RECENT APPROACHES ON HERBAL DRUG DEVELOPMENT IN VIEW OF NANOPARTICLES – A REVIEW

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Abstract

In this review focused on the herbal drug development in view of nanoparticles in that for the better therapeutic value herbal medicines have been mostly used in all over the world from ancient times and have been accepted by physicians and patients. The herbal nanoparticles are the best choice due to their fewer side effects compared to the modern medicines. Mostly in India herbal medicines have gain the more attention due to the ability to treat the several diseases with less adverse effects. To overcome the several constraints like poor solubility and poor bioavailability, in-vivo stability, unspecific site of action and intestinal absorption; the development of the novel drug delivery system is of substantial importance. For treating the chronic diseases like cancer and ravaging diseases the integration of the nano science as a novel drug delivery system in traditional system of medicine enriches the potential of herbal drugs. The synthesis of nanoparticles can be attained by acquiring the novel approaches like Metal nanoparticles, polymeric nanoparticles, solid lipid nanoparticles and ceramic nanoparticles depending on characteristics of the nanoparticles. This review provides a brief discussion of different nanoparticles of herbal medicine and its future effect of nanotechnology on herbal drugs.

Keywords: Herbal drugs, Nanoparticles, Novel drug delivery system, nano phytomedicines etc.
Introduction

The herbal ingredients are commonly used in many medicines. Actually, around 25% of drugs prescribed in the United States accommodate at least one active ingredient extracted from plant. The some are synthesized to mimic natural plant compounds and other are made from plant extracts [1]. The pharmaceutical products made from the chemical compounds are susceptible to adverse side effects. A product that does not occur naturally, human body has a tendency to reject certain chemical compounds. The phytopharma cannot produce a side effect, chemical interactions with other prescription drugs can occur [2].

As compared to the modern medicines, herbal medicines have been generally used worldwide for their superior therapeutic values and less toxic effects. The herbal medicine was not considered for the development of novel formulations for long period of time due to the lack of scientific justification and processing difficulties [3]. But now, in developing novel drug delivery systems (like nanoparticles, microspheres, liposomes, solid lipid nanoparticles etc) the modern phyto-pharmaceutical research can solve the scientific needs of herbal medicines. In the conventional dosage forms, if the drug gets administered produce a limited amount of dose reaches the targeted site, while a majority of the drugs get distributed throughout the body dependent on physicochemical and biochemical properties resulting in low therapeutic effect [4]. The important benefit of the novel drug delivery system is to target the specific site, reduces the dosage frequency, enhance the solubility and absorption although reduced
elimination. The nanoparticles are examined to be an important drug delivery system among all the novel drug delivery system [5]. To cure the diseases, herbal remedies and natural products are being used. The generally used allopathic system, the herbal treatment have thousands of components that all work at the same time against the diseases [6].

In developing countries, the herbal medicines like those used in traditional Chinese medicines (TCMs) are quiet used globally, specially to meet the healthcare needs [7]. Herbal medicines are frequently used as a crude extract and this either dried or not, which is basically a mixture of both the primary and secondary metabolites of the original plants. In the primary metabolites involve plant produced proteins, sugars, amino acid, lipids etc [8]. Secondary metabolites refer to plant produced small molecule compounds, bioactive or otherwise [9].

Nanoparticle or nano-size particle is a palatial class of materials that encompass the specific substance which has not as much of 100 nm in size. It has a extensive range of the revolutionary developments in the field of nanotechnology like treatment, monitoring, control of biological system and diagnosis; and it is an usual field of research of this century. Nanomaterials or nanoparticles have acquired eminent progress in nanotechnology because of their unique physiochemical and biological achievement over their counterparts. The crucial problem of conventional are lack of solubility. Nonspecific and inability to enter inside the cells which offer a considerable opportunity for nanoparticles to play a remarkable role [10].

These days, herbal drugs reside in a leading position in the pharmaceutical industry as their outcome are known and side effects are very insignificant. Furthermore, to fabricate nanoparticles compared to synthetic drugs the herbal drug has a symmetrical way of interest. Although, the herbal drug has huge pharmacological actions with regard to numerous diseases, it is shown in an only restricted effect on the human biological system because of their less kinetic performance like inability to cross the lipid membrane, low absorption, high molecular size and weight, poorly absorbed, resulting in a reduction of bioavailability and efficacy over the biological system. Additionally, several extracts are not used clinically due to some hinders. To control such related issues, carriers have been used as an alternative technique to increase the kinetic and dynamic parts of a drug molecule on a biological system [11].

