



Novel Drug Delivery System: A Review

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Abstract: A drug's performance in terms of patient adherence, safety, and efficacy can be greatly enhanced by evolving it from a standard form to a unique delivery mechanism. A therapeutic molecule that already exists can be given new life as a Novel therapeutic Delivery System. The release of a medicine at a precise spot at a specific pace presents a number of challenges that can be greatly reduced by a novel drug delivery system that is properly developed. Pharmaceutical companies are working on developing innovative drug delivery systems as a result of the requirement to provide medications to patients effectively and with minimal side effects. The fundamentals of novel drug delivery systems are covered in this article, along with a variety of these systems' varieties.

Key words: NDDS, Conventional drug delivery system, New approach,

Introduction: NDDS is defining of an approach; delivering the drug except for the conventional drug delivery system. It combines cutting edge method with innovative dose forms that are far superior than traditional dosage forms. Plants are nature's remedies and human have used them for food and medicine on earth for a very long time today's global efforts to find herbal remedies in lab plants Size, followed by pre-clinical and clinical trials a company having a reliable human medication supply network. Behind it, nature conceals the basic components of any disease's treatment. However, there is room for improvement in the way herbal medication are distributed [1], [2].

Aim: continual release to enhance patient compliance, among the other things. The development of new treatment related drug delivery method does not draw scientist because of the challenge in standardization, extraction and recognition. Nowadays new and advanced approaches for transportation of medicament provide access through technological advancements. To create network for the distribution of natural Drug modern method for delivering drugs. Thus, the importance of changing in supply of herbal medicine has increased in terms of both therapeutic benefit and toxicity reduction. These new approaches for transportation of medicaments can have a great impact over efficacy of the medicine. There are some drugs which have a ideal

concentration of effect if concentration of these drugs changes from ideal concentration they can either cause toxicity in our body or they can be therapeutically ineffective. As a result, new approaches to manage the pharmacokinetic, pharmacodynamics, toxicity, immune response, biorecognition, and efficacy of drug have emerged[13].

NDDS leads to approaches, formulations, technologies & system that are used for transportation of pharmaceutical compound in body which is required to achieve desired therapeutic effect safely. It may also involve aiding systematic pharmacokinetic in any event. It is frequently related to the amount of drug and duration of drug presence. Additionally, it includes the body's specific scientific site targeting.

Need of NDDS: It do not cause fluctuation of drug level in blood unlike conventional dosage forms. NDDS is advanced techniques of drug delivery which has proven beneficial in terms of drug effectiveness, release of the drug in a controlled manner for the sustainably prolonged effect, targeting ant specific tissue. It maintains the concentration of drug within therapeutically window in ordered to minimize undesired effect and maximize therapeutic benefits. Certain medicine such as antibodies, vaccine, proteins may not be taken through conventional route because of enzymatic degradation and poor bioavailability. Such shortcomings has been tackled with NDDS[19],[20].

Advantages:

- Controlled drug delivery by maintaining required drug concentration and controlled rate.
- Accurate dose of drug.
- Improved efficacy and safety.
- Delivery of optimum dose at specific target/site low toxicity and less side effects.
- Improved patient compliance
- . • Decreased frequency of drug dosing.

Current scenario: India has made considerable in pharmaceutical market out of DDS is one of the major branch. India has made development in two aspects one is manufacturing new excipients and second is development advanced drug delivery technology. Interestingly large number of pharmaceutical industries have appreciated NDDS this lead to increase in product and service offered by NDDS such as ocular transportation of medicine transdermal transportation of medicine , pulmonary transportation of medicine etc. Resultantly a milestone was hit in 2022 noted as sale of 20 USD billion dollarswhereas in 2015 the global market of NDDS was noticed as 12.7 billion USD dollars.

Active compound extraction: The active compounds from the medicinal plant are extracted using various methods such as solvent extraction, supercritical fluid extraction, or microwave-assisted extraction.

Formulation development: The extracted compounds are then formulated into various delivery systems such as nanoparticles, liposomes, microparticles, or solid dispersions. The choice of delivery system depends on the physicochemical properties of the active compounds and the desired therapeutic effect.

Characterization: The formulated delivery systems are characterized for their particle size, morphology, surface charge, drug loading, and drug release properties.

In vitro evaluation: The formulated delivery systems are tested in vitro for their cytotoxicity, bioavailability, and efficacy.

In vivo evaluation: The best-performing delivery systems are then tested in vivo in animal models for their safety, efficacy, and pharmacokinetics.

