

Nanoparticles for Herbal Extracts

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Abstract

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. Phytotherapeutics need a scientific approach to delivering the components in a sustained manner to increase patient compliance and avoid repeated administration. This can be achieved by designing novel drug delivery systems (NDDSs) for herbal constituents. NDDSs not only reduce the repeated administration to overcome non-compliance but also help to increase the therapeutic value by reducing toxicity and increasing the bioavailability. One such novel approach is nanotechnology. Nano-sized drug delivery systems of herbal drugs have a potential future for enhancing the activity and overcoming problems associated with plant medicines. Hence, integration of the nanocarriers as an NDDS in the traditional medicine system is essential to conflict more chronic diseases such as asthma, diabetes, cancer, and others. The article describes nano drug delivery systems, properties, advantages, disadvantages, types of nanoparticles, their method of preparation, different nano herbal medicines, and nano herbal cosmetics available in the market.

Key words: Herbal drugs, nanotechnology, novel drug delivery systems

INTRODUCTION

Importance of herbal medicine

Since ancient time, herbal remedies and natural products (NPs) are being used to cure the diseases.^[1] NPs that are isolated from the plants are known as “herbal remedies.” Practically, herbal remedies have the date back long history to the existence of the human civilization. New medicines are being developed and will be developed gradually by the scientists through the different ways. However, always ancient or herbal remedies and NPs have been the roots of these medicines. In the ancient time, before the arrival of high throughput screening concerned to drug discovery, 90–95% drug materials were NPs.^[2] Information on the source of new drugs nearby 1981–2007 specifies that approximately half of the drugs are based on the NPs.^[3,4] It has been proved that NPs are more voluntarily absorbed than synthetic drugs. Although the herbal formulations are not expected to treat diseases properly, they can help in better management of diseases by the patient himself. It can improve the quality of life by giving nutritional supplement as well. Silver nanoparticles have been synthesized for *Cardiospermum helicobacum* leaf extract.^[5]

The pharmaceutical companies were laid when techniques were developed to produce a synthetic replacement for many of the medicines that had been derived from the forests. Now, the pharmaceutical efforts are cracking to developing the new pioneering or indigenous therapies and development the uniqueness of plant-based drugs or herbal remedies.^[6]

Novel drug delivery system

The aim of novel drug delivery system (NDDS) is to provide a therapeutic amount of drug to the appropriate site in the body to accomplish promptly and then maintain the desired drug concentration. The drug delivery system should deliver drug at a rate control by the necessarily of the body over a specified term of treatment. The prime areas of research and development for NDDS are liposomes, noisome, nanoparticles, transdermal drug delivery, implants, oral

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system, microencapsulation/microcapsules, and polymer in drug delivery.

Nano drug delivery systems for herbal extracts

Phytotherapeutics need a scientific approach to deliver the components in a sustained manner to increase patient compliance and avoid repeated administration. This can be achieved by designing NDDSs for herbal constituents NDDSs not only reduce the repeated administration to overcome non-compliance but also help to increase the therapeutic value by reducing toxicity and increasing the bioavailability.^[7] The novel carriers should ideally fulfill two prerequisites. First, it should deliver the drug at a rate directed by the needs of the body over the period of treatment. Second, it should channel the active entity of herbal drug to the site of action. Conventional dosage forms including prolonged-release dosage forms are unable to meet none of these. It has a number of advantages for herbal drugs including enhancement of solubility and bioavailability, protection from toxicity, enhancement of pharmacological activity, enhancement of stability, improving tissue macrophages distribution, sustained delivery, and protection from physical and chemical degradation. Thus, the nano-sized NDDSs of herbal drugs have a potential future for enhancing the activity and overcoming problems associated with plant medicines. Nanocarriers applying to herbal remedies will carry the optimum amount of the drug to their site of action bypassing all the barriers such as acidic pH of stomach, liver metabolism, and increase the prolonged circulation of the drug in the blood due to their small size.^[1,8] Hence, use of herbal remedies in an NDDS will enhance the improvement in the use of herbal remedies that will come forth to treat the various chronological diseases.^[9]

Nanotechnology is approaching new paradigm for drug delivery system by their unique small size and controlled release of the drug. Hence, using “herbal remedy” in the nanocarriers will increase its potential for the treatment of various chronic diseases and health benefits. This field of pharmaceutical technology has grown and diversified rapidly in recent years and emerged tremendously from macro level to micro level and currently growing at molecular level, i.e., nano level. The importance of technology in the field of pharmaceuticals and medicine has been ever growing due to the changing trends of developing drugs and drug delivery systems.^[10] Nanotechnology in some NDDSs like ocular drug delivery has been used to enhance the bioavailability by overcoming the drawbacks of the conventional dosage forms. This is possible due the capacity of the nanocarriers to protect the encapsulated drug molecule and transport it to various areas of the eyes^[11-13] [Figure 1].

