shortness of breath and chest tightness. Additionally, steam inhalation with essential oils offers emotional benefits alongside its health advantages, such as:

- Increasing energy levels
- Assisting with stress reduction
- Reducing anxiety

Steam inhalation of essential oils offers numerous therapeutic benefits of natural aromatherapy without requiring expensive materials or specialized equipment. It supports respiratory health, alleviates sinus congestion caused by colds or allergies, and induces a calming and relaxing effect on both the body and the mind.[48,49]

Fig: 1[49]

DIFFUSER

An oil diffuser is a device that converts essential oils into smaller particles and disperses them into the air, creating a pleasant or relaxing ambiance based on the oil used. Its primary function is to evenly distribute these particles at a pleasant concentration, making it easy to breathe and not overwhelming the space. Essentially, a diffuser is employed to introduce beneficial essential oil molecules into a room, creating a soothing atmosphere and imparting a pleasant aroma.[50] In controlled lab settings, essential oils efficiently reduce bioaerosols through cold diffusion.[51] However, some essential oils, especially when used undiluted, might not be suitable for diffusion. Examples of oils that can be used undiluted include bergamot, Asian rosewood, Roman chamomile, cardamom, lemon true lavender, lavandin super, lemongrass, pistachio mastic, lime blossom, and lovage.[52]

Different types of diffusers include:

REED DIFFUSER

In reed diffusers, a blend of fragrance oil and base solution is combined in a narrow-necked glass bottle. Rattan sticks or reeds are inserted into the liquid, allowing them to extend outside the bottle. These reeds absorb the scented liquid and gradually release it into the surrounding air over time, maintaining a continuous aroma throughout the lifespan of the diffuser. Reed diffusers are notably low-maintenance as they do not require machines, heat, power, or fans. All that's necessary are the reeds, the bottle, and the fragrance oil. While reed diffusers provide a constant and hassle-free fragrance, their inability to be turned off poses a drawback. They continually emit scent, making it challenging to regulate or adjust the fragrance level, unlike pricier electric diffusers. This continuous emission might distribute scent unnoticed in an empty house, especially when away for extended periods.[53]

Fig:2[53]

ULTRASONIC DIFFUSER

Ultrasonic diffusers use a combination of water and ultrasonic waves to disperse essential oils into the surrounding space. They come in various sizes and some models include colored lights. Customers have a wide array of sizes and types to choose from in ultrasonic aromatherapy diffusers, which are becoming increasingly popular and are generally among the more affordable non-passive diffuser options. These diffusers not only disperse essential oils but also humidify the room. However, despite their advantages, ultrasonic diffusers might encounter more frequent malfunctions or other operational issues.[54]

Fig:3[54]

NEBULIZING

Nebulizer diffusers employ a unique method to disperse essential oils into the air, operating without the need for heat or water. They utilize a high-pressure airflow through tiny tubes containing essential oils to create a fine mist, distributing it throughout the space.

Advantages of Nebulizer Diffusers

Nebulizing diffusers stand out as they release essential oils into the air without using water or heat, potentially offering distinct advantages compared to other diffuser types. Unlike ultrasonic diffusers, nebulizing diffusers do not contribute to increased indoor humidity levels as they don't use water to create mist. Additionally, some diffusers utilize heat generated by a candle or another heat source, but because essential oils are flammable, diffusing them over an open flame might pose a risk. Depending on the design, nebulizing diffusers can be made entirely of wood and glass, appealing to those seeking to reduce plastic use.[55,56]

Fig:4[55]

Dry evaporation involves using a dry object, such as a cotton ball or fabric, onto which a few drops of essential oil are applied. You can either hold this close to your nose for inhalation or allow the scent to disperse naturally. Additionally, the scented material can be placed on your pillowcase, shirt collar, or in car vents.[50]

MASSAGE

In our fast-paced modern lives, our bodies face significant daily stress to keep up with the demands. [57] Massages, involving skilled hand techniques to manipulate soft tissue, have been among the oldest known therapies in human history, aiming to reduce muscle tension and enhance blood circulation. [58] Throughout documented history, the act of "laying on of hands" served as the primary healing method. [59] It originates from the human inclination to touch, stroke, and massage someone's skin, aiming to provide physiological comfort by stimulating nerve fibers that diminish the transmission of pain signals. [60] It was among the earliest and remains one of the most straightforward forms of healthcare. Skin contact triggers the body's natural pain relievers, endorphins. Massages alleviate muscle tension, subsequently reducing anxiety, sadness, pain syndromes, autoimmune conditions, and problems related to addiction. [59] Additionally, it promotes a feeling of comfort and overall wellness by reducing the stress hormones cortisol and norepinephrine, which can compromise the immune system.[61] Commonly utilized essential oils for massages include Lavender, Frankincense, Bergamot, Mandarin, Geranium, Sandalwood, Lemon, Grapefruit, Rosemary, and Peppermint. [57]