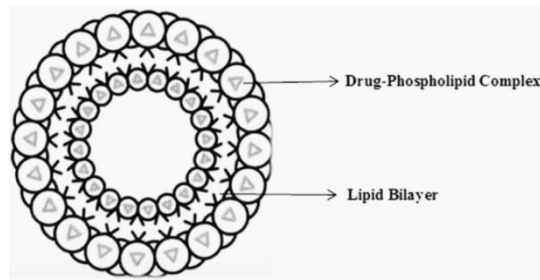
Clinical trials: Finally, the most promising formulations are tested in clinical trials to establish their safety and efficacy in humans.

Recent developments in novel drug delivery system of herbals

- ❖ Phytosomes
- ❖ Nanoparticles
- ❖ Microsphere
- ❖ Ethosomes
- ❖ Solid lipid nanoparticles
- ❖ Controlled drug delivery system
- ❖ Niosomes
- ❖ Proniosomes
- ❖ Dendrimers
- ❖ Liquid crystals
- ❖ Hydrogels

Phytosomes:

Phytosomes are a type of novel drug delivery system that involves complexing plant extracts with phospholipids to enhance their bioavailability and therapeutic efficacy. They have gained



significant attention in recent years due to their potential advantages over conventional drug delivery systems. However, like any other drug delivery system, phytosomes also have their advantages and disadvantage[3].

Let's explore them below:

Advantages of Phytosomes in Novel Drug Delivery System:

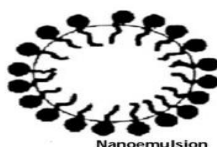
- **Enhanced Bioavailability:** Phytosomes are designed to improve the bioavailability of plant extracts by increasing their solubility and stability, which can result in higher drug concentrations in the bloodstream and target tissues. This can lead to improved therapeutic outcomes as lower doses of the drug may be required to achieve the desired effect[3].
- **Improved Pharmacokinetics:** Phytosomes can alter the pharmacokinetics of the drug by modifying its distribution, metabolism, and excretion. This can lead to prolonged drug action, reduced dosing frequency, and improved patient compliance.
- **Targeted Delivery:** Phytosomes can be designed to selectively deliver drugs to specific tissues or organs, allowing for targeted therapy. This can minimize off-target effects and reduce systemic toxicity.
- **Versatility:** Phytosomes can be prepared from a wide range of plant extracts, making them suitable for various types of drugs and therapeutic applications. They can also be formulated into different dosage forms, including tablets, capsules, creams, gels, and injections, providing flexibility in drug administration[4]

Disadvantages of Phytosomes in Novel Drug Delivery System:

- **Complex Formulation:**Phytosomes require a complex and time-consuming formulation process that involves the preparation of phospholipid complexes, which may increase the production costs compared to conventional drug delivery systems.
- **Limited Research:**Although phytosomes have shown promising results in preclinical and clinical studies, the research on their safety, efficacy, and long-term effects is still limited. Further studies are needed to fully understand their safety and efficacy profiles.
- **Potential for Adverse Effects:**Phytosomes may induce adverse effects related to phospholipids, such as allergic reactions, gastrointestinal disturbances, and changes in lipid metabolism. However, these adverse effects are generally rare and depend on the specific phospholipids used and the individual's sensitivity.
- **Intellectual Property Issues:**Phytosomes may be subject to intellectual property issues, as the composition and formulation techniques used to prepare them can be patented. This may limit the availability and accessibility of phytosome-based drugs in the market.

Nanoparticles

Nanoparticles have emerged as a promising drug delivery system in herbal formulations due to their unique properties, such as small size, large surface area, and high drug loading capacity. They have the potential to improve the therapeutic efficacy of herbal drugs by enhancing their bioavailability, stability, and targeted delivery to specific tissues or cells. Nanoparticles can also enhance the solubility of poorly soluble herbal drugs, thereby improving their bioavailability and therapeutic efficacy[5]



Moreover, nanoparticles can be engineered to have specific surface properties, allowing for targeted drug delivery to specific tissues or cells. This can reduce the systemic toxicity of herbal drugs and enhance their therapeutic index. For example, nanoparticles can be functionalized with ligands or antibodies that specifically target cancer cells, leading to enhanced anticancer effects with reduced side effects compared to conventional herbal formulations.[25].