Advantages of Novel drug delivery system for Herbal drugs [12]
The cultivation process and manufacturing are easy.
Renewable source.
Acceptance by the people as they have long history of use and superior patient tolerance.
Solubility and bioavailability enhancement.
Protect from toxicity
Stability Enhancement
Protection from physical and chemical degradation
Easily available
Improvement of pharmacological action
Enhancement in tissue macrophage distribution

Novel drug delivery approach for Herbal Medicines

Now a day, widen concerns over the dependence and safety of drugs and surgeries make herbal medicines popular. Although, in herbal medicines the conventional drug delivery system have been used then this could decrease the drug efficacy. Due to the great potential of novel drug delivery system, the different researchers are working to produce a novel herbal drug delivery system like sustained and extended-release formulations, nanoparticles, microcapsules, mouth dissolving tablets, mucoadhesive systems etc. In this some have already entered in the market and some of these still under development. Due to the eco-friendly nature and cost-effectiveness the plant-mediated synthesis of nanomaterials has been increasingly gaining popularity. The nanoparticles are the first choice in the novel drug delivery approach for herbal medicines due to their unique properties. Nanoparticles comprise a particle with a nanometer size of 1–100 nm. The nanoscale material has new, unique, and higher physical and chemical properties contrast to its bulk structure, because of enhance in the ratio of the surface area per volume of the particle\[^{13}\].

Nanoparticles mediated Nano phytomedicine:

Nanotechnology is division of science, which deals with nanosized particles. This technology has authorized us with the benefit of protecting drugs from enzymatic or acidic degradation and to decrease the dosing frequency \[^{14,15}\]. The advancements in phytomedicine
nanotechnology mediated drug delivery system have revolutionized. The abstraction of Nano phytotherapy and Rehabilitation; 32(3) phytomedicine has obtained substantial awareness over the past few decades [16]. Herbal drugs or Phytomedicines are include in the conventional medicinal system from a past few decades. Internationally, Herbal medicine is received as voluntary system to the present conventional system of medication. They are not at most employ as therapeutic agent but also as nutraceuticals and functional foods also. For better therapeutic effects and in minimizing their toxicity novel drug delivery system has opened new doors during development of phytomedicine [17,18]. Few restrictions which were the important source of opting nanotechnology as an improvement tool for the phytomedicine administration are as follow:

Ease of administration.

Accumulation of drugs in non-targeted areas.

Dumping of drugs

Instability of plant extracts or herbal extracts to withstand the body conditions like pH, first pass metabolism etc.

Phytoconstituents Incorporated Nano pharmaceuticals

These nanoparticles are either administered topically or in a relevant formulation (like intravenous, transdermaetc.) [19-21] and have manifest them superior than the existing traditional counterpart [22]. For plant actives the development of biodegradable polymeric nanoparticles has developed as a potential drug target [23]. The part of new delivery systems enclosing phytoconstituents can lead to the treatment of several fatal diseases [24]. Likewise, Bharali et al. signify in his study of utilizing nanotechnology to enhance the systemic delivery and bioavailability of any natural product. In their study, they working nanoparticle-mediated delivery for sustained release of epigallocatechin-3-gallate (EGCG), a polyphenol from green tea and announce exceptional results.

Why Nanoparticle is the First Choice in Herbal Medicine

The drawbacks of the traditional herbal drugs are overcome by using the herbal nanoparticles that’s why nanoparticles are the first choice in herbal medicines. And some needs of the nanoparticles in herbal treatment are as follow [25,26]:

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To target the herbal medicine to specific site which improve the selectivity, drug delivery, safety and effectiveness nanoparticles can be used.

Due to poor lymphatic drainage, shows enhanced permeation and retention effect, i.e., enhanced permeation through the barriers because of the small size and retention.

Due to the unique size and high loading capacities, nanoparticles can deliver high concentrations of drugs to disease sites.

Nanoparticles can be employed to enhance the herbal drug solubility and help to restrict the drug in a particular site thus resulting in better efficacy.

Allocating quicker dissolution in the blood, due to the delivering the drug in small particle size and increase the entire surface area of the drugs.

Minimized the side effects.

Without the addition of any particular ligand moiety exhibits passive targeting to the disease site of action.