NANOTECHNOLOGY:

To expand the practical use of essential oils and their bioactive components in various industries, innovative strategies are needed. Essential oils present challenges such as high volatility, strong aroma impacting food taste, photosensitivity leading to autoxidation when exposed to UV light or high temperatures, hydrophobicity causing adverse interactions with fats, starches, and proteins, as well as low stability. Overcoming these limitations requires imaginative and cost-effective research to develop safe and efficient delivery methods, enabling broader industrial applications of essential oil-based preservatives and functional compounds.[62] To facilitate the effective delivery of essential oils, nanotechnology is employed. Nanotechnology, considered one of the most advanced technologies of the twenty-first century, involves the manipulation and control of particles ranging in size from 10 to 1000 nm. It's a pioneering scientific field focused on designing, manufacturing, characterizing, and utilizing particles within this specific size range. [63]

Nanoparticles contribute to enhancing the solubility of pharmaceuticals that are typically insoluble, minimizing the systemic toxicity of drugs, improving drug stability within the body, decreasing the probability of drug resistance, and reducing systemic drug toxicity.[64] In biomedicine and the food industry, this technology offers significant potential. Although encapsulation methods vary widely, they generally fall into two primary categories: chemical and physical processes. Among these, chemical processes stand out due to their remarkable effectiveness. [65]

Nanoencapsulation offers numerous advantages beyond safeguarding essential oils, enhancing their solubility in water, masking strong aromas, preventing adverse interactions with food components, facilitating enhanced bioactivity, and enabling targeted delivery. One notable benefit is the reduction in the necessary effective dose to achieve preservative and functional effects. As per the study, EOS-loaded nanovesicles exhibited sustained activity over a month, demonstrating significant antioxidant, anti-inflammatory, and antibacterial properties. [62] Encapsulation of essential oils using nanotechnology is extensively employed to protect these valuable compounds from external factors and regulate their release as per specific requirements. Utilizing bioactive chemical encapsulation proves to be a viable and efficient approach in this context.[66]

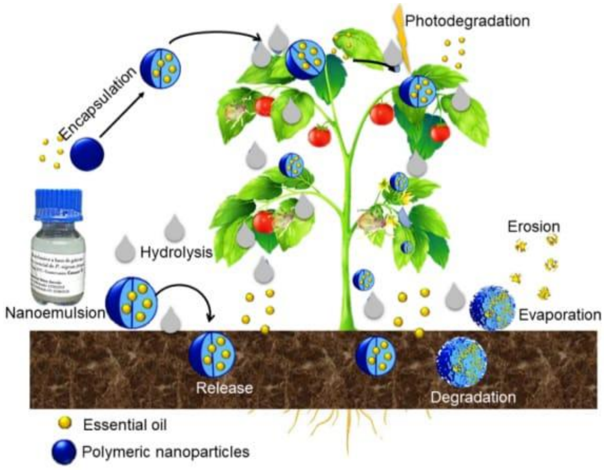

Fig:5

The controlled release can be schematized illustratively, as shown in Figure.[66]
Several nanocarriers, such as liposomes, nano-gels, nanogold, nano-silver, nano-emulsions, solid lipid nanoparticles (SLNs), ribosomes, and niosomes, are utilized as carriers for essential oils. The following section elaborates on these nanocarriers. [10]