Nanoparticles in herbal formulations also offer the advantage of sustained or controlled release of the encapsulated herbal drugs, which can result in a prolonged therapeutic effect and reduce the frequency of dosing. This can improve patient compliance and convenience, and optimize the therapeutic outcomes of herbal

drugs. This allows for flexibility in designing herbal formulations for different patient populations and disease conditions..[26].

Emulsion-based formulations

Emulsion-based formulations have gained significant interest in the field of novel drug delivery systems, including for herbal formulations. Emulsions are colloidal dispersions composed of two immiscible liquids, typically oil and water, stabilized by an emulsifying agent. Herbal formulations, which utilize natural plant-based ingredients for therapeutic purposes, can be incorporated into emulsions to enhance their stability, bioavailability, and targeted delivery.

There are several advantages of using emulsion-based formulations for herbal drug delivery:

- First, emulsions can improve the solubility and bioavailability of herbal compounds that are poorly soluble in water, thus enhancing their therapeutic efficacy.
- The oil phase in the emulsion can solubilize lipophilic herbal ingredients, while the water phase can solubilize hydrophilic herbal ingredients, allowing for a wider range of herbal compounds to be incorporated.
- Additionally, emulsions can protect herbal compounds from degradation or oxidation, thereby increasing their shelf life and preserving their potency.

Emulsions can also be formulated to have controlled release properties, allowing for sustained or targeted delivery of herbal ingredients. By modulating the composition and characteristics of the emulsion, such as droplet size, viscosity, and surface charge, the release rate of herbal compounds can be tailored to meet specific therapeutic requirements. This can result in improved therapeutic outcomes and reduced dosing frequency.

Emulsions can also enhance the stability and safety of herbal formulations. The emulsifying agents used in emulsions can act as stabilizers, preventing phase separation and sedimentation of the herbal ingredients, and can also protect them from chemical and physical degradation.

Microspheres

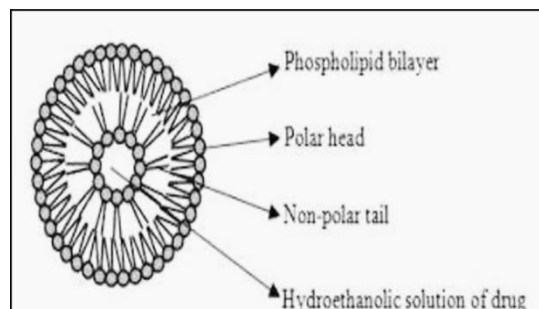
Microspheres are small spherical particles with a size range of 1 to 1000 micrometers that are used in various pharmaceutical formulations for drug delivery. In herbal formulations, microspheres can be used as a targeted drug delivery system to enhance the therapeutic efficacy of herbal drugs[6]. Here's how microspheres can be used in herbal formulations for targeted drug delivery:

- ❖ **Controlled Release:** Microspheres can be designed to release herbal drugs in a controlled manner, providing a sustained release of the drug over an extended period of time. This helps in maintaining a steady concentration of the herbal drug in the body, reducing the frequency of dosing and improving patient compliance.
- ❖ **Site-Specific Targeting:** Microspheres can be engineered to target specific sites in the body where the herbal drug is needed, such as tumors, inflamed tissues, or specific organs. This allows for localized delivery of the herbal drug, reducing systemic side effects and improving the therapeutic effect at the targeted site.
- ❖ **Protection of Herbal Drug:** Microspheres can protect the herbal drug from degradation in the gastrointestinal tract, preventing premature release and improving the bioavailability of the drug. This ensures that the herbal drug reaches the intended site of action in the body with its therapeutic activity intact.
- ❖ **Improved Stability:** Microspheres can enhance the stability of herbal drugs, particularly those that are prone to degradation or have low solubility. Microspheres can encapsulate the herbal drug, protecting it from environmental factors and improving its shelf-life.
- ❖ **Combination Therapy:** Microspheres can be used to deliver multiple herbal drugs or a combination of herbal and conventional drugs in a single formulation. This allows for synergistic effects and improved therapeutic outcomes in herbal formulations.
- ❖ **Customized Formulations:** Microspheres can be tailored to suit the specific requirements of different herbal drugs, such as particle size, surface properties, and drug release characteristics. This allows for customized formulations to optimize the performance of the herbal drug in terms of stability, bioavailability, and targeted drug delivery.

Ethosomes

Ethosomes are lipid-based vesicular carriers that are used to improve the delivery of drugs and bioactive compounds in medicinal plants. They are composed of phospholipids, ethanol, and water, and have a unique structure that allows for enhanced penetration of bioactive compounds through the skin, mucous membranes, and other biological barriers.