There are various types of nanoparticles are used in the preparation of herbal drug delivery development this are as follow:

1. Metallic nanoparticles
2. Polymeric nanoparticles
3. Solid lipid nanoparticles
4. Ceramic nanoparticles

1. Metallic Nanoparticles: The nanoparticles are used for all the aforementioned purposes, the metallic nanoparticles examine as the very encouraging as they contain exceptional antibacterial properties because of their great surface area to volume ratio, which is of interest for researchers expected to the growing microbial resistance in case of metal ions, antibiotics and the evolution of resistant strains\(^{[27]}\). Between the all-noble metal nanoparticles, silver nanoparticle is the product from the field of nanotechnology which has acquire limitless interests due to their unique properties like good conductivity, chemical stability, catalytic and very important antibacterial, antifungal, anti-viral in addition to anti-inflammatory activities which can be integrate into complex fibres, cryogenic superconducting materials, cosmetic products, food industry and electronic constituents\(^{[28,29]}\).
The plants are deliberate to be more acceptable contrast to microbes for green synthesis of the nanoparticles as they are non-pathogenic and the several pathways are rigorously researched. By using a different plant, a wide spectrum of metal nanoparticles has been produced \[^{31,32}\]. These nanoparticles have distinctive thermal, optical, physical, magnetic, chemical and electrical properties in comparison to their equivalent bulk material with various applications in several field of human interest \[^{33}\]. There are several biological entities which are used for silver nanoparticles synthesis.

The leaf extracts of Acalypha indica have reveal the capability to synthesize the silver nanoparticles. The size of a silver nanoparticles gets became substantially homogeneous and ranged from 20-30 nm \[^{34}\]. In further study, Medicago sativa seed excretion was used for the synthesis of silver nanoparticles. The depletion of Ag\(^+\) occur about instantly as nanoparticles had been describe within a minute of the metal salt subjection and 90 % of Ag\(^+\) was decreased at 30 °C in < 50 min. The bringing nanoparticles were flower-like and triangular and spherical with a size range of 5-108 nm and had a heterogeneous size distribution \[^{35}\].

The leaf extract of Ocimum sanctum can also decrease the Ag\(^+\) develop in the silver nanoparticles of 3-20 nm in size production. The particles were spherical and stabilized by the way of the constituent of the leaf broth \[^{36}\].

**Fig. 1: Protocol for synthesis of silver nanoparticles using plant extract** \[^{30}\].

1. Take a plants part
2. Wash it with distilled
3. Colour of solution changes to yellow
4. Add AgNO\(_3\)
5. Filter it
6. Separate silver nanoparticles

Take a plants part
Wash it with distilled
Add AgNO\(_3\)
Filter it
Separate silver nanoparticles
Colour of solution changes to yellow

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In another study of Herbal Plant Synthesis of Antibacterial Silver Nanoparticles by *Solanum trilobatum* and Its Characterization. In this present examination authors report the green synthesis of sliver nanoparticles by using the leaf extract of medicinally important plant *Solanum trilobatum*. The impact of physical and chemical variables on the silver nanoparticles production like incubation time, pH, silver nitrate concentration and temperature are also studied in this present context. The green synthesized silver nanoparticles were specified by UV-vis spectroscopy, X-ray diffraction (XRD), scanning electron microscope (SEM), energy dispersive X-ray (EDX), and transmission electron microscope (TEM). The SEM and TEM substantiate the synthesis of spherical shape of nanocrystalline particles with the size range of 2–10 nm. FTIR disclose that the carboxyl and amine groups may be include in the depletion of silver ions to silver nanoparticles. Antibacterial activity of synthesized silver nanoparticles was done by agar well diffusion method against several pathogenic bacteria. The green synthesized silver nanoparticles can be used in the field of medicine because of their high antibacterial activity.\(^\text{[37]}\).

2. **Polymeric Nanoparticles:** For the purpose of targeted drug delivery system the encapsulation of the herbal extract in the polymeric nanoparticles is an eminent, effective and emerging way. It may distribute as a safer way of targeted drug delivery and may be the answer to the complications related to the presently available drugs as well as the restrictions of the conventional technique of drug delivery. Due to the extensive biocompatibility and ease of modifying properties polymeric nanoparticles have gained the enormous attention in drug delivery applications. Beyond the globe, the several scientists have enlarged different methods like, nanoprecipitation, solvent evaporation, supercritical fluid technology, salting out and emulsification–diffusion for preparation of nanoparticles.\(^\text{[38]}\). Recently, the nanotechnological process including medicinal plants have obtain the focus of researchers, who possess the various inventive delivery systems involve polymeric nanoparticles. For the purpose of controlled drug delivery this material made from biodegradable and biocompatible polymers.\(^\text{[39,40]}\).