Nanoparticles

Nanoparticles are particles between 1 and 100 nanometers in size. In nanotechnology, a particle is defined as a small object that behaves as a whole unit with respect to its transport

and properties. Particles are further classified according to diameter [Figure 2].^[14]

Properties of nanoparticles^[15-17]

- They are effectively a bridge between bulk materials and atomic or molecular structures
- The high surface area to volume ratio of nanoparticles provides a tremendous driving force for diffusion, especially at elevated temperatures. Sintering can take place at lower temperatures, over shorter time scales than for larger particles
- Suspensions of nanoparticles are possible since the interaction of the particle surface with the solvent is strong enough to overcome density differences, which otherwise usually result in a material either sinking or floating in a liquid
- Nanoparticles also often possess unexpected optical properties as they are small enough to confine their electrons and produce quantum effects. For example, gold nanoparticles appear deep red to black in solution
- Nanoparticles with one-half hydrophilic and the other half hydrophobic are termed Janus particles and are particularly effective for stabilizing emulsions. They

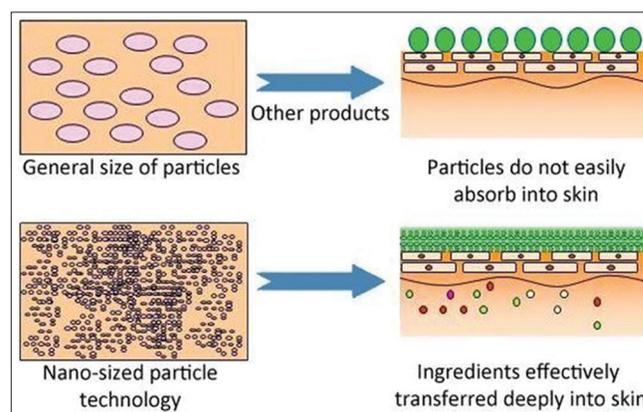


Figure 1: Transport of drug molecules through skin

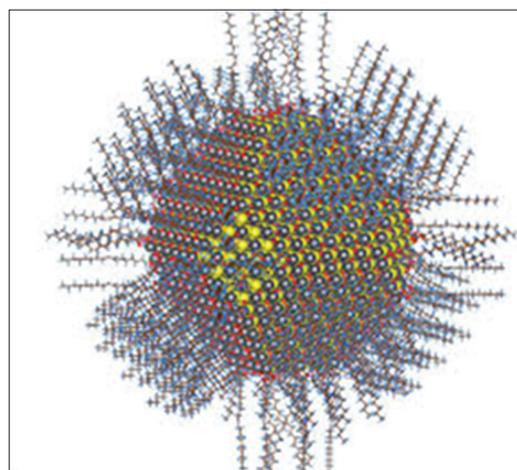


Figure 2: Nanoparticle

can self-assemble at water/oil interfaces and act as solid surfactants

- The photocatalytic activity of the nanoparticles must not lead to a self-destruction of the composite system, and it is essential to check this point before fixing a combination of polymer matrix and nanoparticles.

Role of nanoparticles^[18]

- To deliver the drug in the small particle size that enhances the entire surface area of the drugs allocating quicker dissolution in the blood
- Drug delivery system is targeted in a specific manner
- Permeation of the drugs across epithelial and endothelial barriers
- To deliver the drugs at sites of action
- Combined therapy of the two different modalities or drugs.

Advantages of nanoparticles over other NDDS

- Due its small size than microspheres and liposome's they can easily pass through the sinusoidal spaces in the bone marrow and spleen as compared to other systems with long circulation time
- Nanoparticles increases stability of drug/proteins against enzymatic degradation
- They offer a significant improvement over traditional oral and intravenous (IV) methods of administration in terms of efficiency and effectiveness
- It reduces the toxicity of liver.

Disadvantages of nanoparticles over other NDDS

- Due to high surface area and energy, they tend to high aggregation in biological system
- High immunogenicity
- Long and expensive to cost
- Chance of poor targeting.

TYPES OF NANOPARTICLES

There are two types of nanoparticles, and they are inorganic and organic.

Inorganic nanoparticles

The various types of inorganic particles, namely, magnetic, metallic, ceramic and nanoshells, their description, size, advantages, disadvantages, and applications are produced in Table 1.

Organic nanoparticles

The various types of organic nanoparticles, namely, carbon nanotubes, quantum dots, dendrimers, liposome and polymers, their description and size are described in Table 2.