In the context of medicinal plants, ethosomes are used as a topical delivery system to enhance the efficacy of bioactive compounds extracted from plant sources. Medicinal plants are known to contain various bioactive compounds such as alkaloids, flavonoids, terpenoids, and phenolic compounds that possess therapeutic properties. However, the bioavailability and efficacy of these compounds can be limited by their poor solubility, stability, and permeability[7].



Ethosomes offer several advantages in improving the delivery of bioactive compounds from medicinal plants. First, they can enhance the solubility and stability of bioactive compounds, thereby increasing their bioavailability. Ethosomes can encapsulate hydrophobic bioactive compounds, protecting them from degradation and improving their solubility in the formulation. Additionally, the ethanol component in ethosomes can act as a penetration enhancer, promoting the permeation of bioactive compounds through the skin or other biological barriers.

Ethosomes have been used in medicinal plant-based formulations for various applications, such as in cosmetics, dermatology, wound healing, and pain relief. For example, ethosomes have been used to deliver bioactive compounds from medicinal plants such as Aloe vera, Curcuma longa, Centella asiatica, and many others for their anti-inflammatory, antioxidant, antimicrobial, and wound healing properties.

Solid lipid nanoparticles (SLNs):-

Solid lipid nanoparticles (SLNs) are a type of nanoparticle that have gained significant attention as a novel drug delivery system. They are composed of solid lipids, which are biocompatible and biodegradable materials, and can encapsulate a variety of drugs, including hydrophilic and lipophilic drugs. SLNs offer several advantages for drug delivery compared to conventional drug delivery systems, such as improved drug stability, enhanced bioavailability, controlled drug release, and reduced toxicity.

The solid lipid matrix provides protection to the encapsulated drug, preventing its degradation and enhancing its stability during storage. SLNs also offer controlled drug release, which is advantageous for sustained or targeted drug delivery. The drug release from SLNs can be tailored by adjusting the lipid composition, particle size, and

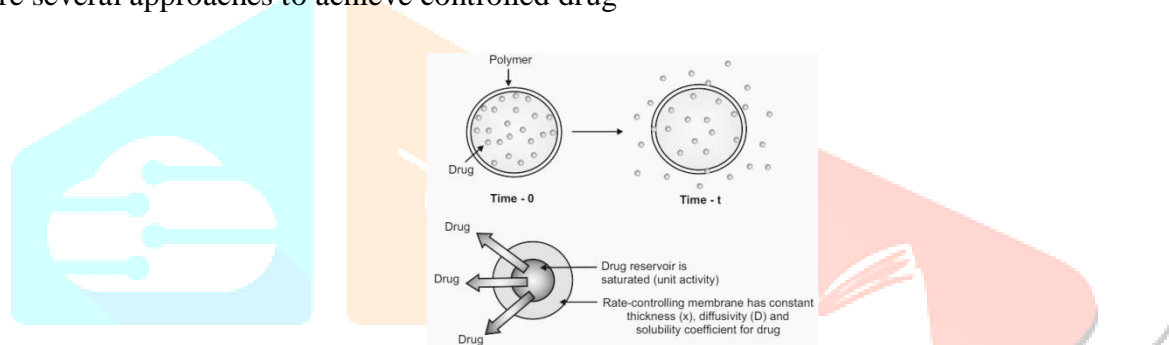
surface modifications. This allows for precise control over the drug release kinetics, leading to prolonged drug action and reduced dosing frequency.

SLNs have been studied for various routes of administration, including oral, parenteral, topical, and pulmonary, and have shown promising results for delivering a wide range of drugs, including anticancer drugs, anti-inflammatory drugs, antibiotics, and many others. SLNs have also been investigated for targeted drug delivery, where they can be surface-modified with ligands, antibodies, or peptides to specifically target certain cells or tissues, improving drug accumulation at the desired site and reducing systemic side effects.

Control drug delivery system

A control drug delivery system in herbal formulations refers to a method or technology that allows for precise and regulated release of active herbal ingredients from a formulation to achieve desired therapeutic effects[12].

There are several approaches to achieve controlled drug



delivery in herbal formulations, including:

- **Microencapsulation**

Microencapsulation involves coating the herbal active ingredient with a protective layer to control its release. This can be achieved using techniques such as spray drying, coacervation, or solvent evaporation. The microcapsules can be designed to release the herbal active ingredient at a specific rate, ensuring controlled and sustained release over time[14].