According to the intended applications and payload the polymeric nanoparticles can be synthesized using the several methods. These particles are construct from natural, artificial and biodegradable polymers. The natural materials are select, due to their advantages, like ability to deliver more than one active component using the same carrier, enhance the residence time in the body, dispense a sustained release system and decrease the side effect.\(^\text{[41]}\). The oral administration of precise conventional formulations may conduct to side
effects, and the degradation of the active components is encouraged by the acidic pH of the stomach. By using the polymeric nanoparticles these problems might be decreased. The nanoparticles control the release of active components, enhancing the ocular bioavailability and decreasing the side effects \[42\].

Basniwal et al. this author developed a novel technique to prepared Curcumin loaded polymeric nanoparticles, which increase the solubility of curcumin. This study also evaluates either this formulation would increase the curcumin's antimicrobial activity. By using a process based on the wet-milling technique the curcumin-loaded polymeric nanoparticles were prepared and these nanoparticles were acquired with a inadequate size distribution of 2-40 nm. The nanocurcumin chemical structure was similar to the indigenous molecule i.e., curcumin, contribute that no chemical change had happen during encapsulation, and manifest that the formulation could be effortlessly scatter in water without surfactant. The antimicrobial activity was assess using a microplate dilution method against S. aureus, E. coli, B. subtilis, Penicillium notatum. Relative to free curcumin, water solubility and small size of nanocurcumin nanoparticles improved an antimicrobial activity. The antibacterial activity of nanocurcumin was further noticeable than its antifungal activity. And in this study TEM analysis was performed and this analysis disclosed that when the nanoparticles were initiate into a bacterium, they entirely demolish the cell wall, resulting in bacterial cell death \[43\].

Another one i.e., Das et al. tested a root extract of the Phytolacca decandra (Phytolaccaceae) in free form and encapsulated form of PLGA in mice dosed with benzopyrene (25 mg/kg) and sodium arsenite (10 mg/kg) in-vivo, additionally, on A549 lung cancer cells in -vitro. The nanoencapsulation of the PD enhanced the drug bioavailability, and created superior chemo preventive action over lungs cancer in-vivo, and on A549 cells in-vitro, than free form of PD\[44\].

In another study, the Rajendran et al. characterized the antimicrobial activity of Ethanolic, methanolic and aqueous extracts of leaves of Ocimum sanctum (Family – Lamiaceae). In this study the authors used an agar diffusion and microdilution methods to regulate the minimum inhibitory concentration (MIC) against B. subtilis, S. aureus, P. aeruginosa, E. coli etc. The accurate results were present to the methanolic extract, by ethanol, petroleum ether and aqueous extracts. After this analysing, the methanolic extracts reveal the accurate antimicrobial activity, and were loaded into the sodium alginate loaded chitosan
nanoparticles, between a cation induced, controlled gelation method. By using a pad dry cure method particle were deposited on cotton fabric\cite{45}.

Zheng et al. these authors select a Honokiol (HN) it is a component of the Chinese medicinal plant Magnolia officinalis (Magnoliaceae). It has various pharmacological effects, like anti-inflammatory, antirheumatic, antithrombotic, antioxidant, with anxiolytic, muscle relaxant activity and central nervous system depressant. Additionally, it also shows a potent antitumor activity. In this compound the hydrophobic properties represent a barrier due to the high hydrophobicity avert vascular administration. Although, the vascular administration was possible when this active constituent was loaded in polymeric nanoparticles. Relative to the free HN new formulation containing HN-loaded polymeric nanoparticles for vascular administration obtained a better result\cite{46}.