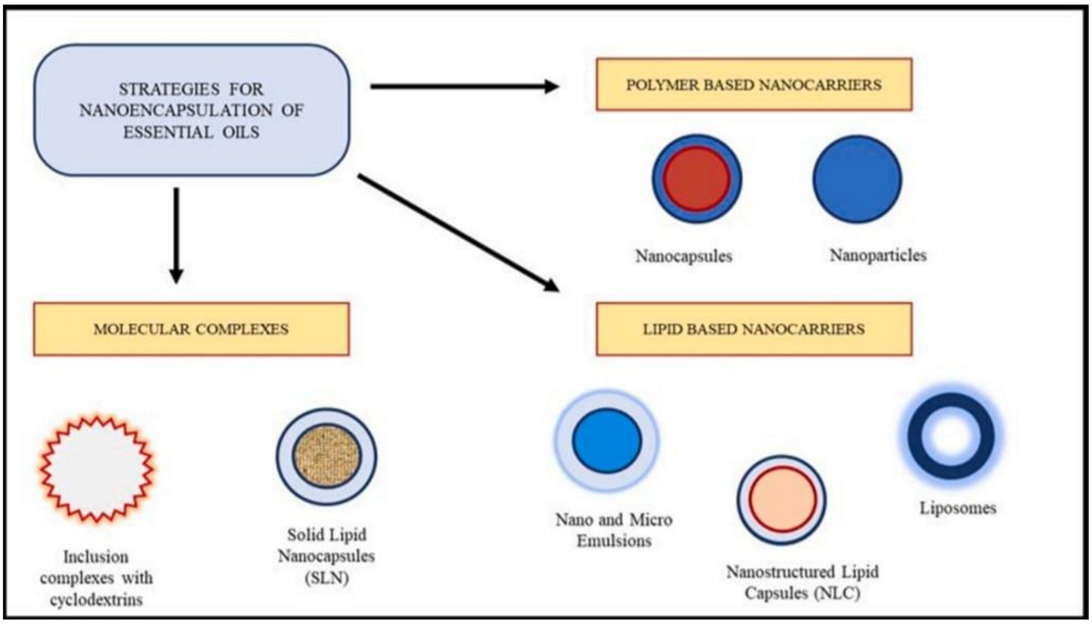

Fig:6

Nanocarriers containing essential oils [10]

NANOPARTICLES

Nanotechnology in medicine has garnered significant attention owing to the distinctive attributes of nanoparticles. Ranging from 10 nm to 1000 nm, nanoparticles are notably smaller than typical pathogens that target cells. Their exceptional physical and chemical properties enable nanoparticles to perform diverse biological functions. Their high surface-to-volume ratio allows for heightened interactions with cell surfaces and access to internal cell environments, leading to enhanced therapeutic effectiveness. Modifying nanoparticles' size, shape, and chemical properties is feasible to further promote interactions with cells, advancing the development of nanoparticles for treating infectious diseases.[67]

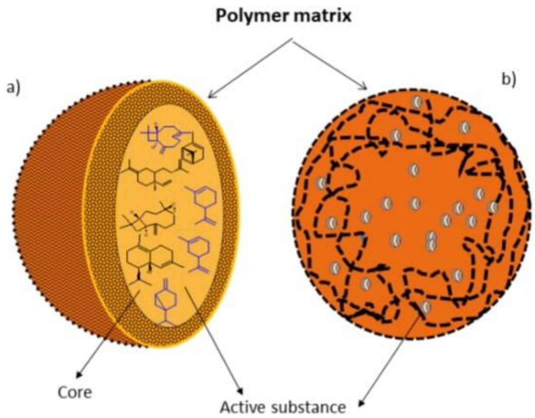

Fig:7 Polymer nanoparticles. (a) Nano capsule: active ingredients dissolved in the matrix core and (b) Nanospheres: active ingredients dissolved throughout the polymer matrix. (Nanoencapsulation of Essential Oils)

SILVER NANOPARTICLE

In nanoscience, silver stands out for its remarkable physical, chemical, and thermal properties, including thermal conductivity, chemical stability, catalytic abilities, and antibacterial activity. Nano-sized silver (nano-Ag) exhibits unique mechanical, optical, and electrical characteristics due to surface and quantum effects, which also influence its chemical reactivity. Recent studies have demonstrated that employing biochemical processes can produce robust, biocompatible, antifungal, antibacterial, and antioxidant silver nanoparticles (Ag NPs). However, the therapeutic effectiveness of synthesized Ag NPs is determined by factors such as their size, shape, surface area to volume ratio, and the composition of the surface modifier. [68] Ag-NPs have found extensive application in the healthcare industry, food preservation, textile coatings, and various environmental uses due to their antibacterial properties. Notably, despite their prolonged use, there remains uncertainty surrounding the toxicity of silver. Ag-NPs have been employed in numerous applications as antibacterial agents.[69]

Antibacterial activity

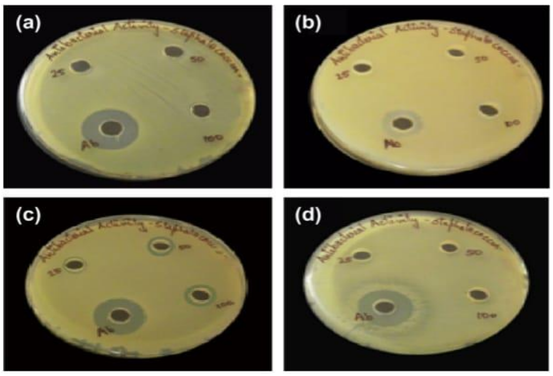

Fig:8

(Mueller–Hinton plates showing inhibition zones by (a) diluted essential oil, (b) silver nitrate, (c) colloid a2, and (d) colloid a5 at different concentrations against S.aureus.)[70]