- **Nanotechnology-based delivery systems**

Nanotechnology has been used to develop various drug delivery systems that can provide controlled release of herbal active ingredients. For example, nanoparticles or liposomes can be used to encapsulate herbal ingredients, allowing for targeted delivery and controlled release at the desired site of action[16].

- **Matrix systems**

Matrix systems involve incorporating the herbal active ingredient into a matrix, which controls its release. The matrix can be made of natural polymers, such as cellulose or chitosan, or synthetic polymers. The release rate can be controlled by modifying the composition, size, or shape of the matrix[15].

- **Time-release formulations**

Time-release formulations involve incorporating the herbal active ingredient into a formulation that releases the ingredient over a prolonged period of time. This can be achieved by using technologies such as slow-release tablets or capsules, transdermal patches, or sustained-release implants[17].

- **pH-sensitive or temperature-sensitive systems**

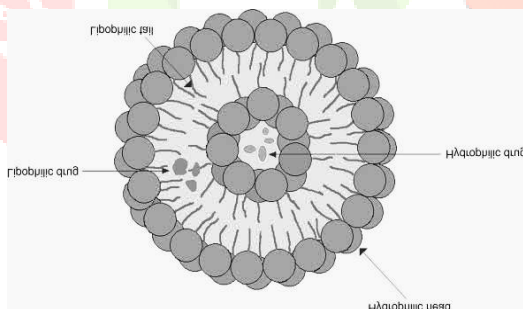
pH-sensitive or temperature-sensitive systems are designed to release the herbal active ingredient in response to changes in pH or temperature at the site of action. For example, the formulation can be designed to release the active ingredient only in the acidic environment of the stomach or in response to body heat.

- **Herbal prodrugs**

Prodrugs are inactive forms of a drug that are converted into their active form in the body. Herbal prodrugs can be designed to release the active herbal ingredient in a controlled manner, ensuring a desired therapeutic effect. For example, ester derivatives of herbal active ingredients can be used as prodrugs that are converted into their active form through enzymatic hydrolysis in the body[24].

Niosomes

Niosomes are non-ionic surfactant-based vesicles that have gained significant attention in the field of drug delivery, including in herbal formulations. Niosomes offer several advantages in targeted drug delivery systems for herbal formulations, including improved drug stability, prolonged drug release, and enhanced bioavailability[8],[9]..



Let's explore the use of niosomes in targeted drug delivery systems for herbal formulations in more detail.

- **Improved Drug Stability:**Herbal formulations often contain active compounds that are sensitive to environmental conditions such as heat, moisture, and light, which can degrade the therapeutic efficacy of the formulation. Niosomes can act as protective carriers for these active compounds, providing a stable environment that helps to preserve their chemical integrity and biological activity.

- **Prolonged Drug Release:**Niosomes can be designed to release the encapsulated herbal active compounds in a controlled and sustained manner, which can help to maintain therapeutic levels of the drug over an extended period of time. This prolonged drug release profile can result in reduced dosing frequency and improved patient compliance. Niosomes can be engineered to release the active compounds in response to specific triggers such as changes in pH or temperature, allowing for targeted drug release at the site of action in the body.
- **Enhanced Bioavailability:**Bioavailability is a crucial factor in the efficacy of herbal formulations as it determines the amount of the active compound that reaches the systemic circulation and the target site. Niosomes can enhance the bioavailability of herbal active compounds by improving their solubility and permeability. Niosomes can encapsulate poorly soluble herbal compounds, enhancing their solubility and allowing for better absorption and distribution in the body. Niosomes can also improve the permeability of herbal compounds across biological barriers such as cell membranes and intestinal epithelium, thereby increasing their bioavailability.
- **Targeted Drug Delivery:**Niosomes can be modified to target specific cells, tissues, or organs in the body, allowing for site-specific drug delivery. Surface modification of niosomes with ligands such as antibodies, peptides, or other targeting moieties can facilitate specific interaction with target cells, improving the localization and accumulation of herbal active compounds at the desired site of action. This targeted drug delivery approach can reduce off-target effects, minimize systemic side effects, and improve the therapeutic index of herbal formulations.

Proniosomes

Proniosomes are a type of drug carrier system that are similar to niosomes, but they are dry and free-flowing powders that can be easily reconstituted into niosomes when in contact with an aqueous medium. Proniosomes have gained attention in the field of drug delivery, including in herbal formulations, due to their unique properties and advantages. Let's explore the use of proniosomes in herbals formulation in more detail[8],[9].