The Camptothecin (CPT) is natural plant alkaloid bring out from the Camptotheca acuminata Decne (Family-Cornaceae), and it has been revealing to be a potent antineoplastic drug, and targeting an intracellular topoisomerase. Although, because of the low water solubility and unstable lactone ring, clinical use is not applicable. The author Min et al. ameliorate a nanoparticle based on hydrophobically adapt glycol chitosan (HGC) as a delivery system. This camptothecine encapsulated nanoparticles was prepared by using dialysis method and this nanoparticle loading efficiency 80 % exceeded. Under a physiological condition the hydrophobic core of the HGC nanoparticles secured the key lactone ring from hydrolysis. A subcutaneous tumour was established by inoculating MDA-MB-231 human breast cancer cells in the back of a mouse verify antitumoral activity of the nanoparticles. After intravenous (iv) injection of CPT-HGC, at 10 mg/kg and 30 mg/kg, tumour growth was considerably inhibited, relative to free CPT (30 mg/kg). The strong antitumoral activity of CPT-HGC was most likely related to prolonged blood circulation, and high accumulation in tumours as confirmed by near infrared study\cite{47}.

Table 1: Herbal formulation of polymeric nanoparticles

<table>
<thead>
<tr>
<th>Herbal medicine</th>
<th>Pharmacological activity</th>
<th>Polymeric nanoparticles formulation</th>
<th>Advantages of formulation</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triptolide</td>
<td>Used in treatment of autoimmune diseases like rheumatoid arthritis, Poly (DL-lactic acid) nanoparticles</td>
<td>Reduced the toxicity and improved</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td><strong>Plant extract of Ziziphus mauritiana</strong></td>
<td>Immunomodulatory activity</td>
<td>Chitosan nanoparticles</td>
<td>Increased the immunomodulatory activity of an extract.</td>
<td>49</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------</td>
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<td>------------------------------------------------------</td>
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</tr>
<tr>
<td><strong>Curcumin</strong></td>
<td>Show the various activities like antioxidant, anti-inflammatory, antitumour, antiplatelet etc.</td>
<td>Methoxy poly (ethylene glycol)-palmitate nanocarrier</td>
<td>The solubility and bioavailability of curcumin get increased</td>
<td>50</td>
</tr>
<tr>
<td><strong>Catechins</strong></td>
<td>Anticarcinogenic, antiviral, antioxidant, antiobesity, anti-inflammatory.</td>
<td>Chitosan nanoparticles</td>
<td>Stability of catechins increased.</td>
<td>51</td>
</tr>
</tbody>
</table>

### 3. Solid lipid Nanoparticles:

Solid lipid nanoparticles (SLNs) are the colloidal carrier systems, that integrate the benefits of another colloidal systems (such as emulsions, liposomes, and polymeric nanoparticles) for drug delivery, while escaping or reducing few of their disadvantages. Solid lipid nanoparticles have more physicochemical stability and offer superior defence against degradation of labile drugs; they also can be simply fabricate on a big scale\[52-55\]. By emulsifiers, solid lipid nanoparticles are colloidal systems made up of a solid lipid core matrix, which is stabilized in aqueous solution. This nano system allows benefits as a drug-delivery carrier, like stability, controlled release kinetics, tolerability, and protection of labile drugs\[56\]. The solid and lipids frequently used in solid lipid nanoparticles are glyceride mixtures, more purified glycerides, or waxes that do not melt at body temperature. The safety of oral nano formulations is a significant bother for their application\[57,58\]. A requirement for a new drug formulation discovery is the verification of its safety when administered to the body. A balanced efficacy and safety are mandatory when developing the nanomedicine for therapeutic application. The solid lipid nanoparticles are developed by solid lipids and emulsifiers normally acknowledge as safe with respect to biocompatibility and nontoxicity. The lipid matrices are the natural or synthetic lipids that
can be degraded, involving triglycerides (trimyristin, tripalmitin, and tristearin), glycercy monostearate (Imwitor), glycercy behenate (Compritol 888 ATO), glycercy palmitostearate (Precirol ATO 5), hard fat types (Witepsol), fatty acids (decanoic acid, palmitic acid, and stearic acid), waxes (cetyl palmitate, beeswax, and carnauba wax) [59,60].

Solid lipid nanoparticles have more physicochemical stability and preserve the labile drugs from degradations the production could be done on large scale basis [61]. These colloidal particles composed of highly purified triglycerides. For stability the structures are made up of solids, lipids and mixtures of them and surfactants used [62]. Solid lipid nanoparticles are created by a core of solid and lipid with a part of lipid matrix which is a bioactive material and stabilized by a surfactant layer. From chemical degradation the matrix of lipid particle is solid which protect the drug. Crystallization of by-product cause coherent encapsulation and release of drugs [63]. As their size is small (50-1000 nm) and biocompatibility of solid lipid nanoparticles, used for several routes of administration such as oral, parenteral, percutaneous [64].