GOLD NANOPARTICLE

Among the myriad of nanoparticles developed for biomedical purposes, metal nanoparticles, especially gold nanoparticles (AuNPs), exhibit considerable appeal. Gold, being a noble metal, displays high resistance to chemical reactions and offers exceptional biocompatibility, making it well-suited for biomedical applications. Furthermore, gold nanoparticles possess adaptable optical properties reliant on their size, shape, and the surrounding dielectric environment. The versatility of AuNPs extends beyond the inherent qualities of their metallic core; their extensive surface area allows for effective functionalization by diverse biomolecules. The stability and size of these nanoparticles in aqueous solutions, crucial for biological applications, primarily depend on the various ligands attached to the nanoparticle surface, imparting hydrophilic characteristics.[71]

Anti-microbial activity

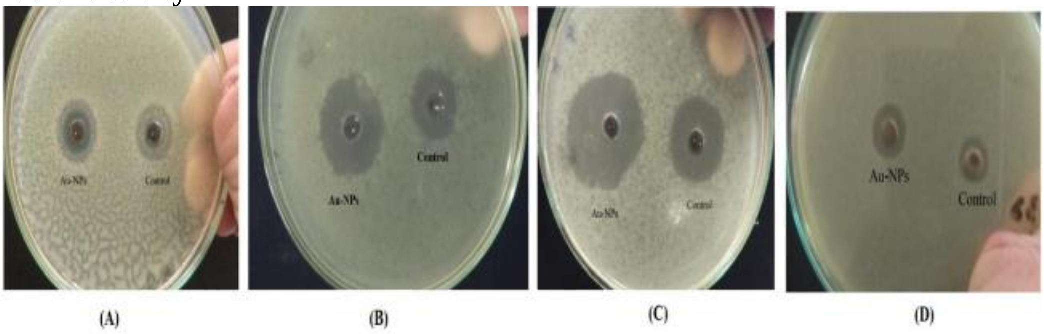

Fig:9

Antimicrobial activity of gold nanoparticles produced by Streptomyces griseus strain (M8) against bacterial species: A) Candidaalbicans, B) Pseudomonas aeruginosa 9027, C) Salmonella typhimurium 14028 and D) Escherichia coli [72]

NANOGEL

Nano-gels, comprised of hydrogel particles at the nanometer scale, are typically formed through the physical interaction between oppositely charged ions, such as chitosan (a polycation) and alginate (a polyanion). These systems find widespread applications, notably in pharmaceutical and medical domains, due to their capability to entrap drugs and bioactive compounds within their nano-gel network. This encapsulation enhances the efficacy, physical stability, and controlled release properties of the substances. The characterization of nanogels involves examining their morphologies, particle size distributions, zeta potential, Fourier transform infrared spectroscopy, and the content of essential oils.[73]

Nano-gels are composed of interlinked polymer chains forming three-dimensional networks at nanoscale dimensions. They are responsive to environmental factors like light, ionic strength, pH, and temperature. Despite this sensitivity, they retain the ability to absorb significant quantities of water or biological fluids while maintaining their structure due to the presence of hydrophilic groups in their chains, such as -OH, -CONH-, -CONH2, and -SO3H. Their distinctive attributes include controlled release capabilities, substantial stability, and a high capacity to hold substances, enabling improved delivery of active compounds to specific sites.[74]

NANO-EMULSION

Nano-emulsions are a specific category of emulsions characterized by droplet sizes ranging from 20 nm to 100 nm. Due to their diminutive droplet size, nano-emulsions typically have a translucent or transparent appearance and exhibit greater stability against phenomena like creaming, coalescence, flocculation, and Ostwald ripening compared to standard emulsions. The creation of the most effective nano-emulsion droplets within emulsions depends on achieving the ideal balance between hydrophilic and lipophilic properties (HLB) and maintaining an optimal concentration of surfactants.[75]

Another promising advancement involves utilizing nano-emulsion as an antimicrobial agent. The antimicrobial properties of EO constituents are commonly harnessed as preservatives in various applications such as foods, therapies, and pharmaceuticals.[76]