- **Improved Stability:**Herbal formulations often contain active compounds that are sensitive to environmental conditions such as heat, moisture, and light, which can degrade the therapeutic efficacy of the formulation. Proniosomes offer improved stability for these active compounds, as they are in a dry powder form and are less prone to degradation compared to liquid niosomes. Proniosomes can protect the herbal active compounds from degradation during storage and transport, helping to preserve their chemical integrity and biological activity until reconstitution.
- **Flexibility in Formulation:**Proniosomes offer flexibility in formulation, as they can be easily reconstituted into niosomes by simple hydration with an aqueous medium, such as saliva, tears, or body fluids. This allows for ease of administration in various dosage forms, including capsules, tablets, powders, and liquid suspensions. Proniosomes can also be easily combined with other excipients or

herbal ingredients to tailor the formulation to specific requirements, such as improved stability, prolonged release, or targeted delivery.

- **Enhanced Bioavailability:** Proniosomes can enhance the bioavailability of herbal active compounds by improving their solubility and permeability, similar to niosomes. Upon reconstitution, proniosomes form niosomes that can encapsulate poorly soluble herbal compounds, enhancing their solubility and allowing for better absorption and distribution in the body. Niosomes can also improve the permeability of herbal compounds across biological barriers, such as cell membranes and intestinal epithelium, thereby increasing their bioavailability.
- **Controlled Drug Release:** Proniosomes can be designed to release the encapsulated herbal active compounds in a controlled and sustained manner, similar to niosomes. The niosomes formed from proniosomes can provide controlled drug release, helping to maintain therapeutic levels of the drug over an extended period of time. This can result in reduced dosing frequency, improved patient compliance, and optimized therapeutic outcomes.
- **Targeted Drug Delivery:** Proniosomes can be modified to target specific cells, tissues, or organs in the body, similar to niosomes. Surface modification of niosomes formed from proniosomes with targeting moieties can facilitate specific interaction with target cells, improving the localization and accumulation of herbal active compounds at the desired site of action. This can result in enhanced efficacy and reduced off-target effects..

Dendrimers

Dendrimers are highly branched, tree-like nanostructures that have been investigated as novel drug delivery systems in herbal formulations. They offer several unique properties that make them attractive for drug delivery applications, including their well-defined structure, uniform size, and the ability to encapsulate drugs within their interior or attach them to their surface. When used in herbal formulations, dendrimers can enhance the therapeutic efficacy and bioavailability of herbal drugs, and also improve their stability, solubility, and controlled release[2].

Liquid crystals

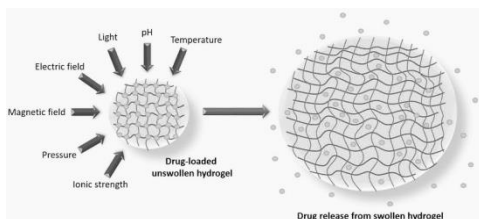
Liquid crystals are a unique state of matter that exhibit properties of both liquids and solids. They are characterized by their ability to flow like a liquid, while also exhibiting long-range molecular order like a solid. Liquid crystals have been used in various applications, including in herbal formulations, due to their unique properties[10].

In herbal formulations, liquid crystals can be used as carriers or delivery systems for herbal ingredients, allowing for improved stability, bioavailability, and controlled release of active compounds. Here are some ways in which liquid crystals can be utilized in herbal formulations:

- ✓ **Improved solubility:** Some herbal ingredients have poor solubility in traditional liquid or solid dosage forms. Liquid crystals can be used to solubilize such ingredients, increasing their bioavailability and improving their therapeutic efficacy.
- ✓ **Enhanced stability:** Liquid crystals can help protect herbal ingredients from degradation, oxidation, or other forms of instability, thereby extending their shelf life and maintaining their potency.
- ✓ **Controlled release:** Liquid crystals can be formulated to release herbal ingredients in a controlled and sustained manner, allowing for prolonged therapeutic effects and reducing the frequency of dosing.
- ✓ **Enhanced skin penetration:** Liquid crystals can be used in topical herbal formulations to enhance the penetration of active ingredients into the skin, improving their absorption and effectiveness in treating skin conditions.
- ✓ **Formulation flexibility:** Liquid crystals offer a wide range of formulation possibilities, including gels, creams, lotions, and other dosage forms, providing flexibility in developing herbal formulations with desired properties.
- ✓ **Enhanced sensory experience:** Liquid crystals can improve the sensory experience of herbal formulations, such as providing a smooth texture, enhancing the appearance, and improving the overall feel and application of the product.