Fig.2: Structure of Solid Lipid Nanoparticles Stabilized by Surfactant Layer

Table 2: Examples of solid lipid nanoparticles of Herbal drugs

<table>
<thead>
<tr>
<th>Herbs</th>
<th>Parts used</th>
<th>Advantage of Formulation</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garlic</td>
<td>Liliaceae family of bulb are used.</td>
<td>Anti-dandruff shampoo</td>
<td>65</td>
</tr>
<tr>
<td>Curcumin</td>
<td>Curcuma longa rhizome used.</td>
<td>Anti-depressant effects</td>
<td>66</td>
</tr>
<tr>
<td>Curcuminoids</td>
<td>Curcuminoids used from Curcuma longa</td>
<td>Anti-inflammatory activity</td>
<td>67</td>
</tr>
<tr>
<td>Neem oil</td>
<td>Azadirachta indica seeds</td>
<td>For the treatment of Acne</td>
<td>68</td>
</tr>
</tbody>
</table>

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Bacoside | Bacopa monniera leaves are used. | Memory enhancer | 69
---|---|---|---
Artemisia arborescens | Leaves of artemisia arborescens used. | Good potential carriers for ecological pesticides in agriculture. | 70
Capsaicin | Capsaicin is an constituents of chilli pepper. | Topical delivery carrier to enhance the penetration of lipophilic drug capsaicin. | 71

Quercetin is a natural flavonoid and when this incorporated in lipid carriers that become more effective. The author Li et al. incorporated Quercetin, which is less soluble in the aqueous media in Solid lipid nanoparticles using an emulsification -solidification technique at very low temperature. In this study the desired amount of Quercetin, glyceryl monostearate and soy lecithin were mixed with the solvent like chloroform: acetone in the ratio 1:1. Falling into the nanoscale range (20-500 nm) the solid lipid nanoparticles were spherical with an average size of 155.3±22.1 nm. Quercetin solid lipid nanoparticles revealed the controlled release in-vitro. The bioavailability of Quercetin solid lipid nanoparticles was more than five times higher, and demonstrated increased absorption in the intestine (rather than the stomach), compared to free Quercetin in the in-vivo experiments\(^\text{[72]}\).

Kakkar et al. performed a study to improve the oral bioavailability of curcumin by incorporating it into Solid lipid nanoparticles composed of soy lecithin. The micro emulsification technique was used to fabricate this formulation. The particles size of solid lipid nanoparticles was spherical and medium-sized (134.6±15.4 nm); drug entrapment efficiency was found to be 92.33%±1.63%. The studies of stability disclosed that solid lipid nanoparticles loaded with curcumin indicate only reduced an about 9% in efficiency of incorporation, after 12 months of storage at 5°C±3°C, showed that the curcumin loaded solid lipid nanoparticles were stable. Although, the curcumin loaded solid lipid nanoparticles revealed extended drug release in-vitro. In- vivo pharmacokinetic studies showed that after orally administered curcumin loaded solid lipid nanoparticles (50 mg/kg, 25 mg/kg, 12.5 mg/kg, and 1 mg/kg), a remarkable advance in oral bioavailability was attained, compared to free Curcumin (by 39, 32, and 155 times at 50 mg/kg, 25 mg/kg, 12.5 mg/kg, and 1 mg/kg doses sequentially)\(^\text{[73]}\).
In another study the authors Martins et al. developed and validated a simple high performance liquid chromatography method to determine the content of Camptothecin (CP) in several organs in rats, after administration of Camptothecin over solid lipid nanoparticles. Their formulations employed cetyl palmitate as the lipid and polysorbate 80 as the surfactant at 5% ratio by weight (w/w) and 2% (w/w). A Prominence UFLC system (Shimadzu Scientific, Kyoto, Japan), equipped with two pumps (LC-20AD; Shimadzu), an autosampler (SIL-20AC; Shimadzu), and a column oven (CTO-20AC; Shimadzu), was used for each and every chromatographic analysis. The optimized method employed a binary gradient mobile phase with 1% (v/v) triethylamine buffer at pH 5.5 as mobile phase A, and acetonitrile as mobile phase B. The flow rate was 1.2 mL/min, and the injection volume was 10 µL. The eluted peaks were monitored at the excitation and emission wavelengths of 360 nm and 440 nm severally. For determining the amount of Camptothecin in samples from organs of rats treated with Camptothecin in suspension and Camptothecin incorporated in solid lipid nanoparticles this method was reliable, precise, and accurate [74].