Table 1: Inorganic nanoparticles^[19]

Inorganic compound	Description	Size range (nm)
Metallic	Gold and silver particles	<50
Magnetic	Super paramagnetic iron oxide particles	5–100
Nanoshells	Dielectric silica core in a thin gold metal shell	10–300
Ceramics	Inorganic porous biocompatible materials	<100

Table 2: Organic nanoparticles^[19]

Organic compound	Description	Size range (nm)
Carbon tubes	Cylindrical graphite sheets	1.5–5000
Quantum dots	Semiconductor crystals with a cadmium core and metal shell	<10
Dendrimers	Highly branched macromolecules	5–20
Liposomes	Phospholipids	5–100
Polymers	Colloidal particles	10–1000

METHODS OF PREPARATION OF NANOPARTICLES

High-pressure homogenization method

In this method, the lipid is pushed with high pressure (100–2000 bar) through a very high shear stress, which results in disruption of particles down to the submicrometer or nanometer range. High-pressure homogenization method is a very reliable and powerful technique for the large-scale production of nanostructured lipid carriers, lipid drug conjugate, solid lipid nanoparticles (SLNs), and parenteral emulsions [Figure 3].^[20,21]

Solvent emulsification-diffusion method

The method involves preparation of an o/w emulsion using oil phase containing polymer and oil in an organic solvent, which is emulsified with the aqueous phase, containing stabilizer, in high shear mixer, followed by addition of water to induce the diffusion of organic solvent, thus resulting in formation of nanoparticles [Figure 4].^[20]

Salting-out method

This method is based on the phenomenon that solubility of a non-electrolyte in water is decreased on addition of an electrolyte [Figure 5].^[20]

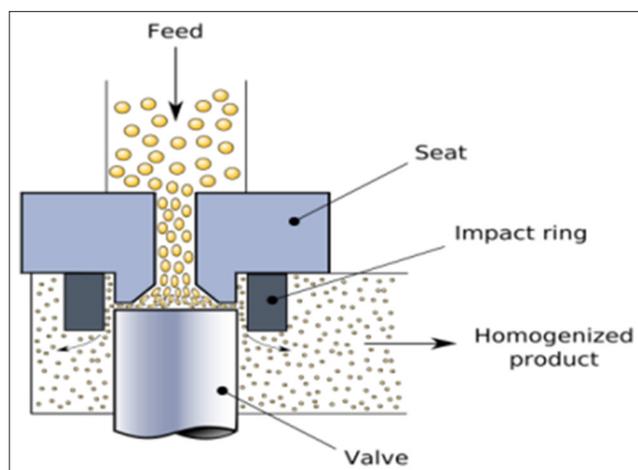


Figure 3: High-pressure homogenization method

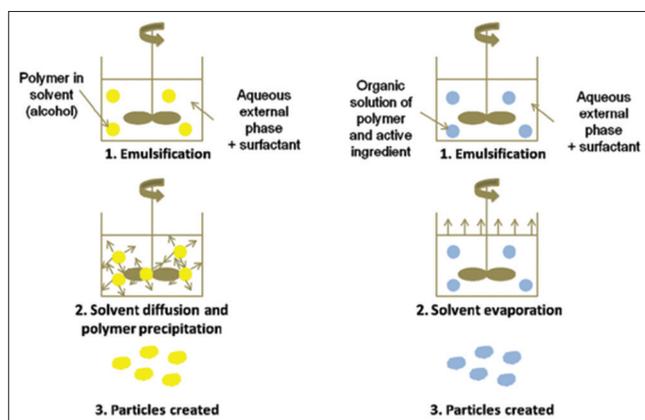


Figure 4: Solvent emulsification-diffusion method

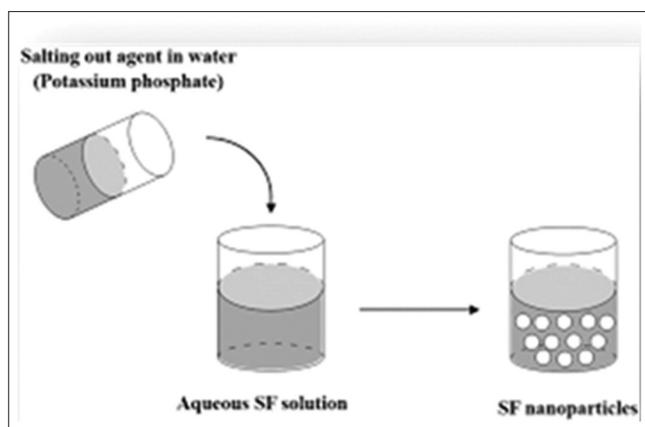


Figure 5: Salting-out method

NANO HERBAL FORMULATIONS

Nanophyto medicines are prepared from plant extracts or their therapeutically active constituents. Nano drug delivery systems help in better bioavailability, decreases side effects and toxicity. Some of the marketed nano herbal medicines are described as below.