Hydrogels

Hydrogels are three-dimensional networks of hydrophilic polymer chains that can absorb and retain large amounts of water. They have gained significant attention in the field of drug delivery due to their unique properties, such as high water content, biocompatibility, and tunable mechanical properties. In recent years, hydrogels have been explored as a novel drug delivery system in herbal formulations[11].



Herbal formulations, which are derived from natural sources, have been used for centuries in traditional medicine for their therapeutic properties. Incorporating hydrogels into herbal formulations can offer several advantages in terms of drug delivery. Here are some ways hydrogels can be used as a novel drug delivery system in herbal formulations:

- ❖ **Controlled release of herbal drugs:**Hydrogels can be designed to have controlled release properties, allowing for sustained release of herbal drugs over an extended period of time. This can help maintain therapeutic drug levels in the body, reducing the frequency of dosing and improving patient compliance.
- ❖ **Protection of herbal drugs:**Hydrogels can encapsulate herbal drugs, providing protection against degradation, oxidation, or other forms of instability. This can help preserve the potency and effectiveness of the herbal drugs, ensuring their optimal performance.
- ❖ **Enhanced bioavailability:** Hydrogels can improve the bioavailability of herbal drugs by increasing their solubility and stability. This can result in higher drug concentrations at the target site, leading to improved therapeutic outcomes.
- ❖ **Site-specific delivery:**Hydrogels can be designed to target specific sites within the body, allowing for site-specific delivery of herbal drugs. This can be particularly useful for herbal formulations that require localized treatment, such as in skin conditions or gastrointestinal disorders.[27].
- ❖ **Combination therapy:**Hydrogels can be used to deliver multiple herbal drugs or combine herbal drugs with synthetic drugs, allowing for combination therapy in a single formulation. This can offer synergistic effects and improved therapeutic outcomes.
- ❖ **Ease of formulation:**Hydrogels can be formulated into various dosage forms, including gels, films, beads, and patches, making them versatile for different routes of administration, such as oral, topical, and transdermal. This can provide flexibility in formulating herbal formulations to suit specific patient needs.
- **Biocompatibility:**Hydrogels are generally biocompatible, meaning they are well tolerated by the body and have low toxicity. This makes them suitable for use in herbal formulations, which are often preferred for their natural and safe characteristics.[23].

Herbs used as a novel drug delivery system offer several advantages, including their natural origin, biocompatibility, and potential for enhanced therapeutic efficacy. However, further research is needed to optimize their formulation, stability, safety, and regulatory approval before they can be widely used in clinical practice. It is important to consult with a qualified healthcare professional before using any herbal-based drug delivery system for therapeutic purposes.[22].

Here are some reasons why a novel drug delivery system is important in herbal formulations:

- **Enhanced Bioavailability:**Herbal ingredients often have low bioavailability, which means that their absorption and distribution in the body may be limited. Novel drug delivery systems, such as nanoemulsions, liposomes, and solid lipid nanoparticles, can improve the bioavailability of herbal ingredients by increasing their solubility, stability, and permeability. This can lead to improved therapeutic outcomes and reduced dosage requirements.
- **Controlled Release:**Herbal formulations may require sustained or targeted delivery to maintain a constant therapeutic effect over an extended period of time or to deliver the active ingredients to specific

sites in the body. Novel drug delivery systems, such as microspheres, nanoparticles, and transdermal patches, can provide controlled release of herbal ingredients, allowing for better dosing control and minimizing potential side effects.

- **Increased Stability:**Herbal ingredients can be sensitive to environmental factors such as light, heat, and moisture, which can lead to degradation and loss of potency. Novel drug delivery systems can protect herbal ingredients from such environmental factors, ensuring their stability during storage and transportation, and maintaining their therapeutic efficacy over time.
- **Improved Targeting:**Herbal formulations may need to be targeted to specific tissues or cells in the body for optimal therapeutic effect. Novel drug delivery systems can facilitate targeted delivery of herbal ingredients to the desired site of action, such as using ligand-conjugated nanoparticles that specifically bind to receptors on target cells, thereby enhancing the accumulation of herbal ingredients at the intended site of action.
- **Enhanced Patient Compliance:**Herbal formulations are often administered orally, and compliance with dosing regimens can be a challenge for some patients. Novel drug delivery systems, such as transdermal patches, intranasal sprays, or inhalation devices, can offer alternative routes of administration that may be more convenient, comfortable, and acceptable to patients, leading to improved compliance and better treatment outcomes.
- **Innovation and Intellectual Property:**The development of novel drug delivery systems for herbal formulations can lead to intellectual property protection, which can provide incentives for further research and development in the field of herbal medicine. It can also open up new opportunities for product differentiation and market exclusivity, which can be valuable for commercialization and business sustainability.[21]