Nano-emulsions of essential oils have shown effectiveness against various issues, particularly drug-resistant microbes, even at lower concentrations than traditional therapeutic doses. This reduction in dosage not only lowers costs but also minimizes the adverse effects of high doses. Additionally, these nano-emulsions present significant potential as carriers for drug delivery, offering enhanced stability, improved bioavailability, better skin permeation, and increased absorption. This paves the way for innovative advancements in skincare products and pharmaceutical formulations, enabling the efficient delivery of drugs with anti-inflammatory, wound healing, and sun-protection properties through topical applications.[77]

NIOSOMES

Niosomes, a form of nanoparticle, function as vesicular drug delivery systems formed by the self-assembly of non-ionic surfactants. They offer compartments for both hydrophilic drugs (in their hydrophilic region) and lipophilic medications (in their lipophilic area). These structures are biocompatible, biodegradable, non-immunogenic, and non-toxic. Moreover, they have the potential for targeted delivery, enabling the specific uptake of drugs to designated sites within the body.[78]Niosomes are tiny layered structures made up of non-ionic surfactants and cholesterol.[79] Research involved niosomal gels infused with betel leaf essential oil as an anti-acne remedy. Niosomes enhance skin penetration and the accumulation of the drug in the upper skin layer, while reducing systemic absorption. Niosomes function similarly to liposomes. Betel leaf oil, obtained via steam distillation, was combined with essential oil. Gas chromatography-mass spectrometry was used for identification. The niosomes preparation was created using two types of cholesterol, employing surfactant ratios, particularly 1:1 (F1) and 1:2 (F2; w/w).[80]

SOLID-LIPID NANOPARTICLES

Solid lipid nanoparticles (SLNs) typically exhibit a spherical morphology and range in size from 10 to 1000 nanometers. When aiming for clear formulations, the SLN diameter ideally falls within the range of 50 to 300 nanometers.[81] Studies have indicated that extracts from E. caryophyllata possess antibacterial properties against several pathogenic bacteria, including Campylobacter jejuni, Salmonella enteritidis, Escherichia coli, and Staphylococcus aureus. However, the essential oil from E. caryophyllata faces challenges due to its hydrophobic nature and volatility, which limit its antimicrobial effectiveness. Researchers have explored the use of SLN formulations with diverse components as a strategy to overcome these limitations. Solid lipid nanoparticles (SLNs) are a recognized colloidal drug delivery system widely employed for transporting hydrophobic substances.[82]

ESSENTIAL OIL TOXICITY

The belief that plants used in therapy are inherently safe and non-toxic stems from their historical usage spanning generations. However, scientific research and documented studies have shed light on the potential toxic effects of essential oils commonly applied for skin conditions, including allergic contact dermatitis, skin irritation, and photosensitization.[83] Oils containing phenols and aldehydes can frequently lead to irritation. Essential oils like C. bergamia, which contain furanocoumarins, have been shown to cause phototoxicity.[84] Before incorporating essential oils (EOs) into therapeutic, cosmetic, food, or feed products, it's crucial to investigate their potential toxicity. Testing for toxicity in EOs remains challenging due to the wide variability in active substance content, viscosity, and hydrophobic properties.[85]

CONCLUSION

Increasing demand for essential oils necessitates efficient administrative technologies. It is very interesting to see how nanotechnology is used in products produced by companies around the world. Nanotechnology is a special science that has brought major changes in the 21st century. Scientists have come up with good ideas for research and business. One interesting thing is that more and more people want products that use tiny particles called nanocarriers. These particles can dissolve a wide range of natural and man-made objects and make them last longer. Essential oils (strongly scented oils made from plants) are also being used in new ways. They are combined with tiny particles to create new types of treatments for skin problems. These new blends are used in many skin products such as creams and lotions. These new products are very interesting because they have many positive effects on our skin. Tiny nanotechnology particles and powerful oils work together to help our skin.

It is a favorite of the people who create these products and the scientists who work on them. But it's important to make sure these new products are safe for us and the environment. Usually, products like makeup and lotions just stay on the skin and that's okay. But it's a little different when trying to fix skin problems. Conditions like psoriasis and eczema can overwhelm our skin's natural defenses. You have to be careful what you use in such cases. Some reports indicate that some small materials such as silver and gold can cause problems. Therefore, it is important to test these products to ensure they are safe. However, the tiny particles of nanotechnology can get very close to our skin, so they perform extremely well. This is great for things like sunscreen and products that make you look younger. These new products also help you smell good for longer and prevent it from going bad as quickly. Vitamin C is good for us, but it doesn't always last long when used. But with the help of nanotechnology, we may find a way to create more effective vitamin C products. But you need rules to do it safely.

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