Nanoparticles of *Cuscuta chinensis*



Cuscuta:

- Formulation: Nanoparticles of *Cuscuta chinensis*
- Active ingredients: Flavonoids and lignans
- Applications of nanostructured formulations: Improve water solubility
- Biological activity: Hepatoprotective and antioxidants effect
- Method of preparation: Nanosuspension method
- Route of administration: Oral.^[22]

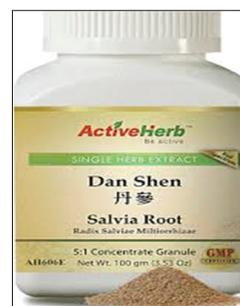
Artemisinin nanocapsule



Artemisinin nanocapsule:

- Formulations: Artemisinin nanocapsules
- Active ingredients: Artemisinin
- Applications of nanostructured formulations: Sustained drug release
- Biological activity: Anticancer
- Method of preparation: Self-assembly procedure
- Route of administration: IV.^[23]

Radix salvia miltiorrhiza nanocapsule



Radix salvia miltiorrhiza:

- Formulations: *R. salvia miltiorrhiza* nanoparticles
- Active ingredients: *R. salvia miltiorrhiza*

- Applications of nanostructured formulations: Improve the bioavailability
- Biological activity: Coronary heart diseases, angina pectoris, and myocardial infarction
- Method of preparation: Spray-drying technique
- Route of administration: IV.^[24]

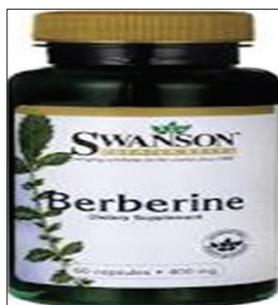
Taxel-loaded nanoparticles



Taxel-loaded nanoparticles:

- Formulation: Taxel-loaded nanoparticles
- Active ingredient: Taxel
- Applications of nanostructured formulations: Enhance the bioavailability and sustained
- Biological activity: Anticancer
- Method of preparation: Emulsion solvent evaporation method
- Route of administration: IV.^[25]

Berberine-loaded nanoparticles



Berberine-loaded nanoparticles:

- Formulation: Berberine-loaded nanoparticles
- Active ingredient: Berberine
- Applications of nanostructured formulation: Sustained drug release
- Biological activity: Anticancer
- Method of preparation: Ionic gelation method
- Route of administration: IV.^[26]

NANO HERBAL COSMETIC FORMULATIONS^[27]

Sunscreens

Ultraviolet (UV) filters are used in nano form rather than bulk form to make the sunscreen transparent rather than white. It is also claimed that they are more effective when used in nano

form. SLN can act as a physical UV blocker them and are able to improve the UV protection [Figure 6].

Breast cream

St. herb nano breast cream claims it is a combination of “nanotechnology and the timeless Thai herb, *Pereira mirifica*” and that niosomes “expands the cellular substructure and development of the lobules and alveoli of the breasts,” with increased size from one to three cups [Figure 7].

Hair care

Red blood cell Life Science’s Nanoceuticals Citrus Mint Shampoo and Conditioner are made with Nano Clusters “nanoclusters to give your hair a healthy shine.” Shampoo with herbal blend of nettle leaf extract, black elderberry extract, chamomile combined with citrus and mint oils.

- Strengthens hair follicles
- Improves scalp circulation
- Helps diminish inflammation and dandruff
- Enhances hair volume and shine [Figure 8].



Figure 6: Sunscreen lotion



Figure 7: Breast cream



Figure 8: Haircare products

Future prospects and opportunities in India

Nanotechnology offers various modern applications in NDDSs that potentially improve the diagnosis, treatment and help to monitor of post-administration transformation of drug composition within the body systems.^[28] Another important milestone to be mentioned here is computer aided drug design, which offers a lot of scope for the development of this kind of novel and advanced systems, helps in designing and developing the drugs and delivery systems consuming less time and resources with more accuracy and quality compared to traditional methods.^[29-31]

CONCLUSION

Nanotechnology is rapidly expanding and potentially beneficial field with tremendous implication for industry, medicine, and cosmetics. The combination of nanotechnology with traditional herbal medicine may provide a very useful tool in designing future herbal medicine with improved bioavailability profile and less toxicity. The combination of nanotechnology with traditional herbal medicine may provide a very useful tool in designing future herbal medicine with improved bioavailability profile and less toxicity. The connection between plant sciences and nanotechnology has the potential to develop an attractive symbiosis between green revolution and nanotechnology with realistic prospects for minimizing the application and generation of toxic chemicals that destroy living organisms. Nanotechnology is rapidly expanding and potentially beneficial field with tremendous, implication for industry, medicine, cosmetics.

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