Here are some key reasons why novel drug delivery systems are important in herbal medicine:-

- **Enhanced bioavailability:** Herbal medicines often contain complex mixtures of bioactive compounds that may have low bioavailability, meaning they are not easily absorbed by the body. Novel drug delivery systems can help enhance the bioavailability of herbal medicines by improving their solubility, stability, and absorption. This can result in more effective and predictable therapeutic outcomes.
- **Controlled release:** Many herbal medicines require sustained or controlled release of their bioactive compounds to achieve optimal therapeutic effects. Novel drug delivery systems, such as nanoencapsulation and microencapsulation, can provide controlled release of herbal compounds, allowing for prolonged and sustained delivery of the active ingredients to the targeted site of action. This can help improve the efficacy and safety of herbal medicines by minimizing fluctuations in drug concentration and reducing the frequency of dosing.[28].

- **Targeted delivery:**Herbal medicines often have multiple bioactive compounds with different pharmacological activities, and their efficacy may be limited by non-specific distribution in the body. Novel drug delivery systems can enable targeted delivery of herbal compounds to specific organs, tissues, or cells, improving their therapeutic effects while minimizing side effects on non-targeted tissues. This can be achieved through various strategies such as encapsulation, conjugation, and ligand-mediated targeting, among others.
- **Improved stability:**Herbal medicines are often susceptible to degradation, oxidation, and other chemical reactions that can affect their stability and potency. Novel drug delivery systems can protect herbal compounds from degradation, improve their stability, and prolong their shelf life, ensuring that the herbal medicine retains its efficacy and safety over time.[29].
- **Patient compliance:**Herbal medicines are commonly administered orally, but their bitter taste, strong odor, or large dosages may pose challenges to patient compliance. Novel drug delivery systems can help overcome these challenges by improving the organoleptic properties of herbal medicines, reducing their dosages, and providing alternative routes of administration, such as transdermal, nasal, or inhalation routes, which may be more convenient and acceptable to patients.

A novel drug delivery system refers to an innovative approach to delivering a drug to the body in a controlled and targeted manner, with the goal of improving its therapeutic efficacy, reducing side effects, and enhancing patient compliance. However, it's important to note that the development and approval of novel drug delivery systems require rigorous testing and regulatory approval, and should be done under the guidance of qualified healthcare professional.[30].

Formulation of NDDS in herbals:-

Formulation	Active ingredients	Biological activity
Ginkgobilobaphytosomes	Flavonoids	Cardioprotective, antioxidant activity
Ginseng phytosomes	Ginsenosides	Nutraceutical
Grape seed lipid based system	Epigallocatechin	Systemic antioxidant
Liposomes encapsulated silymarin	Silymarin	Hepatoprotective
Garlicin liposomes	Garlicin	Lungs
Matrineethosome	Matrine	Anti inflammatory
Artemisnin	Artemisnin	Anticancer
Silybinnanoemulsion	Silybin	Hepatoprotective

Conclusion:-

This review gives information about novel drug delivery system in herbals, their types, Formulation, herbal drugs used and current market status of novel drug delivery system in herbals. An extensive research is going on in the area of novel drug delivery and targeting for plant actives and extracts. However, research in this area is still at the exploratory stage. Many problems in the research, production and application need to be solved. In addition, more attention should be paid to the research on the carrier materials in order to develop more suitable carriers which can reduce the toxicity of drugs, enhance their activity and improve the overall quality of the agents. Herbal medicines have been widely used all over the world since ancient times and have been recognized by physicians and patients for their better therapeutic value as they have fewer adverse effects as compared with modern medicines. The drugs of ayurvedic origin can be utilized in a better form with enhanced efficacy by incorporating in modern dosage forms. However, phototherapeutics need a scientific approach to deliver the components in a novel manner to increase patient compliance and avoid repeated administration. This can be achieved by designing novel drug delivery systems for herbal constituents.

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