Mei et al. incorporated triptolide (TP) in solid lipid nanoparticles (TPSLN) comprise of tristearin glyceride and stearic acid, to enhance solubility and absorption into skin. Triptolide is a purified compound made from a traditional Chinese medicine that was isolated from the shrublike vine, Tripterygium wilfordii Hook (Family - Celastraceae). This study indicate that vine extracts are effective for the treatment of several diseases, involving an inflammatory and autoimmune diseases, like rheumatoid arthritis. The results exhibit that Triptolide-solid lipid nanoparticles enhance the acute anti-inflammatory activity, due to the Triptolide penetrated additionally into the skin [75].

4. Ceramic Nanoparticles: Ceramic nanoparticles are inorganic systems with porous attributes that have recently appear as drug vehicles. In cancer therapy, the biocompatible ceramic nanoparticles like silica 30, titania and alumina can be used. Although, one of the most important concerns is that these particles are non-biodegradable, as they can assembled in the body, thus causing undesirable effects [76].

Table 3: Herbal drugs used in herbal nanoparticles of marketed products
<table>
<thead>
<tr>
<th>Sr.no.</th>
<th>Products</th>
<th>Manufacture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quercetin 500 mg supplement capsules</td>
<td>A Squared Nutrition</td>
</tr>
<tr>
<td>2</td>
<td>Nano Curcumin capsules</td>
<td>One plant Nutrition</td>
</tr>
<tr>
<td>3</td>
<td>Swanson capsules</td>
<td>Swanson premium</td>
</tr>
<tr>
<td>4</td>
<td>Gotukola Powder- Centella Asiatica</td>
<td>Herbal Hills</td>
</tr>
<tr>
<td>5</td>
<td>Sudarshan Ghanvati</td>
<td>Dhanvantari guj.herb</td>
</tr>
<tr>
<td>6</td>
<td>Dodder seed extract VegiCaps</td>
<td>Barlowes Herbal Elixirs</td>
</tr>
<tr>
<td>7</td>
<td>Hawaiian Herbal Kasly Dan Shen Capsules</td>
<td>Hawaiian Herbal</td>
</tr>
</tbody>
</table>

**New challenges and approaches**

To overcome the complications associated with the plant medicines the nanosized drug delivery system for herbal drugs can possibly improve the biological activity. Although, the remarkable challenges persist for execution of clinically feasible therapies in this field. New challenges in the development of nanotechnology-based drug delivery systems involve: the viability of scale-up processes that bring novel therapeutic approaches to the market rapidly, and the probability of procuring multifunctional systems to attain various biological and therapeutic conditions. Several additional new challenges involve probing the targeting efficiency of nanoparticles, and satisfying international standards for their toxicology and biocompatibility.

**Future Prospects of Nano Herbal Medicines**

In an entire world, on the herbal remedies and natural products research as been conducted due to their less side effect as compared to the allopathic medicines and easily available and patient acceptance. The problems associated with herbal drugs; this overcomes by nanosized drug delivery system for herbal drugs can probably increased the biological activity. Nanotechnology offers several modern applications in novel drug delivery system that
possibly enhance the diagnosis, treatment and help to monitor the post-administration transformation of drug composition within the body systems. Because of an amorous pharmacological activity nano herbal preparation appearing a more interest in several fields recently. In pharmaceutics nanotechnology enables drug delivery is notched forthcoming future.

The development of herbal remedies in the drug delivery system in number of organizations being carried out at basic and clinical trial levels. The requirement is to invent the superior system for the proper delivery of such drugs at the specific sites and in the body doses which will not accommodation with subsist treatment. This not only give relieve from the adverse effects such as toxicity and hypersensitive reactions even so also will enhance patient strength from inside is too much advantageous. Consequently, the herbal remedy in nanocarriers will enhance its potential for the treatment of several chronic diseases and health advantage. The approaches of modern drug delivery system i.e., nanotechnology has accepted the desirable therapies to the pharmaceutical in future that will effective for the people health. It is expect that the successful and useful significance of the natural products and herbs being applied with the nanomedicine will improve the importance of existing drug delivery systems.

References


